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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
1133	September 23–24, 2017	Orlando, FL	EXPIRED	Vol 38, No. 4
1134	November 4–5, 2017	Riverside, CA	EXPIRED	Vol 38, No. 4
1135	January 10–13, 2018	San Diego, CA	EXPIRED	Vol 39, No. 1
1136	March 17–18, 2018	Columbus, OH	January 22	Vol 39, No. 2
1137	April 14–15, 2018	Portland, OR	February 6	Vol 39, No. 2
1138	April 14–15, 2018	Nashville, TN	February 13	Vol 39, No. 2
1139	April 21–22, 2018	Boston, MA	February 20	Vol 39, No. 2
1140	June 11–14, 2018	Shanghai, Peoples Rep of China	TBA	NONE
1141	September 29–30, 2018	Newark, DE	July 31	Vol 39, No. 3
1142	October 6–7, 2018	Fayetteville, AR	August 7	Vol 39, No. 3
1143	October 20–21, 2018	Ann Arbor, MI	August 21	Vol 39, No. 4
1144	October 27–28, 2018	San Francisco, CA	August 28	Vol 39, No. 4
1145	January 16–19, 2019	Baltimore, MD	TBA	TBA
1146	March 15–17, 2019	Auburn, AL	TBA	TBA
1147	March 22–24, 2019	Honolulu, HI	January 22	TBA

DENTON, TX, September 9–10, 2017

Abstracts of the 1131st Meeting.

00 ► General

1131-00-105 **Vinod K Arya*** (vinod.arya@untdallas.edu), 7400 University Hills Blvd, Department of Mathematics, Dallas, TX 75077. *Developing and Implementing a Flipping-the-Class Modularized Model to Enhance Student Success Rates in Gatekeeper Mathematics Courses.* Preliminary report.

This paper presents a description of a self-paced, modularized flipping-the-class (Emporium based) model of instruction that has been developed by the author for enhancing the student retention and success rate at the University of North Texas at Dallas (UNTD). The model has been modified to specifically suit the needs of students who struggle in Gatekeeper Mathematics courses with the goal to enhance their success and retention rates. Consequently, the present model adopts a structure that includes a modularized form, in which the entire course content is divided into an appropriate number of modules. As a pilot program, this modularized flipping-the-class model was developed and adopted for a Gatekeeper - College Algebra course. The benefits of employing the model, in terms of enhanced student success rates and performances, have been assessed and the relevant but limited data to show the success of the model in achieving its objectives is presented. (Received July 07, 2017)

1131-00-289 **Adrianna Gillman*** (adrianna.gillman@rice.edu). *Fast direct solvers for boundary integral equations.*

The numerical solution of linear boundary values problems play an important role in the modeling of physical phenomena. As practitioners continue to want to solve more complicated problems, it is important to develop robust and efficient numerical methods. For some linear boundary value problems, it is possible to recast the problem as an integral equation which sometimes leads to a reduction in dimensionality. The trade-off for the reduction in dimensionality is the need to solve a dense linear system. Inverting the dense $N \times N$ matrix via

Gaussian elimination has computational cost of $O(N^3)$. This talk presents solution techniques that exploit the physics in the boundary integral equation to invert the dense matrix for a cost that scales linearly with N and has a small constant. For example, on a laptop computer, a matrix with $N = 100,000$ can be inverted in 90 seconds and applying the solver takes under a tenth of a second. Numerical results will illustrate the performance of the fast direct solvers for a variety applications. (Received July 17, 2017)

01 ► History and biography

1131-01-250 **Alberto A Martinez*** (almartinez@austin.utexas.edu), Dept. of History, Univ. of Texas at Austin, 128 Inner Campus Dr, Stop B7000, Austin, TX 78712. *Negative Signs in the History of Algebra, Vectors, and Relativity.*

I will discuss the role of negative and imaginary numbers in the history of physicists' efforts to represent motion. Such numbers generated controversies and new methods of analysis in physics. I'll note early versions of the Lorentz transformations. Contrary to myths about the Michelson-Morley experiment, I'll discuss how particular experiments on the speed of light influenced Albert Einstein to formulate his special theory of relativity. I'll explain why Einstein called the constancy of the speed of light a postulate, and why it remains a postulate. Next I'll discuss how the Pythagorean theorem links the Galilean transformation and the Lorentz transformation. In 1905 Einstein asserted the covariance of any light sphere with respect to inertial reference frames, and years later he used this as a starting point for derivations of the Lorentz transformations. Finally, I'll discuss how Minkowski used negative and imaginary quantities in his four-dimensional geometric interpretation of Einstein's theory. (Received July 16, 2017)

03 ► Mathematical logic and foundations

1131-03-73 **fred halpern*** (fredhalp@gmail.com), 10845 N. Central Expwy #1141, dallas, TX 75231. *Preservation theorems via dual proof trees.*

We define a natural deduction framework for proving preservation theorems. It automates the proof of the classical preservation theorems (under extension, substructure, and homomorphism, as well as retracts and Keisler sandwiches). It provides a simple correspondence between properties of algebraic situations and the syntactical form of preserved formula.

The methodology is constructive: It computes the form of preserved formulas from the algebraic description and given a preserved formula, it produces a logically equivalent formula in characterized form.

The framework enables the generalization of characterizations like the joint embedding and amalgamation properties. Similarly, the Scott interpolation theorem generalizes to arbitrary operators, yielding the classic definability theorms (Craig interpolation, Robinson consistency, and Svenonius') as corollaries. Also, for Cantor-Bernstein theories, every formula is equivalent to a lattice combination of existential and universal formulas. (Received July 02, 2017)

1131-03-97 **Westin King*** (wking@math.tamu.edu). *Counting Prime Parking Functions Generalized to Rooted, Labeled Trees.*

A *prime* parking function of length n is one for which a driver preferring the first spot can be removed and the resulting sequence is a parking function on the first $n-1$ spots. In this talk, I extend the notion of prime parking functions, by considering edges traversed during the parking procedure, to parking functions on labeled, rooted trees in which the cars move towards the root. Lackner and Panholzer have found that the total number of parking functions on such trees with n vertices is $((n-1)!)^2 \cdot \sum_{j=0}^{n-1} \frac{(n-j)(2n)^j}{j!}$. I will show via bijection that there are, suprisingly, $(2n-2)!$ prime parking functions on the same collection of trees. (Received July 06, 2017)

1131-03-263 **Logan Crone*** (logancrone@my.unt.edu), **Lior Fishman** (lior.fishman@unt.edu) and **Stephen Jackson** (jackson@unt.edu). *Determinacy of Schmidt's Game.*

In this talk, we present theorems regarding the determinacy of Schmidt's game, which in recent years has been used extensively to prove theorems in number theory. (Received July 17, 2017)

05 ► Combinatorics

1131-05-23 **Joseph Kung*** (kung@unt.edu). *The $\mathcal{G}$-invariant versus the Tutte polynomial in matroid theory.* Preliminary report.

The Tutte polynomial is the current champion, as far as most matroid theorists are concerned, but there is a challenger, the $\mathcal{G}$-invariant. As most of the audience will probably not be hard-core matroid theorists, this talk will be expository and historical. I hope to explain why these two invariants are "interesting", summarize the current state of knowledge or ignorance, and pose some general research problems. (Received May 21, 2017)

1131-05-36 **Sami Assaf** and **Anne Schilling*** (anne@math.ucdavis.edu), Department of Mathematics, University of California, One Shields Avenue, Davis, CA 95616. *A Demazure crystal construction for Schubert polynomials.*

Stanley symmetric functions are the stable limits of Schubert polynomials. In this talk, we show that, conversely, Schubert polynomials are Demazure truncations of Stanley symmetric functions. This parallels the relationship between Schur functions and Demazure characters for the general linear group. We establish this connection by imposing a Demazure crystal structure on key tableaux, recently introduced by the first author in connection with Demazure characters and Schubert polynomials, and linking this to the type A crystal structure on reduced word factorizations, recently introduced by Morse and the second author in connection with Stanley symmetric functions. This talk is based on arXiv:1705.09649. (Received June 13, 2017)

1131-05-41 **Eric Swartz*** (easwartz@wm.edu) and **Alex Schaefer**. *Graphs that contain multiply transitive matchings.*

Let Γ be a finite, undirected, connected, simple graph. We say that a matching $\mathcal{M}$ is a *permutable m-matching* if $\mathcal{M}$ contains m edges and the subgroup of $\mathrm{Aut}(\Gamma)$ that fixes the matching $\mathcal{M}$ setwise allows the edges of $\mathcal{M}$ to be permuted in any fashion. A matching $\mathcal{M}$ is a *2-transitive matching* if the setwise stabilizer of $\mathcal{M}$ in $\mathrm{Aut}(\Gamma)$ can map any ordered pair of distinct edges of $\mathcal{M}$ to any other ordered pair of distinct edges of $\mathcal{M}$. These definitions were motivated by a question of Zaslavsky regarding signed graphs. I will discuss constructions and characterizations of graphs with a permutable m-matching, as well as the classification of the graphs with a 2-transitive perfect matching. This is joint work with Alex Schaefer of Binghamton University. (Received June 19, 2017)

1131-05-44 **Thomas Zaslavsky***, Dept. of Math. Sci., Binghamton, NY 13902-6000. *Quasibalanced signed graphs.* Preliminary report.

A signed graph is a graph with edges signed positive or negative. In many ways graphs are like all-positive signed graphs. In particular, signed graphs have a "frame matroid" that is the usual graphic matroid if all signs are positive; more generally, iff the signed graph is "balanced" (every circle has positive sign product). The frame-matroid circuits are the positive circles, the pairs of negative circles that have just one common vertex, and the pairs of disjoint negative circles along with a minimal connecting path.

Bessouf and Khelladi (unpublished) have suggested questions about circuits that lie on the boundary between graphs and matroids. In particular, in which signed graphs is every circuit a positive circle? (Call them "quasibalanced".) An equivalent condition is that every two negative circles have two or more common vertices. I will describe the structure of quasibalanced signed graphs. (Received June 20, 2017)

1131-05-63 **Luis David Garcia Puente*** (lgarcia@shsu.edu), Department of Mathematics and Statistics, Sam Houston State University, Huntsville, TX 77341-2206, and **Benjamin Braun**, **Hugo Corrales**, **Scott Corry**, **Darren Glass**, **Nathan Kaplan**, **Jeremy Martin**, **Gregg Musiker** and **Carlos Valencia**. *Counting Arithmetical Structures.*

Let G be a finite, simple, connected graph. An arithmetical structure on G is a pair of positive integer vectors (d, r) such that $(\mathrm{diag}(d) - A)r = 0$, where A is the adjacency matrix of G. Arithmetical graphs were introduced in the context of arithmetical geometry by Lorenzini in 1989 to model intersections of curves. We investigate the combinatorics of arithmetical structures on path and cycle graphs, as well as the associated critical groups (the cokernels of the matrices $(\mathrm{diag}(d) - A)$. For paths, we prove that arithmetical structures are enumerated by the Catalan numbers, and we obtain refined enumeration results related to ballot sequences. For cycles, we prove that arithmetical structures are enumerated by the binomial coefficients $C(2n-1, n-1)$, and we obtain refined enumeration results related to multisets. In addition, we determine the critical groups for all arithmetical structures on paths and cycles. (Received June 29, 2017)

1131-05-69 **Catherine Yan*** (cyan@math.tamu.edu), **Ron Graham** (graham@ucsd.edu) and **Steve Butler** (butler@iastate.edu). *Parking Distributions on Trees.* Preliminary report.

We consider a generalization of parking functions to parking distributions on trees and study the unordered version and a q-analogue. We give an efficient way to form generating functions to compute these values and establish the positivity and log-concavity of a related polynomial, which replies on the structure of the underlying trees. We also connect the unordered parking distributions on caterpillars (trees whose removal of leaves results in a path) to restricted lattice walks. (Received July 01, 2017)

1131-05-119 **Jacob A White*** (jacob.white@utrgv.edu). *Burnside Tutte invariants for Group-invariant hypergraphs.* Preliminary report.

We study group invariant hypergraphs, which generalize gain graphs and signed hypergraphs. In particular, we can define a notion of deletion and contraction, and hence a universal Tutte invariant. We show that some specializations can be viewed as polynomial endofunctions on the Burnside ring of a group. For ordinary hypergraphs we obtain the chromatic polynomial, and can obtain chromatic polynomials of gain graphs through other specializations. At the end of the talk, we will suggest a further generalization involving topos theory. (Received July 09, 2017)

1131-05-121 **McCabe Olsen*** (mccabe.olsen@uky.edu), 165 Donabrook Court, B-8, Lexington, KY 40517. *Hilbert bases and lecture hall partitions.*

In the interest of finding the minimum additive generating set for the set of $\boldsymbol{s}$-lecture hall partitions, we compute the Hilbert bases for the $\boldsymbol{s}$-lecture hall cones in certain cases. In particular, we determine the Hilbert bases for two well-studied families of sequences, namely the 1 mod k sequences and the ℓ-sequences. Additionally, we provide a characterization of the Hilbert bases for $\boldsymbol{u}$-generated Gorenstein $\boldsymbol{s}$-lecture hall cones in low dimensions. (Received July 10, 2017)

1131-05-128 **Alex Schaefer*** (alex.scha4@gmail.com). *The Dimension of the Negative Cycle Vectors of a Signed Graph.*

A *signed graph* is a graph Γ where the edges are assigned sign labels, either "+" or "−". The sign of a cycle is the product of the signs of its edges. Let $\mathrm{SpecC}(\Gamma)$ denote the list of lengths of cycles in Γ. We equip each signed graph with a vector whose entries are the numbers of negative k-cycles for $k \in \mathrm{SpecC}(\Gamma)$. These vectors generate a subspace of $\mathbb{R}^{\mathrm{SpecC}(\Gamma)}$.

Using Schaefer and Swartz's newly developed theory of permutable matchings, we provide lower bounds on the dimension of this space; in particular, we show for complete graphs, complete bipartite graphs, and a few other graphs that this space is all of $\mathbb{R}^{\mathrm{SpecC}(\Gamma)}$. (Received July 10, 2017)

1131-05-129 **Jesse Taylor*** (jesse.taylor@angelo.edu), Department of Mathematics, 2601 W AVE N, San Angelo, TX 76904. *Graphic matroids that guarantee their duals as minors.*

A natural question for matroids follows: Which matroids N guarantee that, when present as minors in a larger matroid M, their duals are present as minors? The main result of this talk addresses this question with the additional constraints that N and M are 3-connected and graphic. This talk assumes no prior knowledge of matroids and will focus on graph-theoretic arguments. (Received July 10, 2017)

1131-05-171 **Mitch Phillipson*** (mphilli2@stedwards.edu). *Generalized RNA foldings and their move graphs.* Preliminary report.

RNA is a single stranded molecule, unlike its double helix cousin DNA. Much like DNA, RNA consist of 4 nucleotides where each nucleotide can bond with exactly one other nucleotide. This idea is abstracted, instead of the bonding being a matching what if we allow a general graph. The goal of this talk is to determine which graphs preserve certain nice properties that arise when considering only matchings. (Received July 13, 2017)

1131-05-212 **Angela Berardinelli*** (aberardinelli@mercyhurst.edu). *Reduced words and reduced word graphs for elements of complex reflection groups.* Preliminary report.

Reduced words have been an important tool in studying the representation theory and combinatorics of Coxeter groups for at least the last 20-25 years. This tool does not fully translate to complex reflection groups, however. For example, Coxeter groups famously have a unique element of maximal length, but complex reflection groups do not. In this talk, we will discuss some useful properties of reduced words that do extend to complex reflection groups, including reduced word graphs, fully commutative elements, maximal length elements, and elements with a unique reduced word. We will also explore algorithms for generating the list of reduced words for a given element in a reflection group and for generating the corresponding graph whose vertex set is the set of reduced

words for the element and whose edges represent the commuting and braid relations of the group. (Received July 14, 2017)

1131-05-230 **Pavel Galashin**, **Sam Hopkins*** (shopkins@mit.edu), **Thomas McConville** and **Alex Postnikov**. *Vector-firing for root systems.*

Hopkins, McConville and Propp recently introduced a variant of chip-firing on the infinite path where the chips are given distinct integer labels and showed this process sorts certain (but not all) initial configurations of chips. We recast this result in terms of root systems: the labeled chip-firing game can be seen as a "vector-firing" process which allows the moves $\lambda \to \lambda + \alpha$ for $\alpha \in \Phi^+$ whenever $\langle \lambda, \alpha^\vee \rangle = 0$, where Φ^+ is the set of positive roots of a root system of type A_{2n-1}. We give conjectures about confluence for this process in the general setting of an arbitrary root system. We show that the process is always confluent from any initial point after modding out by the action of the Weyl group (an analog of unlabeled chip-firing in arbitrary type). We also show that if we instead allow firing when $\langle \lambda, \alpha^\vee \rangle \in [-k-1, k-1]$ or $[-k, k-1]$, we always get confluence from any initial point. Moreover, in these two settings, the set of weights with given stabilization has a remarkable geometric structure related to permutohedron. This geometric structure leads us to define certain "Ehrhart-like" polynomials that conjecturally have nonnegative integer coefficients. (Received July 16, 2017)

1131-05-235 **Bruno Benedetti***, Dept. of Mathematics, Coral Gables, FL 33146. *Mogami manifolds.*

A "tree of tetrahedra" is a simplicial complex homeomorphic to the 3-ball and such that its dual graph is a tree. "Mogami manifolds" are the 3-manifolds that can be obtained from a tree of tetrahedra by recursively gluing together two *incident* boundary triangles. This cute property, originally introduced in a 1995 quantum physics paper, can be generalized to all dimensions and behaves nicely with respect to other properties we know, like shellability and simply-connectedness. (Received July 16, 2017)

1131-05-246 **Bennet Goeckner*** (bennet@ku.edu). *Colorated homology and balanced complexes.* Preliminary report.

In this talk, we will introduce the idea of colorated homology, which gives rise to a particular decomposition of pure balanced simplicial complexes. This decomposition allows us to create balanced boolean trees and may lead to an extension of Duval and Zhang's result that states that all Cohen-Macaulay complexes can be decomposed into boolean trees. Time permitting, we will discuss how colorated homology relates to the color shifting of a complex. (Received July 16, 2017)

1131-05-249 **Ryan Schneider** (ryan.schneider@wustl.edu) and **John Shareshian*** (shareshi@math.wustl.edu). *Betti numbers of regular Hessenberg varieties and characters of Hecke algebras.*

I will discuss our joint work relating the Betti numbers of regular Hessenberg varieties to evaluation of certain characters of Hecke algebras at Kazhdan-Lusztig basis elements. (Received July 16, 2017)

1131-05-254 **Martina Juhnke-Kubitzke*** (juhnke-kubitzke@uos.de), Albrechtstraße 28a, 49076 Osnabrück, Germany, and **David Cook II**, **Satoshi Murai** and **Eran Nevo**. *Lefschetz properties of balanced 3-polytopes.*

In this talk, we study Lefschetz properties of Artinian reductions of Stanley-Reisner rings of balanced simplicial 3-polytopes. A (d-1)-dimensional simplicial complex is said to be balanced if its graph is d-colorable. If a simplicial complex is balanced, then its Stanley-Reisner ring has a special system of parameters induced by the coloring. We prove that the Artinian reduction of the Stanley-Reisner ring of a balanced simplicial 3-polytope with respect to this special system of parameters has the strong Lefschetz property if the characteristic of the base field is not two or three. Moreover, we characterize (2,1)-balanced simplicial polytopes, i.e., polytopes with exactly one red vertex and two blue vertices in each facet, such that an analogous property holds. In fact, we show that this is the case if and only if the induced graph on the blue vertices satisfies a Laman-type combinatorial condition. (Received July 17, 2017)

1131-05-255 **Alex Fink*** (a.fink@qmul.ac.uk), **David E Speyer** and **Alexander Woo**. *A Gröbner basis for the graph of the reciprocal plane.*

Two different-looking commutative algebraic ways to get the characteristic polynomial of a hyperplane arrangement appear in the literature: from the K-polynomial of the reciprocal plane (Orlik-Terao), and from the multidegree of the graph over this plane (Adiprasito-Huh-Katz). We give a Stanley-Reisner initial degeneration to an extension of the no broken circuit complex explaining why these two are not different after all. (Received July 17, 2017)

1131-05-258 **chris fraser***, chfraser@iupui.edu. *Braid group symmetries of Grassmannian cluster algebras.*

We will give an introduction to the cluster structure on the Grassmannian Gr(k,n), including some conjectures of Fomin and Pylyavskyy describing the cluster combinatorics for Gr(3,n) in terms of planar diagrams known as webs. We will describe an action of the k-strand braid group on the set of clusters for Gr(k, n), whenever k divides n. This action preserves the underlying quivers, defining a homomorphism from the braid group to the "cluster modular group," which is a notion of a symmetry group of a cluster algebra. Using the braid group action, we prove the Fomin-Pylyavksyy conjectures for the Grassmannians Gr(3,9) and Gr(4,8). (Received July 17, 2017)

1131-05-283 **Ellen Beth Robinson*** (ebr21@txstate.edu), 601 University Dr., San Marcos, TX 78666. *A Characterization of Oriented Hypergraphic Laplacian and Adjacency Coefficients and Minors.*

In this talk we use the Weak Walk Theorem for oriented hypergraphs to unify and generalize Sachs' Coefficient Theorem and the All Minors Matrix Tree Theorem for graphs and signed graphs. Oriented hypergraphs are an incidence-centric generalization of graphs and signed graphs. Sachs' Coefficient Theorem provides expressions for the coefficients of the characteristic polynomial of the adjacency matrix for graphs; the All Minors Matrix Tree Theorem relates the number of forests in graphs to a specific minor of the Laplacian matrix. (Received July 17, 2017)

1131-05-300 **Timothy Alland** and **Edward Richmond*** (edward.richmond@okstate.edu), Stillwater, OK 74078. *Pattern avoidance and fiber bundle structures on Schubert varieties.*

In this talk, we give a pattern avoidance criteria for determining when the projection map from the flag variety to a Grassmannian induces a fiber bundle structure on a Schubert variety. To do this, we introduce the notion of split pattern avoidance and show that a Schubert variety has such a fiber bundle structure if and only if the corresponding permutation avoids the split patterns 3|12 and 23|1. Continuing, we also characterize when a Schubert variety is an iterated fiber bundle of Grassmannian Schubert varieties in terms of usual pattern avoidance. (Received July 17, 2017)

1131-05-321 **Anna Weigandt*** (weigndt2@illinois.edu). *Prism tableaux for alternating sign matrix varieties.* Preliminary report.

Alternating sign matrix varieties are defined by determinantal conditions. They generalize matrix Schubert varieties. The multidegree of an ASM variety is a multiplicity free sum of Schubert polynomials. We give a combinatorial formula for this multidegree as a generating series over prism tableaux. Each prism tableau is simply an overlay of semistandard tableaux. This extends joint work with A. Yong. (Received July 17, 2017)

1131-05-337 **Theodosios Douvropoulos*** (douvr001@umn.edu), 127 Vincent Hall, 206 Church St SE, Minneapolis, MN 55408. *Geometric techniques for Coxeter Catalan Combinatorics.*

A common theme in Combinatorics is an unconditional love for the symmetric group. A problem that goes back to Hurwitz and 19th century is to enumerate (reduced) factorizations of the long cycle $(12\cdots n) \in S_n$ into factors from prescribed conjugacy classes.

As is often the case with the more interesting properties of the symmetric group, the natural setting of this problem is the world of Coxeter (-Catalan) Combinatorics. Here we ask to enumerate factorizations of the Coxeter element c.

Bessis gave a beautiful geometric interpretation of such factorizations by using a variant of the Lyashko-Looijenga (LL) map, a finite morphism coming from Singularity theory. We extend some of Bessis' and Ripoll's work and use the LL map to enumerate the so called "primitive factorizations" of c. That is, factorizations of the form $c = w \cdot t_1 \cdots t_k$, where w belongs to a given conjugacy class and the t_i's are reflections. (Received July 18, 2017)

1131-05-348 **Dennis W Hall*** (dennis.hall@angelo.edu), Angelo State University, Station #10900, San Angelo, TX 76909. *Unavoidable Minors for Hypergraphs.* Preliminary report.

It is well know that, for any integer n greater than one, there is a number r such that every 2-connected simple graph with at least r edges has a minor isomorphic to an n-edge cycle or $K_{2,n}$. This result was extended to matroids by Lovasz, Schrijver, and Seymour who proved that every sufficiently large connected matroid has an n-element circuit or an n-element cocircuit as a minor. An analogous result for k-polymatroids has been partially developed, but lacks an explicit description of the minors in all cases except for when $k = 2$. However, an explicit description is possible for 2-connected k-hypergraphs. In this talk, we use results on polymatroids to provide a list of unavoidable minors for 2-connected k-hypergraphs. (Received July 18, 2017)

1131-05-375 **Hailong Dao**, Department of Mathematics, 405 Snow Hall, 1460 Jayhawk Boulevard, Lawrence, KS 66045, and **Jay Schweig***, 401 MSCS, Stillwater, OK 74078. *The type defect of a simplicial complex.*

If K is a simplicial complex of codimension c, we say that the type of K is the total Betti number of the associated Stanley-Reisner ideal in degree c. We then define the type defect of K to be its type minus its codimension. We show that this invariant has many connections to previously studied properties of graphs and simplicial complexes. For example, we show that a graph is chordal iff every induced subgraph has nonnegative type defect. The relationship to chordality also generalizes to higher dimensions, allowing us to study complexes whose duals have linear resolutions; a common feature of many of the different definitions of chordal complexes. (Received July 18, 2017)

1131-05-379 **Will Grilliette*** (w_g28@txstate.edu). *On Categorical Constructions of Hypergraphs.*

This talk is based on joint work with Dr. Lucas Rusnak.

In this talk, I will discuss some issues arising from the category $\mathfrak{H}$ of hypergraphs and the category $\mathfrak{M}$ of (undirected) multigraphs. Specifically, neither $\mathfrak{H}$ nor $\mathfrak{M}$ are cartesian closed, meaning that neither can be a topos, as opposed to the category $\mathfrak{Q}$ of quivers. Moreover, despite $\mathfrak{M}$ being a subcategory of $\mathfrak{H}$, $\mathfrak{H}$ does not have enough projective objects while $\mathfrak{M}$ admits a projective cover for every object.

Thus, we suggest another model of hypergraphs, and multigraphs by extension, which is based on incidence rather than adjacency. The category $\mathfrak{R}$ of these "incidence hypergraphs" will be a presheaf topos like $\mathfrak{Q}$. Indeed, $\mathfrak{Q}$ and $\mathfrak{R}$ are connected by several functors, which seem to encode matricial information into the graph structure itself. (Received July 18, 2017)

1131-05-387 **Maitreyee C Kulkarni***, 3942 Gourrier Avenue Apt 209, Baton Rouge, LA 70808. *Dimer models on cylinders over Dynkin diagrams.*

Let G be a Lie group of type ADE and P be a parabolic subgroup. It is known that there exists a cluster structure on the coordinate ring of the partial flag variety G/P (see the work of Geiss, Leclerc, and Schroer). Since then there has been a great deal of activity towards categorifying these cluster algebras. Jensen, King, and Su gave a direct categorification of the cluster structure on the homogeneous coordinate ring for Grassmannians (that is, when G is of type A and P is a maximal parabolic subgroup). In this setting, Baur, King, and Marsh gave an interpretation of this categorification in terms of dimer models. In this talk, I will give an analog of dimer models for groups in other types by introducing a technique called "constructing cylinders over Dynkin diagrams", which can (conjecturally) be used to generalize the result of Baur, King, and Marsh. (Received July 18, 2017)

1131-05-389 **aBa Mbirika*** (mbirika@uwec.edu). *Involutory and orientation-preserving symmetries in the hyperoctahedral group.* Preliminary report.

It is well known in the symmetric group setting that cycle structure determines the conjugacy classes in S_n and hence the distinct conjugacy classes are in bijection with partitions on n. Similarly in the complex reflection group $G(2,1,n)$ setting—that is, the symmetries of the n-cube, also called the hyperoctahedral group—the conjugacy classes are in bijection with bipartitions of n. We enumerate the conjugacy classes of $G(2,1,n)$ corresponding to involutory elements and the classes corresponding to the orientation-preserving symmetries with a goal of finding those classes in the intersection of both. Lastly, we compute the sizes of all the latter conjugacy classes. (Received July 18, 2017)

1131-05-390 **Tom Braden** (braden@math.umass.edu), **Jacob P. Matherne*** (matherne@math.umass.edu) and **Nicholas Proudfoot** (njp@uoregon.edu). *Kazhdan–Lusztig polynomials of matroids.* Preliminary report.

Kazhdan–Lusztig polynomials for Coxeter groups were introduced in the 1970s, attracting a great deal of research in geometric representation theory, and providing deep relationships among representation theory, topology, and combinatorics. In 2016, Ben Elias, Nicholas Proudfoot, and Max Wakefield defined an analogous polynomial in the setting of matroids. In this talk, I will define these polynomials and give examples of them, including the case of matroids associated to braid arrangements. I will also discuss some recent joint work with Tom Braden and Nicholas Proudfoot concerning the structure of these polynomials and a conjectural definition of intersection cohomology for matroids. (Received July 18, 2017)

1131-05-395 **Pamela E Harris** (peh2@williams.edu), 33 Stetson Court, Williamstown, MA 01267, **Erik Insko** (einsko@fgcu.edu), 10501 FGCU Blvd South, Fort Myers, FL 33965, and **Mohamed Omar*** (omar@g.hmc.edu), 301 Platt Boulevard, Claremont, CA 91711. *The q-analog of Kostant's partition function and the highest root of the classical Lie algebras.*

Kostant's partition function counts the number of ways to represent a particular vector (weight) as a nonnegative integral sum of positive roots of a Lie algebra. For a given weight the q-analog of Kostant's partition function is a polynomial where the coefficient of q^k is the number of ways the weight can be written as a nonnegative integral sum of exactly k positive roots. In this talk we present generating functions for the q-analog of Kostant's partition function when the weight in question is the highest root of the classical Lie algebras of types B, C and D. (Received July 18, 2017)

1131-05-396 **Federico Castillo*** (fcastillo@ucdavis.edu), One Shields Ave., Davis, CA 95616. *Deformation cones for polytopes.*

Given a lattice polytope, the set of all polytopes having the same (or a coarsening) normal fan is a polyhedral cone. This cone has appeared in different contexts, for instance, it is closely related to the nef cone of the associated toric variety. In the case of the regular permutohedron we get the cone of submodular functions. The purpose of this talk is to survey known results and show how to compute this deformation cones in further combinatorial examples. This is joint work with Fu liu and Federico Ardila. (Received July 18, 2017)

1131-05-400 **Robert Guralnick**, **John Shareshian** and **Russ Woodroofe*** (russ.woodroofe@famnit.upr.si). *Non-acyclicity of coset lattices and generation of finite groups.* Preliminary report.

Title: Non-acyclicity of coset lattices and generation of finite groups Abstract: In a 2016 paper, John Shareshian and I showed that the coset lattice of any finite group has non-trivial homology in characteristic 2, hence is not contractible. The general idea is to apply Smith Theory to each chief factor of a group, but the proof requires the classification, and has several difficult details. I'll discuss recent improvements and simplifications to these results from joint work of Bob Guralnick, Shareshian, and myself. (Received July 18, 2017)

1131-05-402 **aBa Mbirika*** (mbirika@uwec.edu) and **Julianna Tymoczko**. *Combinatorial consequences of the representation stability of the cohomology of Springer varieties.*

A sequence of S_n-representations $\{V_n\}$ is said to be uniformly representation stable if the decomposition of $V_n = \bigoplus_\lambda c_{\lambda,n} V(\lambda)_n$ into irreducible representations can be described independently of n for each λ—that is, the multiplicities $c_{\lambda,n}$ are eventually independent of n for each λ. It is known that uniform representation stability holds for the cohomology of flag varieties (the so-called diagonal coinvariant algebra), a well-known Springer representation. We prove that this also holds for every sequence of Springer representations. In this talk we only sketch the proof of how we exhibited the co-FI-module structure (in the sense of Church-Ellenberg-Farb) of a sequence of cohomology rings of Springer varieties parametrized by partitions of n. For the majority of the talk, we explore some combinatorial consequences of this stability of the Springer representation. This will include some conjectures that we have yet to prove but will provide convincing evidence that they indeed hold. (Received July 18, 2017)

1131-05-405 **Cara P Monical*** (cmonica2@illinois.edu), 1409 W. Green Street, Urbana, IL 61801. *Set-Valued Skyline Fillings.*

Set-valued tableaux play an important role in combinatorial K-theory. Separately, semistandard skyline fillings are a combinatorial model for Demazure atoms and key polynomials. We unify these two concepts by defining a set-valued extension of semistandard skyline fillings and we then give analogues of results of J. Haglund, K. Luoto, S. Mason, and S. van Willigenburg. Additionally, we give a bijection between set-valued semistandard Young tableaux and C. Lenart's Schur expansion of the Grothendieck polynomial G_λ, using the uncrowding operator of V. Reiner, B. Tenner, and A. Yong. (Received July 18, 2017)

1131-05-408 **Michael W. Schroeder*** (schroederm@marshall.edu), Huntington, WV 25705. *On cycle systems with no proper subsystems.* Preliminary report.

Let K_n be the complete graph with vertex set V and edge set E. An m-cycle system of order n is a partition $\mathcal{C}$ of E in which each edge set in $\mathcal{C}$ is a cycle of length m. A subset $\mathcal{S} \subseteq \mathcal{C}$ is a subsystem if there exists a nonempty subset of vertices $V' \subseteq V$ such that $\mathcal{S}$ is an m-cycle system of order $|V'|$. In this talk, we will discuss recent work in classifying the existence of cycle systems with no proper subsystems. (Received July 18, 2017)

1131-05-416 **Rachel Karpman*** (rkarpman@umich.edu), Department of Mathematics, 100 Math Tower, 231 West 18th Ave, Columbus, OH 43201, and **Yuji Kodama**. *Realizing plabic graphs from solutions to the KP equation.*

The KP equation is a two-dimensional non-linear differential equation, which provides an excellent model for resonant interactions among standing-water waves. Kodama and Williams showed a remarkable relationship between the KP equation and Postnikov's combinatorial theory of the totally positive Grassmannian. In particular, they show that certain soliton graphs, which encode line-soliton solutions to the KP equation, are examples of Postnikov's plabic graphs, which in turn give coordinate charts on the totally positive Grassmannian. Jihui Huang conjectured that all plabic graphs for the totally positive Grassmannian arise in this way. We prove Huang's conjecture for all finite-type Grassmannians, but show that it is false in general. (Received July 18, 2017)

1131-05-419 **Carolina Benedetti**, **Nantel Bergeron**, **Laura Colmenarejo**, **Franco Saliola*** (saliola.franco@uqam.ca) and **Frank Sottile**. *A Murnaghan-Nakayama Rule for Quantum Cohomology of the Flag Manifold.*

We present a general rule for multiplying a quantum Schubert polynomial by a quantum power sum polynomial. This is achieved by relating the structure constants for the multiplication of a quantum Schubert polynomial by a hook quantum Schur polynomial with the structure constants for the (classical) multiplication of a Schubert polynomial by a hook Schur polynomial. (Received July 18, 2017)

1131-05-425 **Jose Alejandr Samper Casas*** (jasamper88@gmail.com). *The facet polytope of a shifted complex.*

We will discuss the polytope that results from taking the convex hull of a family of pure shifted complexes and argue that it behaves like a matroid basis polytope in many different ways. We will then speculate how this may help unify the theories of independence complexes of matroids and allow for new proof strategies in the world of matroid theory. (Received July 19, 2017)

11 ► Number theory

1131-11-6 **Ajit Hira*** (hira@nnmc.edu), **Jose Pachedo** (jose_l_pacheco@nnmc.edu), **Tommy Cathey** (tecathey@gmail.com) and **Alexis Chato** (alexis_s_chato@nnmc.edu). *Goldbach's Conjecture and Combinatorial Geometry.* Preliminary report.

We apply the methods from Combinatorial Geometry to investigate Goldbach's Conjecture. We have achieved considerable success in the study of some selected sequences of even numbers, namely sub-sequences such as 3n+1, 3n+3, 3n+5, 5n+1, 5n+3, 5n+5, 5n+7, 7n+1 and 7n+3, for n up to 40,000. The method and results presented here are based on the Erdos-Stone Theorem in Extremal Graph Theory and on Blichfeldt's Method of Enlargement in Lattice Packing Theory. (Received April 03, 2017)

1131-11-9 **Dan Fretwell*** (daniel.fretwell@bristol.ac.uk), School of Mathematics, University of Bristol, Bristol, BS81TW, United Kingdom. *An Eisenstein congruence for genus 2 Hilbert-Siegel forms.*

Congruences between modular forms have been a topic of interest for many years. They tell us a wealth of information about Galois representations and Selmer groups.

For classical modular forms one can study congruences between cusp forms and Eisenstein series, e.g. the Ramanujan 691 congruence for the discriminant function. Many results are known about these congruences in general, in particular the (significant) moduli mainly come from critical values of Dirichlet L-functions.

One can also study "Eisenstein congruences" over general reductive groups. In particular for GSp4 there is a long standing conjecture due to Harder, predicting similar congruences for genus 2 Siegel cusp forms. The modulus now comes from a critical value of the L-function of a genus 1 form.

In this talk I will formulate a generalization of this conjecture for Hilbert-Siegel forms and give computational evidence. To do this I will consider certain spaces of algebraic modular forms and provide algorithms for computing with such objects. (Received April 14, 2017)

1131-11-21 **Nickolas Andersen*** (nandersen@math.ucla.edu) and **E. Mehmet Kiral**. *Level reciprocity in the twisted fourth moment of modular L-functions.* Preliminary report.

We prove an exact formula for the twisted fourth moment of modular L-functions of a given level. The formula is a reciprocity relation between the twist and the level. (Received May 19, 2017)

1131-11-30 **Ralf Schmidt*** (rschmidt@math.ou.edu). *The multiplicity one theorem for paramodular forms.*

Classical modular forms enjoy the "strong multiplicity one" property, which states that a newform is determined by almost all of its Hecke eigenvalues. This was proved by Atkin and Lehner in 1970.

For higher rank modular forms, i.e., Siegel modular forms, the analogous theorem fails. In this talk we will explain why the strong multiplicity one property still holds for "paramodular forms", an important class of Siegel modular forms of degree 2. (Received June 02, 2017)

1131-11-48 **David W Farmer*** (farmer@aimath.org). *Automorphic forms from the perspective of L-functions.*

Automorphic forms can be viewed from the perspective of functions on symmetric spaces, or representation theory, or L-functions. I will describe some ways in which each point of view makes various properties appear more natural. (Received June 24, 2017)

1131-11-51 **Neranga Fernando*** (w.fernando@northeastern.edu), Department of Mathematics, 567 Lake Hall, Northeastern University, Boston, MA 02115. *Reversed Dickson polynomials of the $(k+1)$-th kind over finite fields, II.*

Let p be an odd prime and $q = p^e$, where e is a positive integer. Let $\mathbb{F}_q$ be the finite field with q elements. A polynomial $f \in \mathbb{F}_q[\mathrm{x}]$ is called a *permutation polynomial* of $\mathbb{F}_q$ if the associated mapping $x \mapsto f(x)$ from $\mathbb{F}_q$ to $\mathbb{F}_q$ is a permutation of $\mathbb{F}_q$. For $a \in \mathbb{F}_q$, the n-th reversed Dickson polynomial of the $(k+1)$-th kind $D_{n,k}(a,x)$ is defined by

$$D_{n,k}(a,x) = \sum_{i=0}^{\lfloor \frac{n}{2} \rfloor} \frac{n-ki}{n-i} \binom{n-i}{i} (-x)^i a^{n-2i},$$

and $D_{0,k}(a,x) = 2-k$. I am primarily interested in the question: When is $D_{n,k}(a,x)$ a permutation polynomial of $\mathbb{F}_q$ when n is a sum of odd prime powers? It is known that to discuss the permutaion behaviour of $D_{n,k}(a,x)$, one only has to consider $a = 1$. In this talk, I will explain the permutation behaviour of $D_{n,k}(1,x)$ when $n = p^{l_1} + 3$, $n = p^{l_1} + p^{l_2} + p^{l_3}$, and $n = p^{l_1} + p^{l_2} + p^{l_3} + p^{l_4}$, where l_1, l_2, l_3, and l_4 are non-negative integers. I will also explain a generalization to $n = p^{l_1} + p^{l_2} + \cdots + p^{l_i}$. Moreover, I will present some algebraic and arithmetic properties of the reversed Dickson polynomials of the $(k+1)$-th kind. (Received June 25, 2017)

1131-11-52 **David M. Freeman*** (david.freeman@uc.edu), University of Cincinnati Blue Ash College, Dept. of Math, Physics, and Computer Science, 9555 Plainfield Rd., Cincinnati, OH 45236. *Generalized Palindromic Continued Fractions.*

In this talk we will introduce a generalization of palindromic continued fractions. We will provide a simple transcendency criterion for these continued fractions, extending and slightly refining analogous results for palindromic continued fractions obtained by Adamczewski and Bugeaud. By way of examples, we will also explore the relationship between generalized palindromic continued fractions and so-called stammering continued fractions. (Received June 26, 2017)

1131-11-79 **Alan Haynes*** (haynes@math.uh.edu) and **Jens Marklof**. *Higher dimensional Steinhaus and Slater problems via homogeneous dynamics.*

The three gap theorem, also known as Steinhaus conjecture or three distance theorem, states that the gaps in the fractional parts of $\alpha, 2\alpha, \ldots, N\alpha$ take at most three distinct values. Motivated by a question of Erdős, Geelen and Simpson, we explore a higher-dimensional variant, which asks for the number of gaps between the fractional parts of a linear form. Using the ergodic properties of the diagonal action on the space of lattices, we prove that for almost all parameter values the number of distinct gaps in the higher dimensional problem is unbounded. Our results in particular improve earlier work by Boshernitzan, Dyson and Bleher et al. We furthermore discuss a close link with the Littlewood conjecture in multiplicative Diophantine approximation. Finally, we also demonstrate how our methods can be adapted to obtain similar results for gaps between return times of translations to shrinking regions on higher dimensional tori. (Received July 04, 2017)

1131-11-86 **Matthew Krauel*** (krauel@csus.edu), California State University Sacramento, 6000 J Street, Sacramento, CA 95819-6051. *Some differential operators of Jacobi forms arising from vertex operator algebras.*

We will briefly explain how differential operators of Jacobi forms arise in the theory of vertex operator algebras (VOAs). We then introduce a family of differential operators that arise for a certain class of VOAs and explain some possible applications. Time permitting, we will also mention how the theory of VOAs can be used to show how certain polynomials of quasi-Jacobi forms are Jacobi forms. (Received July 05, 2017)

1131-11-94 **Matthew A. Papanikolas*** (papanikolas@tamu.edu), Department of Mathematics, 3368 TAMU, College Station, TX 77008, and **Guchao Zeng**. *Nonarchimedean families of Drinfeld modular forms.*

For classical modular forms the Kummer congruences for Bernoulli numbers lead to constructions of p-adic families of Eisenstein series in the sense of Serre. In the case of the rational function field K over a finite field, the analogous quantities, called Bernoulli-Carlitz numbers, fail to satisfy Kummer-type congruences. Nevertheless we prove that certain subsequences of Bernoulli-Carlitz numbers do have v-adic limits, for v a finite place of K, as do certain constructions involving hyperderivatives and Goss polynomials. This leads to new v-adic limits of Eisenstein series in this context. (Received July 06, 2017)

1131-11-126 **Olivia Beckwith***, 244 N Colonial Homes Cir, Atlanta, GA 30309. *Indivisibility of class numbers of imaginary quadratic fields.*

I quantify a recent theorem of Wiles by proving an estimate for the number of negative fundamental discriminants down to -X whose class numbers are indivisible by a give prime and whose imaginary quadratic fields satisfy almost any given finite set of local conditions. This estimate matches the best results in the direction of the Cohen-Lenstra heuristics for the number of imaginary quadratic fields with class number indivisible by a given prime. I will also show how this result can be applied to study rank 0 twists of certain elliptic curves. (Received July 10, 2017)

1131-11-140 **Tushar Das*** (tdas@uwlax.edu). *Singular systems of linear forms and divergent trajectories on homogeneous spaces.*

We establish a new connection between metric Diophantine approximation and the parametric geometry of numbers by proving a variational principle that computes the Hausdorff and packing dimensions of a variety of sets of interest in Diophantine approximation and their analogues in the setting of homogenous dynamics on the space of unimodular lattices. These results are part of ongoing joint work with Lior Fishman (NorthTexas), David Simmons (York) and Mariusz Urbański (North Texas). (Received July 11, 2017)

1131-11-157 **Ameya Pitale*** (apitale@ou.edu), 2924 elmhurst ave, oklahoma city, OK 73120. *Integral representation and critical L-values for holomorphic forms on $GSp(2n) \times GL(1)$.*

In this talk, we will report on recent joint work with Abhishek Saha and Ralf Schmidt on integral representation of the standard L-function for holomorphic vector-valued Siegel modular forms of arbitrary genus and with respect to arbitrary congruence subgroup. A lot of work has been done on this topic by Andrianov, Harris, Sturm, Garrett, Shimura, Piatetski-Shapiro, Rallis and many others. To obtain the most general result, we adopt the adelic approach and obtain the pullback of an Eisenstein series on $GSp(4n)$ to $GSp(2n) \times GSp(2n)$. The innovation is the choice of vectors in the ramified and the archimedean cases allowing us to get explicit formulas. The potential applications are arithmeticity of special values of L-functions as algebraic numbers (normalized by suitable periods), and one can further ask the prime factorization of those algebraic numbers. We will report on the arithmeticity results for the genus 2 case, which involves a deeper understanding of the structure of nearly holomorphic modular forms. (Received July 12, 2017)

1131-11-162 **Lenny Fukshansky*** (lenny@cmc.edu), 850 Columbia Avenue, Department of Mathematics, Claremont McKenna College, Claremont, CA 91711. *Solving systems of quadratic equations over $\overline{\mathbb{Q}}$.*

We prove the existence of a nontrivial small-height zero of a system of k quadratic forms in an ℓ-dimensional subspace of $\overline{\mathbb{Q}}^n$, $n \geq \ell \geq \frac{k(k+1)}{2}$. Further, assuming a system of one or two inhomogeneous quadratic polynomials and m inhomogeneous linear polynomials in $n \geq m+4$ variables has a nontrivial common zero over $\overline{\mathbb{Q}}$, we prove the existence of such a zero of bounded height. Our investigation extends previous results on small zeros of quadratic forms, including Cassels' theorem and its various generalizations and contributes to the literature of so-called "absolute" Diophantine results with respect to height. All bounds on height are explicit. (Received July 12, 2017)

1131-11-181 **Michael H Mertens***, Mathematisches Institut, der Universtät zu Köln, Weyertal 86-90, 50931 Köln, Germany. *Mixed mock modular forms are vector-valued modular forms.* Preliminary report.

In this talk we investigate vector-valued modular forms of certain arithmetic types which we introduce and show that mock modular forms and mixed mock modular forms as well as second order modular forms as introduced by Goldfeld can be interpreted as components of such forms, therefore providing a common framework for these so far pretty much independent types of modular objects.

This is joint work in progress with M. Westerholt-Raum. (Received July 14, 2017)

1131-11-186 **Yingkun Li*** (li@mathematik.tu-darmstadt.de), Fachbereich Mathematik, TU Darmstadt, Schlossgartenstrasse 7, 64289 Darmstadt, Germany, and **Pierre Charollois** (pierre.charollois@imj-prg.fr), Equipe de théorie des nombres, Case 247 - 4, place Jussieu, 75252 Paris, France. *Harmonic Maass forms associated to real quadratic fields.*

It is well-known that definite quadratic forms give rise to theta series, which are holomorphic modular forms. In 1926, Hecke attached weight one holomorphic theta series to indefinite quadratic forms of signature (1, 1). This ingenious construction reminds one of the Rankin-Selberg unfolding method, yet predates it by a decade. In 2003, Bruinier and Funke introduced the notion of harmonic Maass forms, which have poles and map to classical holomorphic modular forms under a suitable differential operator. In this talk, we will construct harmonic Maass forms that map to Hecke's indefinite theta series, and study their Fourier coefficients. (Received July 14, 2017)

1131-11-187 **Douglas Ulmer***, Department of Mathematics, University of Arizona, 617 N. Santa Rita Ave., Tucson, AZ 85721-0089. *Algebraic approaches to the Brauer-Siegel ratio for abelian varieties over function fields.* Preliminary report.

Let K be the function field of a curve $\mathcal{C}$ over a finite field $\mathbf{F}_q$, and let A be an abelian variety over K. Analogy with the classical Brauer-Siegel theorem led Hindry to consider the ratio

$$BS(A) := \frac{\log\left(|Ш(A)|\mathrm{Reg}(A)\right)}{\log H(A)}$$

where $|Ш(A)|$ is the order of the Tate-Shafarevich group of A, $\mathrm{Reg}(A)$ is the Néron-Tate regulator of A, and $H(A)$ is the exponential differential height of A.

If A_n, $n \geq 1$ is a sequence of abelian varieties of fixed dimension over K with $H(A_n) \to \infty$, the classical analogy would suggest that

$$\lim_{n\to\infty} BS(A_n) = 1.$$

Hindry, Pacheco, and Griffon have used analytic techniques to give several example of families $\{A_n\}$ for which the limit above exists and is equal to 1. (They also gave evidence for the conjecture that a limit of zero is possible.)

I will explain an algebraic technique for estimating $|Ш(A)|\mathrm{Reg}(A)$ which recovers the limit above in all cases considered by Hindry, Pacheco, and Griffon. One novelty in our approach is that we use properties of the function

$$m \mapsto |Ш(A/\mathbf{F}_{q^m}(\mathcal{C}))|$$

to estimate $|Ш(A)|\mathrm{Reg}(A)$ over the original ground field. (Received July 14, 2017)

1131-11-205 **Scott Ahlgren*** (sahlgren@illinois.edu), Department of Mathematics, University of Illinois, 1409 W. Green St, Urbana, IL 61822, and **Nickolas Andersen** and **Detchat Samart**. *A polyharmonic Maass form of depth* 3/2 *for* $\mathrm{SL}_2(\mathbb{Z})$.

Duke, Imamoḡlu, and Tóth constructed a polyharmonic Maass form whose Fourier coefficients encode real quadratic class numbers. A more general construction of such forms was given by Bruinier, Funke, and Imamoḡlu. Here we give a direct construction of such a form for the full modular group and study the properties of its coefficients. (Received July 14, 2017)

1131-11-211 **Richard Gottesman*** (richard.b.gottesman@gmail.com) and **Geoff Mason** (gem@ucsc.edu). *Vector Valued Modular Forms and Their Applications.* Preliminary report.

Vector valued modular forms form a graded module over the ring of modular forms. The structure of the module of vector valued modular forms allows us to show that the component functions of vector valued modular forms are solutions to certain ordinary differential equations. In certain cases, we use Hauptmoduls and hypergeometric series to solve these differential equations. We then obtain the q-series expansions of vector valued modular forms. There are important applications to modular forms on non-congruence subgroups. (Received July 14, 2017)

1131-11-259 **Dermot McCarthy***, dermot.mccarthy@ttu.edu, and **Robert Osburn** and **Armin Straub**. *Sequences, Modular Forms and Cellular Integrals.*

The Apéry numbers, which arise in the irrationality proofs for $\zeta(2)$ and $\zeta(3)$, satisfy many intriguing arithmetic properties, and are also related to the pth Fourier coefficients of modular forms. We describe sequences associated to Brown's cellular integrals, of which the Apéry numbers are special cases. We discuss recent work on proving that the connection to modular forms persists for these sequences in general. (Received July 17, 2017)

1131-11-261 **Aaron Levin*** (adlevin@math.msu.edu), Department of Mathematics, Michigan State University, 619 Red Cedar Road, East Lansing, MI 48824. *Greatest common divisors and Diophantine approximation.* Preliminary report.

In 2003, Bugeaud, Corvaja, and Zannier gave an (essentially sharp) upper bound for the greatest common divisor $\gcd(a^n - 1, b^n - 1)$, where a and b are fixed integers and n varies over the positive integers. In contrast to the elementary statement of their result, the proof required deep results from Diophantine approximation. I will discuss a higher-dimensional generalization of their result and some related problems, all centered around greatest common divisors. (Received July 17, 2017)

1131-11-282 **Geoffrey Mason*** (gem@ucsc.edu), Department of Mathematics, UC Santa Cruz, Santa Cruz, CA 95064. *Hypergeometric approach to the unbounded denominator conjecture.*

The question of whether modular forms on a noncongruence subgroup have unbounded denominators (UBD) goes back to Atkin and Swinnerton-Dyer. We outline an approach to this problem that is successful in low dimensions. It is based on the theory of vector-valued modular forms and is intimately related to Riemann-Hilbert type problems about Fuchsian differential equations. (Received July 17, 2017)

1131-11-294 **Mirela Ciperiani***, mirela@math.utexas.edu. *Divisibility and solvability in the arithmetic of genus one curves.*

Genus one curves, defined over the rationals, need not have rational points. The set of all such curves, whose Jacobian is a fixed elliptic curve E, forms a group, called the Weil-Chatelet group. It has an important subgroup, the Tate-Shafarevich group, formed by those curves which have points over all completions of the rationals.

This talk will address two aspects of the arithmetic of genus one curves: (1) (with J. Stix) the divisibility of the elements of the Tate-Shafarevich group inside the Weil-Chatelet group; (2) (with A. Wiles) the existence of points defined over number fields with solvable Galois group over the rationals on genus one curves that correspond to elements of the Tate-Shafarevich group; we aim to extend this result to the whole Weil-Chatelet group. (Received July 17, 2017)

1131-11-296 **Dan Abramovich** and **Anthony Várilly-Alvarado*** (av15@rice.edu), Department of Mathematics MS 136, Rice University, 6100 S. Main St., Houston, TX 77005. *Vojta's conjecture and uniform boundedness of full-level structures on abelian varieties over number fields.*

In 1977, Mazur proved that the torsion subgroup of an elliptic curve over $\mathbb{Q}$ is, up to isomorphism, one of only 15 groups. Before Merel gave a qualitative generalization of this result to arbitrary number fields, it was known that variants of the *abc* conjecture would imply uniform boundedness of torsion on elliptic curves over number fields of bounded degree. In this talk, I will explain how, using Vojta's conjecture as a higher-dimensional generalization of the *abc* conjecture, one can deduce similar uniform boundedness statements for full-level structures on abelian varieties of fixed dimension over number fields. (Received July 17, 2017)

1131-11-313 **Anastassia Etropolski*** (aetropolski@rice.edu), Department of Mathematics, Rice University, 6100 Main St., Houston, TX 77005. *Torsion on elliptic curves over cubic number fields.*

In Mazur's celebrated 1978 Inventiones paper, he classifies the torsion subgroups which can occur in the Mordell-Weil group of an elliptic curve over $\mathbf{Q}$. His result was extended to elliptic curves over quadratic number fields by Kamienny, Kenku, and Momose, with the full classification being completed in 1992. What both of these cases have in common is that each subgroup in the classification occurs for infinitely many elliptic curves, but this no longer holds for cubic number fields. In 2012, Najman showed that there exists an elliptic curve whose torsion subgroup over a particular cubic field is $\mathbf{Z}/21$. This was the first "sporadic" example, because the modular curve $X_1(21)$ classifying such elliptic curves has only finitely many cubic points, therefore there can only be finitely many such curves. Recently, my collaborators and I completed the classification of groups which can occur as the torsion part of the Mordell-Weil group of an elliptic curve over a cubic number field by showing that no other sporadic curves exist. (Received July 17, 2017)

1131-11-315 **Lior Fishman**, **Keith Merrill*** (merrill2@brandeis.edu) and **David Simmons**. *A Continued Fraction Algorithm for Spheres.* Preliminary report.

Classical Diophantine approximation seeks to describe how well an irrational number can be approximated by rational numbers, in a quantitative sense. Building upon the theory of (intrinsic) Diophantine approximation on quadratic hypersurfaces recently developed by Fishman, Kleinbock, Merrill, and Simmons, we define a "continued fraction algorithm" which assigns to every irrational point on the n-sphere $\mathbb{S}^n$ a sequence of rationals which are

good approximants in a technical sense. We then exhibit numerous striking similarities between the resultant theory and that of the theory of classical continued fractions for real numbers.

This talk will utilize ideas from number theory, dynamics, and hyperbolic geometry, but should be mostly accessible to a large audience. (Received July 17, 2017)

1131-11-323 **Karl Mahlburg*** (mahlburg@lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Asymptotic analysis of partial theta functions.*

Partial theta functions arise in Kac and Wakimoto's character formulas for affine Lie algebras. An important related problem is to determine the asymptotic behavior for general partial theta functions. In this talk I will present recent results. (Received July 17, 2017)

1131-11-330 **Riad Masri*** (masri@math.tamu.edu), **Adrian Barquero-Sanchez** and **Frank Thorne**. *The distribution of G-Weyl CM fields and the Colmez conjecture.*

In this talk, we will describe a connection between the arithmetic statistical problem of counting number fields of fixed degree and bounded discriminant with prescribed Galois group, and the Colmez conjecture. (Received July 18, 2017)

1131-11-342 **Padmavathi Srinivasan*** (psrinivasan41@math.gatech.edu), 686 Cherry Street NW, Atlanta, GA 30313. *Conductors and minimal discriminants of hyperelliptic curves.*

Conductors and minimal discriminants are two measures of degeneracy of the singular fiber in a family of hyperelliptic curves. In the case of elliptic curves, the Ogg-Saito formula shows that (the negative of) the Artin conductor equals the naive minimal discriminant. In the case of genus two curves, Qing Liu showed that equality no longer holds in general, but the two invariants are related by an inequality. We extend Liu's inequality to hyperelliptic curves of arbitrary genus assuming that the Weierstrass points are rational. We also present explicit examples that suggest that Liu's inequality extends without any assumptions on the rationality of the Weierstrass points. We explain the difficulties in adapting the proof of the inequality in the case of rational Weierstrass points to the general case. (Received July 18, 2017)

1131-11-363 **Jennifer Berg*** (jb93@rice.edu). *Brauer Manin obstruction to integral points on affine Châtelet surfaces.*

In 1970, Manin showed that the Brauer group can obstruct the existence of rational points on varieties, even when there exist points everywhere locally. In 2009, Colliot-Thélène and Xu showed that the Brauer group is in fact relevant for obstructions to integral points on non-proper varieties as well. In this talk, we consider this obstruction to S-integral points for affine Châtelet surfaces over a number field defined by an equation of the form $x^2 - ay^2 = P(t)$, where $P(t)$ is an irreducible, separable polynomial and a is not a square. We show that, unlike their smooth proper compactifications, these affine surfaces can have Brauer groups that are neither generated by quaternion algebras nor their higher dimensional generalizations. Moreover, we show that the Brauer-Manin obstruction does not explain the failure of the existence of integral points for a family of surfaces that have $\mathbb{Z}_p$ points for all p and even points over $\mathbb{Q}$. (Received July 18, 2017)

1131-11-410 **Arunabha Biswas*** (arunabha.biswas@queensu.ca). *A short story about higher Mahler measure.*

In number theory, Mahler measure is kind of a height function of a polynomial and it is associated with Lehmer's conjecture which is an open problem for more than eight decades. Higher Mahler measure is a generalization of Mahler measure. In this talk I shall tell some old stories about Mahler measure and some new stories about higher Mahler measure. (Received July 18, 2017)

1131-11-411 **Corey Stone***, 4066 Brant St, San Diego, CA 92103. *Higher Fitting Ideals of Iwasawa Modules.*

In their 1984 paper, Mazur and Wiles proved the Iwasawa main conjecture, which says that the initial (zeroth) Fitting ideal of the classical Iwasawa module associated to an abelian extension of $\mathbb{Q}$ is generated by a p-adic L-function. Since then, other authors have proven main conjectures for various other fields, and have used them to attack other conjectures in number theory. In a 2003 paper, Kurihara formulated an extension of the main conjecture, asking how the higher Fitting ideals are generated by special values of L-functions, and proving his conjecture for the first Fitting ideal of certain abelian extensions of $\mathbb{Q}$. In this talk, we will give a proof of this conjecture for all of the higher Fitting ideals in the case when the base field is $\mathbb{Q}$ (Received July 18, 2017)

1131-11-423 **Ricardo Conceicao*** (rconceic@gettysburg.edu), 300 N Washington st, Gettysburg, PA 17325, and **Rachael Kelly** and **Samuel VanFossen**. *Solutions of the Hurwitz equation over polynomial rings.* Preliminary report.

Let A and n be positive integers. The structure of the set of integral solutions of the equation

$$x^2 + y^2 + z^2 = Axyz \tag{1}$$

was first studied by Markov, because of its relationship to diophantine approximation. In particular, Markov showed that all integral solutions can be generated by the action of certain automorphisms of the hypersurface defined by (1) on the solution (1,1,1). Ever since, several authors have extended Markov's work to the study of solutions of (1) over finite fields and number fields. Our goal is to discuss some progress made in understanding the solutions of (1) over the polynomial ring $k[t]$, where k is a field. (Received July 19, 2017)

12 ► Field theory and polynomials

1131-12-174 **Carlos E. Arreche*** (arreche@utdallas.edu), Department of Mathematical Sciences, University of Texas at Dallas, Richardson, TX 75080. *Differential Galois theory for difference equations and hypertranscendence.*

There is a differential Galois theory that associates to a given linear difference equation a geometric object, called the Galois group, that encodes the differential equations satisfied by the solutions. I will describe this Galois theory and some algorithms that have been used recently to prove that certain generating series arising in combinatorics are hypertranscendental. (Received July 13, 2017)

13 ► Commutative rings and algebras

1131-13-5 **Caitlin Lienkaemper** (clienkaemper@g.hmc.edu), 301 Platt Blvd, Claremont, CA 91711, and **Mohamed Omar*** (omar@g.hmc.edu), 301 Platt Blvd, Claremont, CA 91711. *Convex codes and commutative algebra.*

Recently, much attention has been given to the use of commutative algebra in understanding questions on convex incidences. We report on these advances, and discuss recent work on understanding piercings in convex realizations through an algebraic lens. (Received March 16, 2017)

1131-13-19 **Robert M Walker*** (robmarsw@umich.edu), 530 East Church Street, 2070 East Hall, ANN ARBOR, MI 48109-1043. *Uniform Symbolic Topologies in Normal Toric Rings.*

A Noetherian ring R has the uniform symbolic topology property (USTP) if there's an integer $D := D(R) > 0$ such that the symbolic power $P^{(DN)} \subseteq P^N$ for all prime ideals P in R and all integers $N > 0$. For instance, all excellent finite-dimensional regular rings have USTP, and a large class of isolated singularities also have USTP (Ein-Lazarsfeld-Smith, Hochster-Huneke, Huneke-Katz-Validashti, Ma-Schwede). A toric ring is a domain of finite type over a field, generated by Laurent monomials. In this talk, we present a formula for the multiplier $D(R)$ such that any normal toric ring R has USTP on the set of monomial primes: this is one of the conditional USTP results my dissertation affords for rings whose singular locus may have positive dimension. (Received May 12, 2017)

1131-13-46 **Whitney I Liske*** (liske.2@nd.edu), 1207 Congress Ave., South Bend, IN 46615. *Rees Rings of Artinian Gorenstein Ideals.* Preliminary report.

Let $R = k[x_1, \ldots, x_d]$ be a polynomial ring in d variables over a field k. Let $m = (x_1, \ldots, x_d)$ be the maximal homogenous ideal of R. Let I be a Gorenstein ideal generated by all the generators of m^2 except for one. For each fixed d these ideals are all equivalent, up to change of coordinates. The goal is to compute the defining equations of the special fiber ring and the Rees ring of these ideals. A secondary goal is to study the algebraic properties of these blowup algebras. To compute the Rees ring, we study the Jacobian dual and the defining equations of the special fiber ring of m^2. (Received June 21, 2017)

1131-13-56 **Jack Jeffries*** (jackjeff@umich.edu) and **Luis Núñez-Betancourt**. *Quantifying singularities using differential operators.*

The F-signature of a local ring of positive characteristic is a numerical invariant that detects many interesting properties. For example, this invariant detects (non)singularity and strong F-regularity. However, it is very difficult to compute.

We define a numerical invariant for rings of characteristic zero or p that exhibits many of the useful properties of the F-signature. We also compute many examples of this invariant, including cases where the F-signature is not known.

This is joint work with Luis Núñez-Betancourt. (Received June 28, 2017)

1131-13-66 **Saeed Nasseh*** (snasseh@georgiasouthern.edu) and **Ryo Takahashi**. *Local rings with quasi-decomposable maximal ideal.*

We will talk about the syzygies of finitely generated modules over local rings with decomposable maximal ideal. We also investigate the properties of modules over local rings for which a quotient of the maximal ideal by a regular sequence is decomposable. (Received June 30, 2017)

1131-13-76 **Brittney Falahola** and **Thomas Marley*** (tmarley1@unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68502. *Characterizing Gorenstein rings using iterations of the Frobenius endomorphism.*

We give several characterizations of Gorenstein local rings by considering the action of Frobenius on an arbitrary bounded complex (not necessarily with finitely generated homology) of finite injective dimension and such that the maximal ideal is in its small support. Two examples of such complexes are the injective hull of the residue field (concentrated in degree zero) and a dualizing complex. (Received July 03, 2017)

1131-13-81 **Ela Celikbas**, **Christina Eubanks-Turner** and **Sylvia M Wiegand*** (swiegand1@unl.edu), Math. Dept., UNL 0130, LINCOLN, NE 685880130. *Prime ideals in rings of polynomials and power series.*

I will describe the structure of the set of prime ideals in low-dimensional integral domains consisting of polynomials and power series. (Received July 05, 2017)

1131-13-93 **Christopher Francisco*** (chris.francisco@okstate.edu), Department of Mathematics, 401 MSCS, Oklahoma State University, Stillwater, OK 74078, and **Jeffrey Mermin** and **Jay Schweig**. *Borel ideals and their surprising appearance in discrete geometry.*

While Borel ideals have been studied for a long time, investigating them from the perspective of Borel generators rather than the usual minimal monomial generating set has led to some interesting new results. Adopting this approach, we describe how certain Borel ideals arise in some counting questions in discrete geometry. This is joint work with J. Mermin and J. Schweig. (Received July 06, 2017)

1131-13-104 **Susan Elaine Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, San Marcos, TX 78666. *Depths of Monomial Ideals.*

This talk will focus on classes of monomial ideals that have a graphical representation. Classes will include square-free monomial ideals, which have a variety of representations including edge ideals of clutters or generalizations of path ideals of graphs. The talk will also include classes of monomial ideals that while not square-free, still have a graphical representation, such as powers of edge ideals or polarizations of monomial ideals. The goal will be to use a combination of algebraic and combinatorial techniques to determine information about depth properties of these ideals. (Received July 07, 2017)

1131-13-111 **Craig Huneke**, **Srikanth Iyengar** and **Roger Wiegand*** (rwiegand1@unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Rigid ideals in complete intersection domains.* Preliminary report.

In 1994 Craig Huneke and Roger Wiegand made the following conjecture, for a local Gorenstein domain R: If both M and the tensor product of M with its algebraic dual M^* are maximal Cohen-Macaulay modules, then M must be free. The conjecture (still open) reduces to the one-dimensional case, where it can be restated as follows: If M is finitely generated, torsion-free, and rigid, then M is free. (A module M is said to be rigid provided every self-extension of M splits.) In this talk I will describe progress on the conjecture for the case of ideals in one-dimensional complete intersection domains. (Received July 09, 2017)

1131-13-118 **Robert M. Roy*** (rmroy@syr.edu), 215 Carnegie Building, Syracuse University, Syracuse, NY 13244-1150. *Auslander-Reiten sequences for Gorenstein rings of dimension one.*

Let R be a complete (or graded-) local Gorenstein ring of dimension one, with maximal ideal m. Then using a mild additional assumption which is satisfied whenever R is a hypersurface, we show that a particular endomorphism of m produces the Auslander-Reiten sequences of Cohen-Macaulay R-modules. We have applied this result to determining the shape of some components of stable Auslander-Reiten quivers. (Received July 09, 2017)

1131-13-125 **Michael DiPasquale*** (mdipasq@okstate.edu), Department of Mathematics, 401 Math Sciences Building, Stillwater, OK 74078. *Splines on semi-algebraic cells.* Preliminary report.

In approximation theory, a 'cell' in real three dimensional space is a union of tetrahedra that all meet at the origin; a C^r spline on the cell is a function which is continuously differentiable to order r and whose restriction to each tetrahedron is a polynomial. In this talk we consider 'semi-algebraic cells': where the faces of each tetrahedron lie in the real zero locus of an irreducible homogeneous polynomial in three variables. Under appropriate assumptions, the asymptotic dimension of the space of splines of degree d (equivalently the Hilbert polynomial of the spline module) on a semi-algebraic cell can be computed using homological methods developed by Billera, Schenck, and Stillman, and which have been extended to the semi-algebraic setting by (among others) Stiller, Sottile, Sun, and the author. (Received July 10, 2017)

1131-13-143 **Louiza Fouil***, Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003, and **Bruce Olberding**. *Reductions of ideals over a local Noetherian ring with finite residue field.* Preliminary report.

Let R be a local Noetherian ring with residue field k and let I be an ideal of R. We say that $J \subset I$ is a reduction of I if there exists an integer $r > 0$ such that $I^{r+1} = JI^r$. When k is an infinite field, I has either infinitely many proper reductions or I is basic, i.e. I is the only reduction of itself. When k is finite that is not necessarily the case. We will discusss the existence or lack of proper reductions and the number of generators needed for a reduction in the case k is a finite field. This is joint work with Bruce Olberding. (Received July 11, 2017)

1131-13-147 **Petter Andreas Bergh** and **David A. Jorgensen*** (djorgens@uta.edu). *Categorical matrix factorizations.* Preliminary report.

A *matrix factorization* of an element x in a commutative ring R is a pair of maps $f : F \to G$ and $g : G \to F$ between free modules F and G such that $fg = 1_G$ and $gf = 1_F$. It is well-known that with the obvious definitions of shift, morphism and homotopy, the homotopy category of a matrix factorizations of x forms a triangulated category. In this talk we will generalize this construction to "matrix factorizations" of a natural transformation x between the identity functor and the nth suspension endofunctor of a suspended additive category $\mathcal{C}$. The resulting homotopy category of "matrix factorizations" is again a triangulated category, and we recover the classical category of matrix factorizations when x is multiplication by an element in a commutative ring R, $\mathcal{C}$ is the category of free R-modules, and $n = 0$. (Received July 11, 2017)

1131-13-149 **Mark Johnson** and **Paolo Mantero*** (pmantero@uark.edu). *Betti numbers of the conormal module of a Gorenstein ideal.* Preliminary report.

Let R be a polynomial ring over a field, and I a perfect ideal that is generically a complete intersection, the conormal module I/I^2 is an R/I-module of interest for several purposes. When I is not a regular ideal, I/I^2 has an infinite minimal free resolution as an R/I-module.

In the present work we provide sharp lower bounds on all the Betti numbers $\beta_i^{R/I}(I/I^2)$; these bounds are more interesting when R/I is Gorenstein. Somewhat surprisingly, the lower bounds are essentially given by the Fibonacci sequence! (Received July 11, 2017)

1131-13-156 **Ela Celikbas*** (ela.celikbas@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506, and **Jai Laxmi** and **Jerzy Weyman**. *Embeddings of Canonical Modules.*

It is well-known that, for a Cohen-Macaulay local ring S with a canonical module ω_S, if S is generically Gorenstein, then ω_S can be identified with an ideal of S, that is, ω_S embeds into S. In this talk, we are concerned with a specific embedding of a canonical module of $R/I_{m,n}$ to itself, where $I_{m,n}$ is an ideal generated by all square-free monomials of degree m in a polynomial ring R with n variables. We discuss how to construct such an embedding using a minimal generating set of $\mathrm{Hom}_R(R/I_{m,n}, R/I_{m,n})$. (Received July 12, 2017)

1131-13-158 **Michael Dipasquale**, **Chris Francisco**, **Jeff Mermin*** (mermin@math.okstate.edu) and **Jay Schweig**. *Free Multiplicities on the A_3 braid arrangement.*

We classify the free multiplicities on the A_3 braid arrangement (Received July 12, 2017)

1131-13-166 **Saeed Nasseh**, **Sean Sather-Wagstaff*** (ssather@clemson.edu), **Ryo Takahashi** and **Keller VandeBogert**. *Semidualizing modules give a defective Gorenstein defect.* Preliminary report.

One can argue that the number $s_0(R)$ of isomorphism classes of semidualizing modules over a local, complete, Cohen-Macaulay ring R is a good measure of the severity of the singularity of R, namely, how far R is from

being Gorenstein. (Here a finitely generated R-module C is *semidualizing* provided that $\mathrm{Hom}_R(C,C) \cong R$ and $\mathrm{Ext}^{\geqslant 1}_R(C,C) = 0$.) For instance, one always has $s_0(R) \geq 1$, with equality holding if and only if R is Gorenstein. However, in this talk, we will exhibit such a ring R with $\dim(R) = 1$ such that $s_0(R_{\mathfrak{p}}) > s_0(R)$ for some prime ideal $\mathfrak{p}$. In other words, this invariant suggests that the singularity can get worse under localization, which is undesirable behavior for such an invariant. (Received July 12, 2017)

1131-13-168 **Linquan Ma*** (lquanma@math.utah.edu) and **Raymond C Heitmann** (heitmann@math.utexas.edu). *Extended plus closure in complete local rings.* Preliminary report.

The (full) extended plus closure was introduced by R. Heitmann in order to attack the homological conjectures, and it was hoped that it might play the same role in mixed characteristic as tight closure in characteristic p. Using the recent solution of the direct summand conjecture by Andre, we prove that extended plus closure satisfies the colon-capturing property for complete local domains. As a corollary, we recover Lipman-Sathaye's version of the Briancon-Skoda theorem in the mixed characteristic case. This is a joint work with R. Heitmann. (Received July 12, 2017)

1131-13-175 **Eloísa Grifo***, eloisa.grifo@virginia.edu. *A stable version of Harbourne's Conjecture.* Preliminary report.

The Containment Problem for ordinary and symbolic powers of ideals asks when the containment $I^{(a)} \subseteq I^b$ holds. If I is a radical ideal in a regular ring, a famous result of Ein-Lazersfeld-Smith, Hochster-Huneke and Ma-Schwede partially answers this question. Harbourne proposed an improvement on this result, which unfortunately does not hold in full generality. In this talk, we will discuss a stable version of Harbourne's Conjecture, which does hold for the known counterexamples of the original conjecture. (Received July 13, 2017)

1131-13-184 **Michael DiPasquale*** (mdipasq@okstate.edu), Department of Mathematics, 401 Math Sciences Building, Stillwater, OK 74078. *Freeness of multi-Coxeter arrangements of type A.*

Freeness of arrangements and multi-arrangements is a difficult and central topic in arrangement theory. Terao (2002) showed that multi-Coxeter arrangements with the same multiplicity on each hyperplane are free by constructing derivations defined using the ring of invariants. In this talk we will describe some recent progress in understanding freeness of multi-braid arrangements; that is multi-Coxeter arrangements of type A. The most general class of free multi-braid arrangements to date, due to Abe, Nuida, and Numata (2009), can be described via signed-eliminable graphs (a signed generalization of chordal graphs). We extend their work to show that on a large cone in the lattice of potential multiplicities, the only free multi-braid arrangements are those identified by Abe-Nuida-Numata. This partially extends joint work with Francisco, Mermin, and Schweig on the A_3 braid arrangement. No knowledge of arrangements will be assumed. (Received July 14, 2017)

1131-13-188 **Jen-Chieh Hsiao**, Mathematics Department, National Cheng Kung University, Tainan City, 70101, Taiwan, and **Laura Felicia Matusevich***, Department of Mathematics, Texas A&M University, College Station, TX 77843. *Bernstein-Sato polynomials on normal toric varieties.*

We generalize the Bernstein–Sato polynomials of Budur, Mustaţă, and Saito to ideals in normal semigroup rings. In the case of monomial ideals, we also relate the roots of the Bernstein–Sato polynomial to the jumping coefficients of the corresponding multiplier ideals. In order to prove the latter result, we obtain a new combinatorial description for the multiplier ideals of a monomial ideal in a normal semigroup ring. (Received July 14, 2017)

1131-13-191 **Andrew Windle*** (andrew.windle@huskers.unl.edu). *Cohomological operators on quotients by an exact zero divisor.* Preliminary report.

We construct cohomological operators on the quotient ring R of a commutative ring S by an exact zero divisor $x \in S$. The construction is analogous to the construction of cohomological operators over a local complete intersection ring, but produces somewhat different results. We also connect this construction to the computation of the derived Hochschild cohomology of R over S. (Received July 15, 2017)

1131-13-192 **William D Taylor*** (wdtaylor@uark.edu), 2050 N East Oaks Dr, Apt 6, Fayetteville, AR 72703. *Generalizing Multiplicity Using Interpolation.*

Hilbert-Samuel multiplicity is an important invariant of a dimension 0 ideal in a local ring which captures data about the asymptotic behavior of the powers of the ideal. In a local ring of positive characteristic we can study the Hilbert-Kunz multiplicity of a dimension 0 ideal which captures data about the asymptotic behavior of the Frobenius powers of the ideal. In this talk we will examine some of the proposed ways to expand the definitions of the two multiplicities to allow for measuring the multiplicity of ideals of positive dimension. We will define

a function, called s-multiplicity, that interpolates continuously between the Hilbert-Samuel and Hilbert-Kunz multiplicities of dimension 0 ideals. We will examine some of the properties of this interpolating multiplicity and discuss how it can help us determine the best way to expand our notions of multiplicity beyond the dimension 0 case. (Received July 14, 2017)

1131-13-198 **Justin Chen*** (jchen@math.berkeley.edu). *Mono: an algebraic study of torus closures.* Preliminary report.

Given an ideal I in a polynomial ring, let $\text{mono}(I)$ denote the largest monomial ideal contained in I. We study mono as an interesting operation in its own right, guided by questions that arise from comparing the Betti tables of I and $\text{mono}(I)$, especially in the case that I is Artinian graded. For instance, how similar are the shapes of the Betti tables of I and $\text{mono}(I)$? Does I Gorenstein imply $\text{mono}(I)$ Gorenstein, or conversely? To what extent is taking mono non-unique? We give many examples to illustrate these questions and their answers. (Received July 14, 2017)

1131-13-199 **Alessandro De Stefani**, **Thomas Polstra** and **Yongwei Yao*** (yyao@gsu.edu). *Globalizing F-invariants.*

In this paper we define and study the global Hilbert-Kunz multiplicity and the global F-signature of prime characteristic rings which are not necessarily local. Our techniques are made meaningful by extending many known theorems about Hilbert-Kunz multiplicity and F-signature to the non-local case. (Received July 14, 2017)

1131-13-217 **Hailong Dao*** (hdao@ku.edu) and **Alessandro De Stefani** (ads@kth.se). *When is the product of ideals Golod?* Preliminary report.

Let I, J be homogenous ideal in a polynomial ring R over a field. It has been asked whether the product IJ is always Golod. A proof was given for I, J monomial by Faridi-Welker but it rests on an incorrect characterization of Golodness. Finally De Stefani gave a counter-example for I, J monomial ideals in 4 variables. In this work we study necessary and sufficient conditions for Golodness using ideal-theoretic conditions. In particular we show that the product of two monomial ideals in 3 variables is Golod. (Received July 15, 2017)

1131-13-218 **Hailong Dao*** (hdao@ku.edu) and **Jonathan Montaño** (jmontano@ku.edu). *Local cohomology of powers of ideals.*

Local cohomology was introduced by Grothendieck in early 1960s. Since then it has become an essential tool and active research topic in commutative algebra and algebraic geometry. While local cohomology modules contain many useful and subtle information, one fundamental obstacle in understanding them is that they are often not finitely generated. Let I be a graded ideal in a polynomial ring over a field. In this talk I will describe a recent work with Jonathan Montaño on estimating the asymptotic behavior of length of local cohomologies of powers of I. Two interesting technical ingredients were crucial: asymptotic "Kodaira type" vanishing results and counting functions for Presburger arithmetic. (Received July 15, 2017)

1131-13-222 **Glenn D Appleby*** (gappleby@scu.edu) and **Tamsen Whitehead** (tmcginley@scu.edu). *Hives Determined by Pairs in the Affine Grassmannian over Discrete Valuation Rings.*

Let $\mathcal{O}$ be a discrete valuation ring with quotient field $\mathcal{K}$. The *affine Grassmannian* $\mathcal{G}r$ is the set of full-rank $\mathcal{O}$-modules contained in $\mathcal{K}^n$. Given $\Lambda \in \mathcal{G}r$, invariant factors $inv(\Lambda) = \lambda \in \mathbb{Z}^n$ stratify $\mathcal{G}r$. We stratify $\mathcal{G}r \times \mathcal{G}r$ under left-multiplication by $GL_n(\mathcal{K})$ where $inv(N, \Lambda) = \mu$ if (N, Λ) and (I_n, M) are in the same $GL_n(\mathcal{K})$ orbit, and $inv(M) = \mu$. We present an elementary map from $\mathcal{G}r \times \mathcal{G}r$ to hives (in the sense of Knutson and Tao) of type (μ, ν, λ) where $inv(N, \Lambda) = \mu$, $inv(N) = \nu$, and $inv(\Lambda) = \lambda$. Earlier work by Kamnitzer utilized properties of MV polytopes to define such a map over $\mathcal{O} = \mathbb{C}[[t]]$. Our proof uses only linear algebra methods, where hive entries are minima over certain submodules of orders of their invariant factors. Our map is analogous to a conjectured construction of hives from Hermitian matrix pairs due to Danilov and Koshevoy. We show the S_3 symmetries of hives correspond naturally to alternate factorizations of matrix representatives of pairs in $\mathcal{G}r \times \mathcal{G}r$. (Received July 15, 2017)

1131-13-231 **Alexandra Seceleanu*** (aseceleanu@unl.edu). *The Waldschmidt constant for monomial ideals.*

The Waldschmidt constant is an asymptotic invariant associated to a homogeneous ideal. It measures the rate of growth of the initial degree of the symbolic powers of the given ideal. The study of Waldschmidt constants is motivated by geometric considerations, i.e. estimating the lowest degree of a hypersurface vanishing at all the points of a variety to a given order.

In this talk, we give several combinatorial interpretations for the Waldschmidt constant of a monomial ideals. While Waldschmidt constants are generally very difficult to compute, this will allow us to determine them and to prove a lower bound conjectured by Cooper-Embree-Ha-Hoefel in several important cases. The results are partially based on joint work with Bocci, Cooper, Guardo, Harbourne, Janssen, Nagel, Van Tuyl and Vu. (Received July 16, 2017)

1131-13-243 **Lukas Katthän*** (katth001@umn.edu). *Linear maps in the resolutions of Stanley-Reisner rings.*

Let Δ be a simplicial complex. Let further $I \subset S$ be its Stanley-Reisner ideal and let F be the minimal free resolution of the Stanley-Reisner ring S/I. By Hochster's formula, generators of F correspond to cohomology classes on induced subcomplexes of Δ. In this talk, I will present an extension of this correspondence, namely that the linear part of F corresponds to the inclusion maps between the induced subcomplexes of Δ.

As an application, we obtain a characterization of those simplicial complexes whose Stanley-Reisner ideal is componentwise linear. (Received July 16, 2017)

1131-13-253 **Tai Ha*** (tha@tulane.edu), Tulane University, Department of Mathematics, 6823 St. Charles Avenue, New Orleans, LA 70118. *Depth and regularity modulo a principal ideal.*

We shall discuss the relationship between depth and regularity of a homogeneous ideal I and those of (I, f) and $(I : f)$, where f is either a linear form or a monomial. We shall also give a number of interesting consequences on depth and regularity of edge ideals of hypergraphs and of powers of homogeneous ideals. (Received July 17, 2017)

1131-13-275 **Jennifer Biermann**, **Augustine O'Keefe*** (aokeefe@conncoll.edu) and **Adam Van Tuyl**. *Bounds on the regularity of toric ideals of graphs.*

Let G be a finite simple graph. We give a lower bound for the Castelnuovo-Mumford regularity of the toric ideal I_G associated to G in terms of the sizes and number of induced complete bipartite graphs in G. When G is a chordal bipartite graph, we find an upper bound for the regularity of I_G in terms of the size of the bipartition of G. (Received July 17, 2017)

1131-13-277 **Linquan Ma** and **Karl Schwede*** (schwede@math.utah.edu). *F-rational mod p implies rational singularities in characteristic zero.*

In her dissertation, Karen Smith proved that if a singularity in characteristic zero (say defined over $\mathbb{Z}$) had the property that its mod p reduction had F-rational singularities for all $p \gg 0$, then the singularity in characteristic zero had rational singularities.

In joint work with Linquan Ma we show that in fact it sufficient for a single mod p reduction to have rational singularities. This relies on recent advances in our understanding of singularities in mixed characteristic. (Received July 17, 2017)

1131-13-284 **Patricia J Klein*** (triciajk@umich.edu). *A Generalization of a Theorem of Lech's.*

Let (R, m) be a complete local ring of dimension d. Lech's inequality states that for every m-primary ideal I, $\dfrac{e_I(R)}{\ell(R/I)} \leq d! \cdot e_m(R)$, where $e_I(R)$ denotes the multiplicity of I on R. We will discuss conditions on R and on R-modules M that allow us to bound $\dfrac{e_I(M)}{\ell(M/IM)}$ above and below independent of the m-primary ideal I. (Received July 17, 2017)

1131-13-301 **Ian M Aberbach*** (aberbachi@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, and **Thomas Polstra**. *The dual free syzygy property and the homological theorems.* Preliminary report.

Let $A = R/I$, where R is a Cohen-Macaulay local ring and I is a height n ideal. We say that A satisfies the dual free syzygy property over R if the nth syzygy module in a minimal R-free resolution of $\mathrm{Ext}^n_R(A, R)$ has an R-free summand.

S. Dutta has shown that the validity of the homological conjectures (now theorems) for all local rings is equivalent to the condition that every homomorphic image of every regular local ring R satisfies the dual free summand property over R.

We explore this condition more carefully, especially as it pertains to the relationships among the various homological conjectures/theorems. (Received July 17, 2017)

1131-13-316 **Liana M Şega*** (segal@umkc.edu), **Andrew Kustin** and **Adela Vraciu**. *Compressed local Artinian rings.*

Compressed Artinian algebras are algebras that have maximal length, given the socle type and embedding dimension. This notion was introduced more than 30 years ago and has been studied using the Macaulay inverse system or similar duality theories that are dependent on the ring containing a field. We show that the definition of a compressed local ring as an extremal object makes sense even when the ring does not contain a field. More precisely, we develop a new duality theory over local rings (that may not contain a field) that allows to define and study a notion of compressed local Artinian ring. We further establish structural results that allow to derive conclusions on the Poincaré series of finitely generated modules, under certain assumptions on the socle type. Let $(R, \mathfrak{m}, k)$ be a compressed local Artinian ring with odd top socle degree s, at least five, and $\operatorname{socle}(R) \cap \mathfrak{m}^{s-1} = \mathfrak{m}^s$. We prove that the Poincaré series of all finitely generated modules over R are rational, sharing a common denominator, and that there is a Golod homomorphism from a complete intersection onto R. (Received July 17, 2017)

1131-13-319 **Tucker Kevin*** (kftucker@uic.edu), 851 S Morgan St, UIC MSCS SEO m/c 249, Chicago, IL 60607-7045, Chicago, IL 60607, and **Smirnov Ilya**. *F-signature of Cartier Modules.*

The F-signature of a local ring R in positive characteristic measures singularities by analyzing the asymptotic behavior of splittings of the iterated Frobenius endomorphism. It has a number of useful properties: it detects singularity and F-regularity, respects localization, and determines a semicontinuous function on $\operatorname{Spec}(R)$. Several attempts have been made to define an analogous invariant for F-rationality: Hochster-Yao introduced the F-rational signature $s_{rat}(R)$ and later Sannai defined the dual F-signature $s(\omega_R)$. Yet neither of these invariants share all of the desirable properties of the F-signature. We propose a definition of the F-signature $s(\phi)$ of a Cartier module (M, ϕ), in the sense of Blickle-Böckle. With mild assumptions, this invariant detects F-regularity, and gives a lower semi-continuous function. The most important example comes from the trace of Frobenius $Tr_F \colon (\omega_R)^{1/p} \to \omega_R$. We refer to $s(Tr_F)$ as the Cartier signature, and like the dual and F-rational signatures, it detects F-rationality; additionally, the Cartier signature respects localization and is semicontinuous. (Received July 17, 2017)

1131-13-322 **Jay Schweig*** (jayschweig@gmail.com), 401 MSCS, Stillwater, OK 74075. *Old and new results on flag h-vectors.* Preliminary report.

Recall that a (d-1)-dimensional simplicial complex is balanced if its 1-skeleton admits a proper d-coloring. The flag h-vector of a balanced simplicial complex is a refinement of the classical h-vector with a beautiful topological interpretation. We review some facts about the flag h-vector, and present some recent results about flag h-vectors of certain complexes with extra combinatorial structure. (Received July 17, 2017)

1131-13-336 **Oana Veliche***, 360 Huntington Avenue, Boston, MA 02115, and **Lars Winther Christensen** and **Jerzy Weyman**. *Linkage classes of grade three perfect ideals.* Preliminary report.

We say that a local ring $R = Q/I$, with Q a regular local ring and I a grade 3 ideal, has the format $(1, m, m + n - 1, n)$ if the minimal free resolution of R over Q is of the form $0 \leftarrow Q \leftarrow Q^m \leftarrow Q^{m+n-1} \leftarrow Q^n \leftarrow 0$. Associated to this format is a graph with three arms of lengths n, $m - 3$ and 1 attached to a central vertex. The classification of generic resolutions associated to these graphs, obtained by Jerzy Weiman, suggests that the Dynkin graphs (formats) play a special role. We investigate whether these formats are special from the point of view of linkage. When the format is not Dynkin, we can find a perfect ideal with the resolution of that format which is the smallest in its linkage class. We conjecture, and give evidence for it, that if the format is Dynkin then the ideal is in the linkage class of a complete intersection (licci). (Received July 18, 2017)

1131-13-340 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu) and **Oana Veliche**. *The Golod property of powers of the maximal ideal.* Preliminary report.

We identify minimal cases in which a power of the maximal ideal $\mathfrak{m}$ of a local ring R is not Golod, i.e. the quotient $R/\mathfrak{m}^i$ is not a Golod ring. Complementary to a 2014 result by Rossi and Şega, we prove that for a generic artinian Gorenstein local ring $(R, \mathfrak{m})$ of socle degree 3, the quotient $R/\mathfrak{m}^3$ is not Golod. This is assuming that $\mathfrak{m}$ is minimally generated by at least 3 elements. Indeed, we show that if $\mathfrak{m}$ is 2-generated, then every proper quotient $R/\mathfrak{m}^i$ is Golod. (Received July 18, 2017)

1131-13-362 **Rebecca R.G.*** (rirebhuh@syr.edu) and **Felipe Perez**. *Test ideals for all characteristics.* Preliminary report.

We define the test ideal of a general closure operation and give some of its properties. If the closure comes from a big Cohen-Macaulay module or algebra, or a family of such modules or algebras, then the test ideal behaves

similarly to the tight closure test ideal used in characteristic $p > 0$. These test ideals may be used to study both the singularities of the ring and the family of big Cohen-Macaulay modules or algebras over the ring. (Received July 18, 2017)

1131-13-368 **Janet Page*** (jpage8@uic.edu). *Some Examples of Frobenius Complexity.*
Central to the study of singularities in characteristic p is the Frobenius morphism and its splittings. Given a commutative ring R of positive characteristic, the total Cartier algebra is the ring of all potential Frobenius splittings of R (or all p^{-e} linear maps on R), and it has been studied in various contexts in its relation to singularities. This ring need not be finitely generated over R, which led Enescu and Yao to define Frobenius complexity as a measure of its non-finite generation. In their examples, Frobenius complexity is not always even rational, but its limit as $p \to \infty$ is an integer. Few other examples have been computed. In this talk, I will discuss some results on the limit Frobenius complexity of a certain class of toric rings called Hibi rings. (Received July 18, 2017)

1131-13-393 **Adam Boocher*** (boocher@math.utah.edu) and **James Seiner** (seiner@umich.edu). *Lower Bounds for Betti Numbers.*
Inspired by the Buchsbaum-Eisenbud-Horrocks rank conjecture, many people have conjectured various lower bounds for the Betti numbers of graded modules over a polynomial ring. In this talk I'll discuss these conjectures, their status, and some recent work with Jimmy Seiner concerning strong lower bounds in the case of monomial ideals. (Received July 18, 2017)

1131-13-399 **Gabriel Sosa*** (gsosa@amherst.edu), **Amanda Croll**, **Roger Dellaca**, **Justin Hoffmeier**, **Anjan Gupta**, **Vivek Mukundan**, **Denise Rangel Tracy**, **Liana M Sega** and **Peder Thompson**. *Detecting Koszulness and related homological properties from the algebra structure of Koszul Homology.*
Let k be a field and R a standard graded k-algebra. We denote by H^R the homology algebra of the Koszul complex on a minimal set of generators of the irrelevant ideal of R. We discuss the relationship between the multiplicative structure of H^R and the property that R is a Koszul algebra. More generally, we work in the setting of local rings and we show that certain conditions on the multiplicative structure of Koszul homology imply strong homological properties. (Received July 18, 2017)

14 ► Algebraic geometry

1131-14-40 **Erik Insko**, **Julianna Tymoczko** and **Alexander Woo*** (awoo@uidaho.edu). *Another formula for the cohomology and K-theory classes of regular Hessenberg varieties.*
We give a formula for polynomial representatives of the Grothendieck ring and cohomology classes of the regular nilpotent Hessenberg varieties (of type A) in the Grothendieck and cohomology rings of the flag variety. Our formulas give these classes as specializations of Grothendieck and Schubert polynomials, but they are different from the earlier formula of Anderson and Tymoczko; indeed they produce different polynomial representatives for the cohomology classes in some examples. Our methods come from commutative algebra and the interpretation of Grothendieck and Schubert polynomials as K-polynomials and multidegrees of matrix Schubert varieties. (Received June 18, 2017)

1131-14-45 **Emanuele Ventura*** (emanueleventura.sw@gmail.com), 4302 College main, Bryan, TX 77801. *Phylogenetic complexity of group-based models.*
In algebraic statistics, Jukes-Cantor and Kimura models are of great importance. Sturmfels and Sullivant generalized these models associating to any finite abelian group a family of toric varieties. In this talk, we will see that the ideals of these toric varieties are generated in bounded degree, which only depends on the group. For the Kimura 3-parameter model, we show that these ideals are generated in degree at most four. This is a joint work with M. Michałek. (Received June 21, 2017)

1131-14-71 **Nida Obatake*** (nida@math.tamu.edu), **Elizabeth Gross** and **Nora Youngs**. *Place field diagrams of convex neural codes.*
A rat has special neurons that encode its geographic location. These neurons are called place cells and each place cell corresponds to a region in the space, called a place field. Neural codes are collections of the firing patterns of place cells. In this talk, we investigate how to algorithmically draw a place field diagram of a convex neural code, building on existing work studying neural codes, ideas developed in the field of information visualization,

and the toric ideal of a neural code. This talk is based on joint work with Elizabeth Gross and Nora Youngs. (Received July 02, 2017)

1131-14-96 **Dan Bates*** (bates@math.colostate.edu), **Karleigh Cameron** and **Margaret Cheney**. *Numerical algebraic geometry for geolocation.* Preliminary report.

Given an RF emitter and multiple receivers, there are various formulations of polynomial systems that can be used to recover the emitter location from received measurements. In this talk, we describe some recent advances in approaching this problem with various techniques from numerical algebraic geometry. (Received July 06, 2017)

1131-14-103 **Jonathan Hauenstein*** (hauenstein@nd.edu), 153 Hurley Hall, Notre Dame, IN 46556, and **Luca Chiantini**, **Christian Ikenmeyer**, **Giorgio Ottaviani** and **J.M. Landsberg**. *Polynomials and the exponent of matrix multiplication.*

The determination of the exponent of matrix multiplication is a central question in algebraic complexity theory. By consider symmetrized versions of matrix multiplication, we study the exponent of matrix multiplication by way of polynomials. This results in different paths for bounding the exponent of matrix multiplication. The ranks and border ranks of particular examples will be demonstrated throughout the talk. (Received July 07, 2017)

1131-14-151 **Yuyu Zhu*** (zhuyuyu@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, 77843. *PSD and SOS Cones for Ternary Sextics.*

In 1960s, Motzkin famously proved that the ternary sextic $x^2y^4 + x^4y^2 + z^6 - 3x^2y^2z^2$ is nonnegative but not a sum of squares of real polynomials. Inspired by this example, we compute the volume ratios of the cone of sums of squares (SOS) in the cone of nonnative polynomials (PSD) for some families of ternary sextics. We will also compare the quality of corresponding SOS relaxations with the original global minimization problems. (Received July 12, 2017)

1131-14-153 **Kaitlyn Phillipson*** (kphillip@stedwards.edu), 3001 South Congress Ave., Austin, TX 78704, and **Sarah Ayman Goldrup**. *Structure of the Neural Ideal for Convex and Non-convex Codes.* Preliminary report.

Combinatorial codes can be used to represent neural activity, called neural codes. It has been found that certain neurons fire in convex regions in the stimulus space. Given a neural code, how can we determine if it can represent convex sets? Complete conditions for convexity are still unknown. One tool for investigating this problem is a polynomial ideal that encodes the combinatorial information about the neural code, called the neural ideal. We can extract from this ideal a special set of generators called the canonical form, which represent minimal relationships among the stimulus space. Another well-known set of generators for an ideal is the Gröbner basis. Recent results show some cases where the canonical form is a Gröbner basis for the neural ideal. A natural question, then, is how does this relate to the convexity of the neural code itself? We will discuss some results on the connection between convexity and determining if the canonical form is a Gröbner basis for the neural ideal. (Received July 12, 2017)

1131-14-238 **Laura Escobar*** (lescobar@illinois.edu), Urbana, IL 61801, and **Allen Knutson**. *The multidegree of the multi-image variety.*

The multi-image variety models taking pictures with n rational cameras. It can be described as a subvariety of $\mathrm{Gr}(2,4)^n$. We compute its cohomology class in the cohomology ring of $\mathrm{Gr}(2,4)^n$ and its multidegree in the Plücker embedding $(\mathbb{P}^5)^n$. Joint work with Allen Knutson. (Received July 16, 2017)

1131-14-247 **Derek Tomlin*** (derek.tomlin@mavs.uta.edu) and **Michaela Vancliff**. *Line Schemes of Quantum $\mathbb{P}^3$s.*

In this talk, we consider some geometrical information associated to certain regular algebras of global dimension four. In particular, we discuss the one-dimensional line schemes of a few quadratic quantum $\mathbb{P}^3$s. (Received July 16, 2017)

1131-14-260 **Erik A Insko*** (einsko@fgcu.edu), 3040 Oasis Grand Blvd, Apt 1705, Ft Myers, FL 33916, and **Martha Precup**. *Singularities of semisimple Hessenberg varieties.*

Semisimple Hessenberg varieties are subvarieties of the flag variety with important connections to representation theory, algebraic geometry, and combinatorics. Like Schubert varieties, the structure of semisimple Hessenberg varieties can be studied using the combinatorics of the symmetric group. In this talk, we will define these

varieties and give a combinatorial criterion for identifying singular points in certain semisimple Hessenberg varieties. (Received July 17, 2017)

1131-14-262 **David McKinnon*** (dmckinnon@uwaterloo.ca), Pure Mathematics Department, 200 University Avenue West, Waterloo, ON N2L3G1, Canada. *Integral points and higher codimension.*

There are lots of smooth varieties with a dense set of rational points but a degenerate set of integral points over every finite extension of the base field. However, if the "locus at infinity" has codimension two or more, no such examples are known.

Hassett and Tschinkel have asked if this is a general phenomenon, or if it is possible to delete a set of codimension at least two from a smooth, projective variety and thereby transform a dense set of rational points into a never-dense-no-matter-how-much-you-extend-the-base-field set of integral points. In this talk, I'll discuss this question, with some new examples. (Received July 17, 2017)

1131-14-281 **Elizabeth Drellich***, edrelli1@swarthmore.edu. *On the structure of regular nilpotent Hessenberg varieties.*

Hessenberg varieties are a large family of subvarieties of the flag variety defined by two parameters, a linear operator and a particular type of Lie algebra subspace called a Hessenberg space. If the linear operator is a regular nilpotent element of the Lie algebra, then every Hessenberg space defines a distinct Hessenberg variety, which is not true for a general linear operator. This talk will discuss the structure of regular nilpotent Hessenberg varieties and how they differ from other Hessenberg varieties. (Received July 17, 2017)

1131-14-310 **Lourdes Juan*** (lourdes.juan@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Applications of Algebraic Geometry to Symbolic Integration.* Preliminary report.

In this talk we will present, in an expository way, results concerning the application of algebraic-geometric techniques to the symbolic integration of algebraic functions, that need to be more widely known. These results enlarge the class of functions whose integral can be computed in closed form. (Received July 17, 2017)

1131-14-324 **Gordon Heier*** (heier@math.uh.edu), Department of Mathematics, University of Houston, 4800 Calhoun Road, Houston, TX 77204, and **Steven Lu**, **Bun Wong** and **Fangyang Zheng**. *Reduction of manifolds with semi-negative holomorphic sectional curvature.*

The interplay of various notions of hyperbolicity and the geometry and structure of a projective manifold is an important and intriguing topic in complex geometry. In this spirit, we investigate a projective Kähler manifold M of semi-negative holomorphic sectional curvature H. We introduce a new differential geometric numerical rank invariant which measures the number of linearly independent *truly flat* directions of H in the tangent spaces. We prove that this invariant is bounded above by the nef dimension and bounded below by the numerical Kodaira dimension of M. We also prove a splitting theorem for M in terms of the nef dimension and, under some additional hypotheses, in terms of the new rank invariant. (Received July 17, 2017)

1131-14-332 **Robert L Williams*** (william7@rose-hulman.edu). *Restrictions on Galois groups of Schubert problems.*

A Schubert variety is a collection of linear spaces that satisfy special incidence conditions with respect to other fixed linear spaces. If one takes a collection of Schubert varieties such that their intersection is finite, then some of the structure of the linear spaces in this intersection is encoded by a Galois group. Not all groups appear as a Galois group of such a structure, but it is unknown precisely which groups do. We present some relations that may be used to build infinite families of Schubert problems whose Galois group is much smaller than the full symmetric group on the collection of linear spaces. (Received July 18, 2017)

1131-14-345 **Taylor Brysiewicz*** (tbrysiewicz@math.tamu.edu), 2101 Southwood Drive, Apt 7, College Station, TX 77840. *Computing Newton Polytopes via Witness Sets.*

Often a hypersurface is given as the image of a map and the defining polynomial is too costly to compute. Moreover, even when computable, this polynomial can be so large that it is not useful. The Newton polytope of this polynomial, however, encodes a large amount of algebraic and geometric data regarding the hypersurface and can be computed using a numerical algebraic geometry algorithm proposed by Hauenstein and Sottile. In this talk, I will give a brief introduction to numerical algebraic geometry, discuss this algorithm's current implementation, and show an example of its success on a hypersurface coming from algebraic vision. (Received July 18, 2017)

1131-14-359 **Brandilyn Stigler*** (bstigler@smu.edu), Dallas, TX 75275. *Model Selection via Groebner Bases.*

Recently, tools from algebraic geometry have been employed to infer the network structure of biological systems. For a given set of data points over a finite field, the ideal of points can be used to describe the space of polynomials that fit the data and each reduced Groebner basis of the ideal represents a distinct choice of minimal model for the underlying network. Because these models may give rise to vastly different predictions about the network, identifying which ideals have unique reduced Groebner bases is of importance. In this talk, we identify properties of the ideal that result in a unique reduced Groebner basis. We also consider ideals with the same number of reduced Groebner bases. This is joint work with Elena Dimitrova, Qijun He, and Lorenzo Robbiano. (Received July 18, 2017)

1131-14-371 **Alexander Woo** (awoo@uidaho.edu), Department of Mathematics, University of Idaho, 875 Perimeter Drive, MS 1103, Moscow, ID 83844-1103, **Benjamin J. Wyser*** (bwyser@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801, and **Alexander Yong** (ayong@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801. *Singularities of K-orbit closures and interval pattern avoidance.* Preliminary report.

The local structure of symmetric subgroup orbit closures on the flag variety is of importance in the theory of Harish-Chandra modules for real Lie groups. Thanks largely to work of McGovern and McGovern-Trapa, certain local properties of such orbit closures, such as smoothness, are known to be characterized by pattern avoidance in many cases. However, there are more refined local properties which cannot be characterized in the same way. I will describe a generalization of pattern avoidance, which we call interval pattern avoidance, which governs all reasonable local properties of K-orbit closures in the case where $G = GL_{p+q}$ and $K = GL_p \times GL_q$. Although combinatorial in nature, this result follows from underlying geometry: An interval pattern embedding implies an isomorphism of two "slices" of the corresponding orbit closures. This work is joint with Alexander Woo and Alexander Yong. (Received July 18, 2017)

1131-14-392 **Stephen Oloo*** (stephen.oloo@kzoo.edu), 1200 Academy Street, Kalamazoo, MI 49006. *Generalized Moment Graphs and the Equivariant Intersection Cohomology of the Wonderful Compactification of a Group.*

We describe a method for computing the equivariant intersection cohomology of certain subvarieties of the wonderful compactification of a semisimple adjoint complex algebraic group. Specifically, we compute equivariant intersection cohomology of the borel orbit closures with respect to a torus action. This approach uses only the structure of certain low dimensional torus orbits, encoding this information combinatorially in what we call a *generalized moment graph* and yielding a functorial description of the cohomology in terms of 'sheaves' on the generalized moment graph. This work generalizes the moment graph approach of Braden and MacPherson to computing equivariant intersection cohomology of schubert varieties. (Received July 18, 2017)

1131-14-409 **Alicia Dickenstein**, **Mercedes Perez Millan** and **Anne Shiu**, College Station, TX 77840, and **Xiaoxian Tang***, 2250 Dartmouth St, Apt 313a, College Station, TX 77840. *Investigating multistationarity in structured reaction networks.*

Many dynamical systems arising in chemical reaction networks exhibit multistationarity (2 or more positive steady states), but it is non-trivial to find the witness. Even for a reaction network already known to admit multiple steady states. Here, we present a heuristic method for investigating this problem for some structured networks, which are common in biological signaling pathways. We demonstrate in several examples that our approach works well, and develop the associated mathematics. (Received July 18, 2017)

1131-14-412 **Min Ru** (minru@math.uh.edu), Department of Mathematics, University of Houston, 4800 Calhoun Road, Houston, TX 77204, and **Paul Vojta*** (vojta@math.berkeley.edu), Department of Mathematics, University of California, 970 Evans Hall #3840, Berkeley, CA 94720-3840. *Birational Nevanlinna constants and work of Autissier.* Preliminary report.

In 2002, Corvaja and Zannier obtained a new proof of Siegel's theorem (on integral points on curves) based on Schmidt's celebrated Subspace Theorem. Soon after that (and based on earlier work), Evertse and Ferretti applied Schmidt's theorem to give diophantine results for homogeneous polynomials of higher degree on a projective variety in $\mathbb{P}^n$. This has led to further work of A. Levin, P. Autissier, M. Ru, G. Heier, and others. In particular, Ru defined a number, $\mathrm{Nev}(D)$, that concisely describes the best diophantine approximation obtained by this method. Here D is an effective Cartier divisor on a projective variety X.

In this talk, we will give a birational variant of $\mathrm{Nev}(D)$, defined using the theory of b-divisors and corresponding b-Weil functions. If time permits, we will sketch how work of Autissier can be derived using this constant. (Received July 18, 2017)

1131-14-414 **Linda Chen** and **Julianna Tymoczko*** (jtymoczko@smith.edu), Department of Mathematics and Statistics, Smith College, Northampton, MA 01063. *Hessenberg varieties and affine Schubert cells.*

Given a linear operator, we can consider its "eigenflags," namely the set of flags fixed by the linear operator. Hessenberg varieties are a family of subvarieties of the flag variety that generalize this idea, instead asking for flags that a linear operator shifts in a restricted way, as measured by a subspace H. The affine Grassmannian is an infinite-dimensional analogue of the flag variety, apparently unrelated to Hessenberg varieties. Both Hessenberg varieties and affine Grassmannians have a kind of Schubert decomposition, and both decompositions can be described by similar linear algebra and combinatorics. We describe explicit connections between certain Hessenberg varieties and affine Schubert cells. (Received July 18, 2017)

15 ► Linear and multilinear algebra; matrix theory

1131-15-165 **J. Maurice Rojas*** (rojas@math.tamu.edu), TAMU 3368, College Station, TX 77843-3368, and **Jens Forsgard** (jensf@math.tamu.edu) and **Mounir Nisse** (mounir.nisse@gmail.com). *Sharper Topological Bounds for Near-Circuit Exponential Sums.*

Suppose $\mathcal{A}$ is a subset of $\mathbb{R}^n$ of cardinality $n+3$ with non-defective (generalized) $\mathcal{A}$-discriminant. We show that an exponential sum g supported on $\mathcal{A}$ has at most $O(n^2)$ connected components for its real zero set Z. (This implies an analogous bound for the positive zero sets of n-variate $(n+3)$-nomials.) The best previous bound (for just the number of non-compact connected components) was exponential in n. Our bound is based on a more refined look at the singularities of Z as g varies along certain monomial curves in coefficient space. (Received July 12, 2017)

16 ► Associative rings and algebras

1131-16-39 **Jonathan Kujawa** and **Jieru Zhu*** (jieru.zhu-1@ou.edu). *Presenting cyclotomic Schur algebras.*

A classical result states that the action of $\mathfrak{gl}(V)$ and the symmetric group on d letters mutually centralize each other on the d-fold tensor of V. If V admits an action by $\mathbb{Z}/r\mathbb{Z}$, it induces an action of the wreath product of $\mathbb{Z}/r\mathbb{Z}$ and the symmetric group on d letters. A Levi Lie subalgebra $\mathfrak{g}$ of $\mathfrak{gl}(V)$ gives the full centralizer of this action, and we further showed a presentation for the cyclotomic Schur algebra as a quotient of the enveloping algebra of $\mathfrak{g}$. This also provides a PBW type basis and a second presentation with idempotent generators. These results extend to the quantum setting and yield similar presentations and a basis for the the cyclotomic q-Schur algebra. When $r = 2$, they become presentations for the Type B hyperoctahedral Schur algebra defined by Richard Green. (Received June 17, 2017)

1131-16-49 **Jason Gaddis*** (gaddisj@maimioh.edu) and **Daniel Rogalski**. *Quivers supporting graded Calabi-Yau algebras.*

A graded Calabi-Yau algebra of global dimension 3 is necessarily the path algebra of a quiver modulo relations determined by a superpotential on the quiver. In this talk, I will present a classification of quivers that support such algebras under the additional hypothesis that the algebras have finite GK dimension. (Received June 24, 2017)

1131-16-50 **Jason Gaddis*** (gaddisj@maimioh.edu) and **S. Paul Smith**. *A birational equivalence between non-commutative analogs of $\mathbb{P}^2$ and $\mathbb{P}^1 \times \mathbb{P}^1$.* Preliminary report.

An example that appears in every introductory course on projective algebraic geometry consists of blowing up a pair of distinct points on the projective plane $\mathbb{P}^2$ then contracting the strict transform of the line through them to obtain a surface isomorphic to $\mathbb{P}^1 \times \mathbb{P}^1$. In this talk, I will present a non-commutative analog of this construction. A particularly interesting special case is related to the Lie algebra $\mathfrak{sl}_2$. (Received June 24, 2017)

1131-16-60 **Xingting Wang*** (xingting@temple.edu), **Xianlan Yu** and **Yinhuo Zhang**. *Calabi-Yau property under monoidal Morita-Takeuchi equivalence.*

Two Hopf algebras are said to be Morita-Takeuchi equivalent if their comodule categories are tensor equivalent. In this talk, we will discuss homological properties of Hopf algebras that are invariant under Morita-Takeuchi equivalence. We will be focusing on the AS-Gorenstein condition and Calabi-Yau property which are enjoyed by a large family of well-known Hopf algebras or quantum groups. We will study these results in the framework of cogroupoids introduced by Bichon. This is a joint work with Xiaolan Yu and Yinhuo Zhang. (Received June 29, 2017)

1131-16-70 **Mihai D Staic*** (mstaic@bgsu.edu), Bowling Green State University, Bowling Green, OH , and **Bruce R Corrigan-Salter** (brcs@wayne.edu), Wayne State University, Detroit, MI. *Higher Order and Secondary Hochschild Cohomology.*

Higher order Hochschild (co)homology is associated to a simplicial set X, a commutative algebra A and an A-bimodule M. When X is the standard simplicial set for the sphere S^1, one recovers the usual Hochschild cohomology. We give a generalization of Pirashvili's construction by replacing the simplicial set with a simplicial pair, and we show that the secondary Hochschild cohomology is a particular case of this new construction. (Received July 01, 2017)

1131-16-77 **Alexandru Chirvasitu*** (chirvasitua@gmail.com), University at Buffalo, Buffalo, NY 14228, and **Ryo Kanda** and **S. Paul Smith**. *Calabi-Yau non-commutative extensions.*

Superpotential algebras are non-commutative analogues of projective schemes that arise in connection to a diverse array of topics: the representation theory of quivers, mirror symmetry, and so on.

The talk focuses on three-dimensional superpotential algebras that serve as non-commutative versions deformations of two-dimensional smooth stacks. Specifically, we discuss a procedure that leverages such an algebra to produce higher dimensional non-commutative schemes that stack up naturally as flat families over a parameter space.

The technique consists of dropping one of the relations of the initial algebra and replacing it with several one-degree-higher relations, and the result is a family of non-commutative analogues of smooth three-dimensional stacks (e.g. a stacky weighted projective spaces). The process is particularly fruitful when the initial algebra is Calabi-Yau, in which case the resulting family of noncommutative stacks is very rich and consists of what seem to be new examples of four-dimensional Artin-Schelter regular connected graded algebras.

(joint w/ Ryo Kanda and S. Paul Smith) (Received July 04, 2017)

1131-16-122 **Robert Won*** (wonrj@wfu.edu), **Jason Gaddis** and **Daniel Yee**. *Discriminants of Taft algebra smash products and applications.*

We study the smash product $A\#H$ where H is a Taft algebra acting on A a quantum plane or quantum Weyl algebra. We determine when the center of $A\#H$ is the fixed ring A^H. We then compute the discriminant of $A\#H$ over its center and apply it to compute the Azumaya locus and restricted automorphism group of $A\#H$. (Received July 10, 2017)

1131-16-144 **Lauren Grimley*** (lgrimley@shc.edu), Department of Mathematics, Spring Hill College, 4000 Dauphin St, Mobile, AL 36608, and **Christine Uhl**. *Truncated quantum Drinfeld Hecke algebras.*

Representations of Hecke algebras can provide information about the representations of certain corresponding groups. In this talk, we develop a class of algebras which we call truncated quantum Drinfeld Hecke algebras. These algebras may be constructed as filtered algebras, in which Bergman's Diamond Lemma and noncommutative Grobner bases may be used, or constructed as deformations of the quantum exterior algebra extended by finite groups, in which homological tools may be used. We focus our attention on examples involving complex reflection groups. (Received July 11, 2017)

1131-16-145 **Lauren Grimley***, Department of Mathematics, Spring Hill College, 4000 Dauphin St, Mobile, AL 36608. *Group extensions of quantum exterior algebras.*

The Hochschild cohomology of an associative algebra contains clues about representations and deformations of the algebra. In this talk, we describe the Hochschild cohomology of group extensions of quantum exterior algebras, detailing the Gerstenhaber algebra structure on cohomology, with a view toward deformations. (Received July 11, 2017)

1131-16-155 **Zachary K Cline***, Department of Mathematics, Temple University, 1805 N Broad St, Philadelphia, PA 19122. *Extending actions to the Drinfel'd double of various Hopf algebras "close" to Taft algebras.* Preliminary report.

Susan Montgomery and Hans-Jürgen Schneider classified all non-trivial n-dimensional module algebras A over the Taft algebras H of dimension $n^2, n > 2$. They further showed that each such module structure extends uniquely to make A a module algebra over the Drinfel'd double of H. We explore what it is about the Taft algebras that leads to this uniqueness, by examining Hopf algebras "close" to the Taft algebras in various directions, and their module algebras. (Received July 12, 2017)

1131-16-163 **Bach Nguyen***, bnguy38@lsu.edu, and **Kurt Trampel** and **Milen Yakimov**. *Discriminants of quantum groups at root of unity.* Preliminary report.

The notion of discriminant is an important tool in number theory, algebraic geometry and noncommutative algebra. However, discriminants are difficult to compute in concrete situations. This has been done for few noncommutative algebras, relying on direct calculations. We will present a formula for the discriminants of all quantized coordinate rings of simple algebraic groups at roots of unity. It is derived from a general method for computing noncommutative discriminants that relies on representation theory and Poisson geometry. (Received July 12, 2017)

1131-16-183 **Peter Goetz*** (pdg11@humboldt.edu) and **Andrew Conner**. *Quadraticity and Koszulity for Graded Twisted Tensor Products.*

Given two unital associative algebras A and B over a field $\mathbb{K}$, it is natural to consider algebra structures on the space $A \otimes_{\mathbb{K}} B$. Such structures were characterized by Căp, Schichl, and Vanžura in 1995 and are determined by certain maps $\tau : B \otimes_{\mathbb{K}} A \to A \otimes_{\mathbb{K}} B$. Ore extensions and smash products are examples of such structures.

We study the quadratic and Koszul property for the algebra $A \otimes_\tau B$ when τ is graded. We show that if A and B are Koszul, then $A \otimes_\tau B$ need not be Koszul nor even quadratic. We characterize when $A \otimes_\tau B$ is quadratic in terms of a certain extension property of the map τ. Finally we construct a large class of graded twisting maps which we call *separable* and study the Koszul property for the associated twisted tensor product algebras.

This is joint work with Andrew Conner. (Received July 14, 2017)

1131-16-194 **Jiafeng Lv**, **Sei-Qwon Oh** and **Xingting Wang*** (xingting@temple.edu), Department of Mathematics, Temple University, Philadelphia, PA 19122, and **Xiaolan Yu** and **Guangbin Zhuang**. *Enveloping algebras of Poisson-Ore extensions.*

For any commutative Poisson algebra, we will introduce the concept of a Poisson enveloping algebra, which is an associated algebra whose module category is equivalent to the category of Poisson modules over the corresponding Poisson algebra. We prove that the Poisson enveloping algebra of a (double) Poisson-Ore extension is an iterated double Ore extension. As an application, properties that are preserved under iterated (double) Ore extensions are invariants of the Poisson enveloping algebra of a (double) Poisson-Ore extension. (Received July 14, 2017)

1131-16-200 **Van C. Nguyen***, Department of Mathematics, Hood College, Frederick, MD 21701, and **Gordana Todorov** and **Shijie Zhu**. *Preprojective algebras of tree-type quivers.*

In this talk, we recollect several descriptions of preprojective algebras and show that these descriptions are indeed equivalent for any tree-type quiver Q. In particular, we construct irreducible morphisms, in the Auslander-Reiten quiver of the tranjective component of the bounded derived category of its path algebra kQ, that satisfy what we call the λ-relations, where λ is a nonzero element in the field k. When $\lambda = 1$, the relations are known as mesh relations. When $\lambda = -1$, they are known as commutativity relations. Using this technique together with the results given by Baer-Geigle-Lenzing, Crawley-Boevey, Ringel, and others, we show that for any tree-type quiver Q, several descriptions of its preprojective algebra are equivalent. (Received July 14, 2017)

1131-16-225 **Siu-Hung Ng*** (sng@lsu.edu), Louisiana State University, Baton Rouge, LA 70803. *Abelian 3-cocyles of finite abelian groups.*

Abelian 3-cocycles of a finite abelian group G are those complex valued 3-cocycles ω of G such that the twisted quantum double $D^\omega(G)$ is a commutative algebra. These 3-cocycles are different from the Eilenberg-MacLane cocycles of G but they can be characterized by the alternating trilinear forms associated with the 3-cocycles of G. If G has odd order, its abelian 3-cocycles are exactly those images of the restriction of the 3-cocycles of the generalized dihedral group $G \rtimes \mathbb{Z}_2$ on G. In this talk, we will discuss these characterizations. (Received July 15, 2017)

1131-16-265 **Andrew B Conner*** (abc12@stmarys-ca.edu). *Knörrer periodicity for noncommutative matrix factorizations: the odd-degree graded case.* Preliminary report.

In the representation theory of commutative local rings, Knörrer periodicity is a powerful tool for classifying complete Gorenstein local rings of finite Cohen-Macaulay (CM) type. By a theorem of Herzog, all such rings are hypersurface singularities. Knörrer periodicity can be used to prove that a simple hypersurface singularity has finite CM type, and to prove that a hypersurface singularity of finite CM type is a simple (ADE) singularity. These proofs exploit the connection, due to Eisenbud, between maximal Cohen-Macaulay modules over $R/(f)$ for a regular local ring R, and matrix factorizations of f.

More recently, the study of finite CM type for noncommutative graded algebras of has emerged, with Artin-Schelter regular algebras playing the role of regular local rings. With Cassidy, Kirkman, and Moore, the author established a version of Eisenbud's correspondence for rings of the form $A/(f)$ where A is an Artin-Schelter regular algebra and f is normal, regular, homogeneous element; that is, for noncommutative (graded) hypersurfaces. In this talk I will discuss an analog of Knörrer periodicity in the noncommutative graded setting, focusing on the case where the degree of f is odd. (Received July 17, 2017)

1131-16-276 **Cathy Kriloff*** (krilcath@isu.edu) and **Briana Foster-Greenwood** (brianaf@cpp.edu). *Deforming skew group algebras of dihedral and symmetric groups: Candidate representations.*

Certain representations of reflection groups are natural candidates for constructing deformations of a skew group algebra. The deformations arising from Hochschild two-cocycles of polynomial degree at most one simultaneously generalize several types of algebras of interest in representation theory, algebraic combinatorics, and noncommutative geometry. They were termed Drinfeld orbifold algebras by Shepler and Witherspoon, who gave algebraic as well as cohomological conditions characterizing them. We explore the open question of which groups and representations yield such deformations by considering some representations of symmetric and dihedral groups for which we are able to classify resulting Drinfeld orbifold algebras. (Received July 17, 2017)

1131-16-278 **Briana Foster-Greenwood*** (brianaf@cpp.edu) and **Cathy Kriloff** (krilcath@isu.edu). *Deforming skew group algebras of dihedral and symmetric groups: Which cocycles lift?*

Since their introduction in the 1980's, graded Hecke algebras have appeared in various guises and settings ranging from symplectic reflection algebras in orbifold theory to rational Cherednik algebras used to prove results in algebraic combinatorics. Graded Hecke algebras, and their generalization to Drinfeld orbifold algebras, may be viewed as quotient algebras as well as formal deformations of skew group algebras. In the latter perspective, one invokes cohomological tools and asks: Which Hochschild 2-cocycles lift to define a Drinfeld orbifold algebra? We explore this question in the context of deformations of skew group algebras arising from certain representations of symmetric and dihedral groups, comparing and contrasting with the graded Hecke algebra case along the way. (Received July 17, 2017)

1131-16-279 **Ellen E. Kirkman*** (kirkman@wfu.edu), Box 7388 Reynolda Station, Department of Mathematics and Statistics, Wake Forest University, Winston-Salem, NC 27109. *Reflection Hopf Algebras.* Preliminary report.

The Shephard-Todd-Chevalley Theorem states that when a finite group G acts linearly on a commutative polynomial ring $A = k[x_1, \ldots, x_n]$ over a field k of characteristic zero, the invariant subring A^G is a commutative polynomial ring if and only if G is generated by reflections. More generally, let H be a finite dimensional semisimple Hopf algebra that acts on an Artin-Schelter regular algebra A so that A is an H-module algebra, the grading on A is preserved, and the action of H on A is inner faithful. When A^H is Artin-Schelter regular, we call H a reflection Hopf algebra for A. We present some examples of such pairs (A, H). (Received July 17, 2017)

1131-16-280 **Ellen E. Kirkman*** (kirkman@wfu.edu), Box 7388 Reynolda Station, Department of Mathematics and Statistics, Wake Forest University, Winston-Salem, NC 27109, and **Kenneth Chan**, **Chelsea Walton** and **James J. Zhang**. *The McKay Correspondence for Semisimple Hopf Actions on Regular Graded Algebras.*

Let $\Bbbk$ be an algebraically closed field of characteristic zero. Let H be a semisimple Hopf algebra acting on an Artin-Schelter regular algebra A of dimension 2, where A is a graded H-module algebra, and the H action on A is inner faithful with trivial homological determinant. We extend many of the results of the classical McKay correspondence, when $A = \Bbbk[u, v]$ and G is a finite subgroup of $\mathrm{SL}_2(\Bbbk)$ acting on A naturally, to this non(co)commutative setting. (Received July 17, 2017)

1131-16-295 **Jason Gaddis**, **Ellen Kirkman** and **W. Frank Moore*** (moorewf@wfu.edu), 127 Manchester Hall, PO Box 7388, Winston-Salem, NC 27109, and **Robert Won**.
Auslander's Theorem for permutation actions on noncommutative algebras.

When $A = k[x_1, \ldots, x_n]$ and G is a small subgroup of $\mathrm{GL}_n(k)$, Auslander's Theorem says that the skew group algebra $A\#G$ is isomorphic to $\mathrm{End}_{A^G}(A)$ as graded algebras. We prove a generalization of Auslander's Theorem for permutation actions on (-1)-skew polynomial rings, (-1)-quantum Weyl algebras, three-dimensional Sklyanin algebras, and a certain homogeneous down-up algebra. We also show that certain fixed rings A^G are graded isolated singularities in the sense of Ueyama. (Received July 17, 2017)

1131-16-338 **Anne V. Shepler*** (ashepler@unt.edu). *Universal enveloping algebras of color Lie rings.*

We investigate some applications of deformation theory to color Lie rings, groups acting on quantum polynomial rings, graded affine Hecke algebras, and Poincaré-Birkhoff-Witt type theorems for quadratic algebras. (Received July 18, 2017)

1131-16-350 **César Galindo***, Universidad de los Andes, Bogotá, Colombia, and **Iván Angiono**.
Pointed finite tensor categories over abelian groups.

We give a characterization of finite pointed tensor categories obtained as de-equivariantizations of finite-dimensional pointed Hopf algebras over abelian groups only in terms of the (cohomology class of the) associator of the pointed part. As an application we prove that every coradically graded pointed finite braided tensor category is a de-equivariantization of a finite dimensional pointed Hopf algebras over an abelian group. (Received July 18, 2017)

1131-16-353 **Jesse S F Levitt***, USC Dornsife, Department of Mathematics, 3620 S. Vermont Ave., KAP 104, Los Angeles, CA 90089, and **Milen Yakimov**. *Rigidity of quadratic Poisson tori.*

We describe a rigidity theorem regarding the automorphism groups of completed quadratic Poisson tori in characteristic 0. It yields a method for the explicit computation of the automorphism groups of N-graded connected cluster algebras with respect to the Gekhtman-Shapiro-Vainshtein Poisson structure. As an example, we will describe the automorphism groups of the coordinate rings of the Schubert cells of all symmetrizable Kac-Moody groups whose flag varieties are given the standard Poisson structure. (Received July 18, 2017)

1131-16-360 **Olga Kharlampovich*** (okharlampovich@gmail.com), 317 E 111 st, apt 2c, New York, NY 10029, and **Alexei Miasnikov**. *What does a group algebra of a free group "know" about the group?*

We will show that the set of all free bases of a free group F is 0-definable in the group algebra $K(F)$ when K is an infinite field, the set of geodesics is definable, and many geometric properties of F are definable in $K(F)$. Therefore $K(F)$ "knows" some very important information about F. We will show that similar results hold for group algebras of limit groups. (Received July 18, 2017)

1131-16-361 **Johannes Flake*** (flake@math.rutgers.edu) and **Siddhartha Sahi**. *Dirac cohomology, Hopf–Hecke algebras and infinitesimal Cherednik algebras.*

Dirac operators and their cohomology have been used to study representations of different algebraic objects, including semisimple Lie groups and degenerate affine Hecke algebras. Looking for a common generalization, as suggested by Dan Barbasch and Siddhartha Sahi, we consider a class of PBW deformations with an orthogonality condition, which we call Hopf–Hecke algebras.

We will discuss results on the classification of Hopf–Hecke algebras, on the relation between Dirac cohomology and central characters in this general setting, and on the Dirac cohomology of infinitesimal Cherednik algebras of the general linear group as a new example. (Received July 18, 2017)

1131-16-415 **Sarah R. Bockting-Conrad*** (sarah.bockting@depaul.edu). *A decomposition between the split decompositions for a tridiagonal pair.*

Let A, A^* denote a tridiagonal pair over a finite dimensional vector space V. There are four mutually opposite flags on V which are naturally associated with the tridiagonal pair A, A^*. Using these mutually opposite flags, one can induce 12 different decompositions of the underlying vector space V. We are interested in the relationship between these 12 decompositions. Given a pair of decompositions with the same induced flag, we study the relationship between them by introducing an intermediate decomposition which has the same induced flag. The ultimate goal of this investigation is to be able to better relate decompositions which do not have the same induced flag. In this talk, we will discuss our findings related to the intermediate decompositions with special focus on the case when A, A^* is thin. (Received July 18, 2017)

17 ► Nonassociative rings and algebras

1131-17-161 **Weiqiang Wang*** (ww9c@virginia.edu). *Character formulae in exceptional super category $\mathcal{O}$.*

There are 3 simple exceptional Lie superalgebras over $\mathbb{C}$, that is, $D(2|1;a)$ depending on a complex parameter a, $G(3), F(3|1)$, and they appear as part of the classification of the so-called basic Lie superalgebras. In recent years, there has been conceptional Kazhdan-Lusztig type solutions to the irreducible character problem in the BGG category $\mathcal{O}$ for basic classical Lie superalgebras. In this talk, we shall describe the character formulae in the exceptional BGG category $\mathcal{O}$ for $D(2|1;a)$ and $G(3)$. This is joint work with Shun-Jen Cheng (Taipei). (Received July 12, 2017)

1131-17-170 **Ben D Johnson*** (bjohnson@math.umass.edu), Department of Mathematics and Statistics, University of Massachusetts, 710 N. Pleasant Street, Amherst, MA 01003, and **Eric N Sommers** (esommers@math.umass.edu), Department of Mathematics and Statistics, University of Massachusetts, 710 N. Pleasant Street, Amherst, MA 01003. *Equations for some nilpotent varieties.*

Given a simple complex Lie algebra, we want to understand the ideals defining its nilpotent varieties, which are the closures of its nilpotent orbits. It is a classic result of Kostant that the principal nilpotent variety is the nilpotent cone, whose defining ideal is generated by a complete set of fundamental invariants. A minimal generating set for the ideal of the subregular nilpotent variety was found by Broer by studying line bundles on the cotangent bundle of the flag variety. In this talk, which is joint work with Eric Sommers, we extend this result to find a minimal generating set for the ideal corresponding to any Richardson orbit induced from a parabolic subalgebra that is generated by orthogonal short simple roots. (Received July 13, 2017)

1131-17-176 **Matthew Lee*** (mlee@math.ucr.edu). *Global Weyl modules for non standard maximal parabolics of twisted Affinne lie algebras.*

In this talk we will discuss the structure of non standard maximal parabolics of twisted affine Lie algebras, global Weyl modules and the associated commutative associative algebra, $\mathbf{A}_\lambda$. Since the global Weyl modules associated with the standard maximal parabolics have found many applications the hope is that these non-standard maximal parabolics will lead to different, but equally interesting applications. (Received July 13, 2017)

1131-17-196 **Elena Poletaeva*** (elena.poletaeva@utrgv.edu). *On the finite W-algebra for Lie superalgebra Q(n).*

A finite W-algebra is a certain associative algebra attached to a pair (g, e), where g is a classical Lie superalgebra and $e \in g$ is an even nilpotent element.

J. Brown, J. Brundan and S. Goodwin described finite W-algebras for $gl(m|n)$ associated to even regular nilpotent e as truncations of shifted super-Yangians of $gl(1|1)$.

We study the finite W-algebra for the queer Lie superalgebra $Q(n)$ associated with non-regular even nilpotent coadjoint orbits in the case when the corresponding nilpotent element has Jordan blocks each of size l. We prove that this finite W-algebra is isomorphic to a quotient of the super-Yangian of $Q(\frac{n}{l})$.

It is a joint work with V. Serganova. (Received July 14, 2017)

1131-17-215 **Michael Reeks*** (mar3nf@virginia.edu) and **Can Oguz**. *Trace of the twisted Heisenberg algebra.*

Categorification is a process by which structures can be lifted to higher categorical levels, often revealing new information. The original structure can be recovered through an inverse process, decategorification. Decategorification is typically accomplished by taking the Grothendieck group. Several recent works have shown that an alternative decategorification functor, the trace (or zeroth Hochschild homology), can reveal additional rich algebraic structures. In this talk, we shall describe the trace of a categorification of the twisted Heisenberg algebra and connect it to a certain infinite dimensional Lie algebra known as a W-algebra. (Received July 15, 2017)

1131-17-216 **Nicholas Davidson*** (ndavidson@math.ou.edu). *Categorical Actions and Supercategory $\mathcal{O}$.*

I will discuss some recent work using techniques from categorification and higher representation theory in order to study the BGG (super)category $\mathcal{O}$ associated to the Lie superalgebra $\mathfrak{q}_n(\mathbb{C})$. (Received July 15, 2017)

1131-17-234 **Bojko Bakalov*** (bojko_bakalov@ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695, and **McKay Sullivan** (mckay.sullivan@dixie.edu), Department of Mathematics, Dixie State University, Saint George, UT 84770. *Twisted logarithmic modules of lattice vertex algebras.*

Twisted modules over vertex algebras formalize the relations among twisted vertex operators and have applications to conformal field theory and representation theory. A recent generalization, called twisted logarithmic module, involves the logarithm of the formal variable and is related to logarithmic conformal field theory. We investigate twisted logarithmic modules of lattice vertex algebras, reducing their classification to the classification of modules over a certain group. This group is a semidirect product of a Heisenberg group and a central extension of the additive group of the lattice. (Received July 16, 2017)

1131-17-339 **Vera Serganova*** (serganov@math.berkeley.edu), Department of Mathematics, UC Berkeley, Berkeley, CA 94720, and **Ivan Penkov**. *On a certain version of category O for direct limit Lie algebras.* Preliminary report.

We will define an analogue of Bernstein-Gelfand-Gelfand category O for infinite-dimensional Lie algebras of infinite rank, for example sl(infinity) and discuss analogue of Kazhdan-Lusztig theory in this case. (Received July 18, 2017)

1131-17-352 **Elizabeth G Jurisich*** (jurisiche@cofc.edu). *On the representation theory of three-point algebras.*

The three-point algebra is perhaps the simplest nontrivial example of a Krichever-Novikov algebra beyond an affine Kac-Moody algebra. Even though the three-point algebras are not graded by root lattices, nor are they **Z**-graded, they can be given a coordinatization. This coordinatization allows a generalization of field or vertex operator type representations to be constructed. We provide a natural free field realizations in terms of a beta-gamma system and the oscillator algebra of the three-point an affine Lie algebra when g = sl(2, C). In addition, one can construct central extensions of an N-point generalization of the Witt algebra, and a corresponding representation on the Fock space. (Received July 18, 2017)

1131-17-418 **Ben L Cox*** (coxbl@cofcedu), Charleston, SC 29401. *On the module structure of the center of certain hyperelliptic Krichever-Novikov algebras.* Preliminary report.

Let $\mathfrak{g}$ denote a finite dimensional simple complex Lie algebra and R a commutative algebra over $\mathbb{C}$. It is well known the universal central extention of $\mathfrak{g} \otimes R$ has center Ω/dR, the space of Kähler differentials modulo exact forms. The automorphism group of R acts on this center and for a particular family of hyperelliptic curves R we describe how the center decomposes into a sum of irreducible representations. In this description certain families of recursively defined polynomials appear that arise from hyperelliptic integrals. This is joint work with Mee Seong Im. (Received July 18, 2017)

18 ► Category theory; homological algebra

1131-18-189 **Kent Barton Vashaw*** (kvasha1@lsu.edu). *The Prime Spectra of 2-Categories.*

We describe a general theory of prime, completely prime, semiprime, and primitive ideals of (abelian) 2-categories and the positive parts of $\mathbb{Z}_+$-rings. On the one hand, these notions provide a bridge between prime spectra of noncommutative rings and total positivity. On the other hand, they lead to a natural set of integrality conditions under which a quotient algebra by a prime ideal is categorifiable. As an application of the general theory we obtain monoidal categorifications of the quantization of coordinate rings of Richardson varieties for arbitrary symmetric Kac-Moody algebras. This is a joint work with Milen Yakimov. (Received July 14, 2017)

1131-18-193 **Eric Carson Rowell*** (rowell@math.tamu.edu). *Metaplectic Modular Categories.*

I will discuss recent joint work on so-called metaplectic modular categories: those with the same fusion rules as the categories $SO(N)_2$ constructed from quantum groups of types B and D at certain roots of unity. We have a complete classification of these categories and can prove that the associated braid group representations have finite image. See ArXiv: 1401.5329 (Quantum Topol. 2017), 1601.05460 (J. Algebra 2016) and 1609.04896 (Proc. AMS, to appear). (Received July 14, 2017)

1131-18-224 **Rina Anno*** (ranno@ksu.edu), Department of Mathematics, Kansas State University, 138 Cardwell Hall, Manhattan, KS 66506, and **Timothy Logvinenko**. *Bar categories of modules.*

Given a DG-category A we introduce the *bar category of modules* over A. It is a DG-enhancement of the derived category $D(Mod-A)$ which is isomorphic to the category of DG A-modules with A_∞-morphisms between them. However, it is defined intrinsically in the language of DG-categories and requires no complex machinery or sign conventions of A_∞-categories.

The intended application is working with DG-bimodules as enhancements of exact functors between triangulated categories. In particular, using bar categories allows us to construct explicitly homotopy adjunctions lifting pairs of adjoint exact functors and prove the existence of natural Postnikov towers for certain differential complexes of exact functors. Such techniques can be instrumental in working with categorical representations of Lie algebras since pairs of adjoint functors arise naturally there. (joint work with T. Logvinenko) (Received July 15, 2017)

1131-18-233 **Julia Plavnik*** (julia@math.tamu.edu), Department of Mathematics Mailstop 3368, Texas A&M University, College Station, TX 77843, and **Sara Witherspoon**. *Projectivity of tensor products for some Hopf algebras.*

In this talk, we will pose some questions of projectivity and tensor products of modules for finite dimensional Hopf algebras. To give some answers to these questions, we will construct some examples coming from smash copropucts of Sweedler Hopf algebras. One of the fundamental tools that we use to understand the modules of these Hopf algebras is the theory of support varieties. If time allows, we will mention the definition and some of the main properties of the support varieties for these examples. (Received July 16, 2017)

1131-18-385 **Paul P Gustafson*** (pgustafs@math.tamu.edu). *On the Property F Conjecture.* Preliminary report.

A braided fusion category has Property F if all associated braid group representations have finite image. Rowell's Property F conjecture states that Property F is equivalent to weak integrality, i.e. that the Frobenius-Perron dimension of the category is an integer. In this talk, I will outline recent progress on the Property F conjecture, including progress on a version of the conjecture for arbitrary mapping class groups. In particular, I will show that any twisted Dijkgraaf-Witten representation of a mapping class group of an orientable, compact surface with boundary has finite image. I will also discuss efforts to prove Property F for metaplectic modular categories. (Received July 18, 2017)

20 ► Group theory and generalizations

1131-20-38 **Majid Butler**, McDonogh 35 High School, 4000 Cadillac St, New Orleans, LA 70122, **Sandernisha Claiborne**, McDonogh 35 High School, 4000 Cadillac St, New Orleans, LA 70122, **Tomme Denney** (margolinr@bloomberg.net), McDonogh 35 High School, 4000 Cadillac St, New Orleans, LA 70122, **De'Janeke Johnson**, McDonogh 35 High School, 4000 Cadillac St, New Orleans, LA 70116, and **Tianna Robinson*** (margolinr@bloomberg.net), McDonogh 35 High School, 4000 Cadillac St, New Orleans, LA 70116. *The Unknown Subgroup of W(E_8).*

Nearly all the maximal subgroups of W(E_8) have been described–all except $2A_9$. We will provide several descriptions of $2A_9$, and two of them are especially simple: $2A_9$ permutes nine scale copies of E_8 generated by the $9{\cdot}240 = 2160$ norm 4 vectors; and $2A_9$ partitions the 135 isotropic points of $E_8/2E_8$ into nine disjoint isotropic 4-spaces of 15 points each (so the isomorphism $A_8 \cong L_4(2)$ is visible within E_8.)

Finally, we will describe some of the new combinatorial structure that $2A_9$ brings to E_8. (Received July 17, 2017)

1131-20-43 **Gordon Brown*** (gbrown@math.ou.edu). *Webs for spin permutation modules.* Preliminary report.

Webs are a type of diagram introduced by Kuperberg in the 1990s to describe intertwiners between certain modules of Lie algebras. In this talk, I will discuss how one can present the idempotented version of the Schur algebra (due to Doty-Giaquinto) in terms of webs, which in turn translates the intertwiners between permutation modules M^λ of the symmetric group into webs. I will then briefly describe how the same idea can be used to produce webs for a spin (projective) analog of M^λ. (Received June 21, 2017)

1131-20-75 **Rigoberto Florez*** (rflorez1@citadel.edu), 171 Moultri St., Department of Mathematics, Charleston, SC 29409. *Projective Rectangles.* Preliminary report.

A *projective rectangle* (PR) is a generalization of the projective plane concept. The elements of this incidence structure are called points and lines. There is a special point and the lines containing the special point are called special. A projective plane is a familiar example of a PP. In this case any point can play the role of special. However, in a more general case there is a unique special point, as well special lines and parallel lines. This is a work in progress.

In this talk we discuss an axiomatization of PR. We give examples and some of its properties. We also present some connections with graphs, biased graphs and harmonic matroids. (Received July 03, 2017)

1131-20-159 **Alexander Olshanskii*** (alexander.olshanskiy@vanderbilt.edu), 1326 Stevenson Center, Nashville, TN 37240. *On the growth rates of Dehn functions of finitely presented groups.* Preliminary report.

Dehn functions of finitely presented groups are closely related to isoperimetric functions of simply connected Riemannian manifolds. The minimal non-decreasing function $f\colon \mathbf{N} \to \mathbf{N}$ such that every word w vanishing in a group $G = \langle A \mid R\rangle$ and having length at most n is freely equal to a product of at most $f(n)$ conjugates of relators from $R^{\pm 1}$, is called the *isoperimetric or Dehn function* of the presentation $G = \langle A \mid R\rangle$. The author will discuss the asymptotic behavior of Dehn functions and give a more complete formulation of a result published by M.Sapir, J.-C. Birget and E.Rips in 2002. (Received July 12, 2017)

1131-20-167 **Arman Darbinyan*** (arman.darbinyan@vanderbilt.edu). *Word and Conjugacy Problems in Lacunary Hyperbolic Groups.*

In my talk I will discuss word and conjugacy problems in lacunary hyperbolic groups (LHG). In particular, I will discuss general framework and its applications which allowed us to construct lacunary hyperbolic groups with word and conjugacy problems highly controllable both in terms of computability and computational complexity.

As an application, we are able, to construct versions of well-known 'monster' groups with 'almost' linear time word and polynomial time conjugacy problems.

As another application, we show that for any recursively enumerable subset $\mathcal{L} \subseteq \mathcal{A}^*$, where $\mathcal{A}^*$ is the set of words over arbitrarily chosen non-empty finite alphabet $\mathcal{A}$, there exists a LHG $G_{\mathcal{L}}$ such that the membership problem for $\mathcal{L}$ is 'almost' linear time equivalent to the conjugacy problem in $G_{\mathcal{L}}$. Moreover, for the mentioned group the word and individual conjugacy problems are decidable in 'almost' linear time.

Yet another application is the construction of a LHG with 'almost' linear time word problem and with all the individual conjugacy problems being undecidable except the word problem.

Finally, as a consequence of the main results, we are able to answer several open questions. (Received July 12, 2017)

1131-20-219 **Chris McDaniel*** (cmcdanie@endicott.edu). *A GKM description of the equivariant coinvariant ring of a finite reflection group.*

The equivariant cohomology ring of a flag manifold can be described in terms of the invariant theory of the associated Weyl group–this is the so-called equivariant coinvariant ring. GKM theory gives an alternative description of the equivariant cohomology ring in terms the torus orbit structure on the flag manifold. In this talk I will describe an algebraic analogue of GKM theory for the equivariant coinvariant ring of an arbitrary finite reflection group. (Received July 15, 2017)

1131-20-244 **Susan Hermiller*** (hermiller@unl.edu) and **Zoran Sunic**. *No positive cone in a free product is regular.* Preliminary report.

We show that there exists no left order on the free product of two nontrivial, finitely generated, left-orderable groups such that the corresponding positive cone is represented by a regular language. Since there are orders on free groups of rank at least two with positive cone languages that are context-free (in fact, 1-counter languages), our result provides a bound on the language complexity of positive cones in free products that is the best possible within the Chomsky hierarchy. It also provides a strengthening of a result by Cristóbal Rivas stating that the positive cone in a free product of nontrivial, finitely generated, left-orderable groups cannot be finitely generated as a semigroup. (Received July 16, 2017)

1131-20-268 **Nathan Corwin**, **Gili Golan**, **Susan Hermiller**, **Ashley Johnson*** (ajohnson18@una.edu) and **Zoran Sunic**. *Autostackability of Thompson's Group F.* Preliminary report.

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. This talk will present an overview

of autostackable groups and discuss an autostackable structure for Thompson's Group F. (Received July 17, 2017)

1131-20-287 **Ines Klimann*** (klimann@irif.fr), IRIF, Univ Paris Diderot & CNRS, Case 7014, 75205 Paris cedex 13, France, and **Thibault Godin**. *On bireversible Mealy automata and the Burnside problem.*

There exist undoubtedly strong links between the Burnside problem and the class of automaton groups. Indeed, many interesting examples of infinite Burnside groups are automaton groups, in particular the simplest one, the Grigorchuk group, arises in this class. However there is no known example of such a group generated by a reversible Mealy automaton.

In this talk I will explain why a connected reversible Mealy automaton of prime size cannot generate an infinite Burnside group. (Received July 17, 2017)

1131-20-293 **Drew E. Tomlin*** (dtillis@gmail.com) and **J. Matthew Douglass** (mdouglas@nsf.gov). *Using descent algebras to compute cohomology.*

The cohomology of the complement of a type A hyperplane arrangement affords a representation of the symmetric group. In this talk, I will discuss how that representation can be computed using the descent algebra of the symmetric group. Moreover, I will mention progress toward computing the cohomology of the complement of a type B hyperplane arrangement using a generalization of the descent algebra for the hyperoctahedral group. (Received July 17, 2017)

1131-20-311 **Robin Tucker-Drob*** (rtuckerd@math.tamu.edu), Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Approximations of standard equivalence relations and Bernoulli percolation at the uniqueness threshold.*

I will discuss approximation of equivalence relations by subrelations, with applications to the behavior of the Bernoulli percolation on Cayley graphs at the uniqueness threshold. This is joint work with Damien Gaboriau. (Received July 17, 2017)

1131-20-347 **Rachel Skipper*** (skipper@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University, PO Box 6000, Binghamton, NY 13902-6000. *The congruence subgroup problem for a family of branch groups.*

A group acting on a spherically homogeneous rooted tree has the congruence subgroup property if every subgroup of finite index contains a level stabilizer. The congruence subgroup problem then asks to quantitatively describe the kernel of the surjection from the profinite completion to the topological closure as a subgroup of the automorphism group of the tree.

We will study the congruence subgroup property for a family of branch groups whose construction generalizes that of the Hanoi Towers group, which models the game "The Towers of Hanoi". (Received July 18, 2017)

1131-20-369 **Krystofer Baker** and **Dmytro M Savchuk*** (savchuk@usf.edu), 4204 E Fowler ave, CMC 342, Dept of Math and Stats, USF, Tampa, FL 33620. *Explicit finite generating sets of the stabilizers of rational numbers in Thompson's group F.*

We construct explicit finite generating sets for the stabilizers of rational numbers under the standard action of Thompson's group F on $[0,1]$. Thus we partially give an alternative proof of the result of Golan and Sapir who, in particular, proved that these subgroups are finitely generated. However, the obtained generating sets turned out to be much simpler. (Received July 18, 2017)

1131-20-372 **Said Najati Sidki*** (ssidki@gmail.com), Brasilia, Brazil. *On finitely presented self-similar groups.*

We construct new classes of self-similar groups via virtual endomorphisms : S-aritmetic groups, affine groups and metabelian group. Most of the soluble ones are finitely presented and of type FP_n for an appropriate n. This is joint work with Dessislava Kochloukova. (Received July 18, 2017)

1131-20-382 **Tsachik Gelander**, **Gili Golan*** (gili.golan@vanderbilt.edu) and **Kate Juschenko**. *Invariable generation of Thompson groups.*

A subset S of a group G invariably generates G if for every choice of $g(s) \in G$, $s \in S$ the set $\{s^{g(s)} : s \in S\}$ generates G. We say that a group G is invariably generated if such S exists, or equivalently if $S = G$ invariably generates G. In this paper, we study invariable generation of Thompson groups. We show that Thompson group F is invariable generated by a finite set, whereas Thompson groups T and V are not invariable generated. (Received July 18, 2017)

1131-20-388 **Jacob P. Matherne*** (matherne@math.umass.edu). *Derived geometric Satake equivalence, Springer correspondence, and small representations.*

A recurring theme in geometric representation theory is the ability to describe representations in terms of the geometry or topology of certain spaces. Two major theorems in this area are the geometric Satake equivalence and the Springer correspondence, which state:

(1) For G a semisimple algebraic group, we can realize $\mathrm{Rep}(G)$ using intersection cohomology of the affine Grassmannian for the Langlands dual group.

(2) For W a Weyl group, we can realize $\mathrm{Rep}(W)$ using intersection cohomology of the nilpotent cone.

In the late 90s, M. Reeder computed the Weyl group action on the zero weight space of the irreducible representations of G, thereby relating $\mathrm{Rep}(G)$ to $\mathrm{Rep}(W)$. More recently, P. Achar, A. Henderson, and S. Riche established a functorial relationship between the two phenomena above. In my talk, I will review this story and discuss a result which extends their functorial relationship to the setting of mixed, derived categories. (Received July 18, 2017)

1131-20-401 **Andrew Penland*** (adpenland@email.wcu.edu). *Finitely Constrained Groups of Small Hausdorff Dimension.*

Grigorchuk introduced the notion of *groups of finite type*: profinite topological groups of tree automorphisms defined by sets of local *allowed patterns*. One application of groups of finite type is the construction of concrete examples whose Hausdorff dimension is easily calculated. Groups of finite type are also called finitely constrained groups. Known families of finitely constrained groups, including those due to Sunik and Bartholdi & Nekrashevych, have Hausdorff dimension approaching 1 as the pattern size groups. We construct an infinite family of topologically finitely generated, finitely constrained groups of binary tree automorphisms. These groups have a combinatorial structure inspired by the Grigorchuk group, and they all have Hausdorff dimension less than 1/2. (Received July 18, 2017)

1131-20-404 **Volodymyr Nekrashevych*** (nekrash@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843. *Simple groups of intermediate growth.*

I will describe a new class of torsion groups of intermediate growth. They are constructed by deforming minimal actions of dihedral groups. The class contains both residually finite and simple groups. (Received July 18, 2017)

1131-20-406 **David Carroll**, **Benjamin Francisco** and **Zoran Sunic***, Department of Mathematics, Roosevelt Hall, Hofstra University, Hempstead, NY 11549-0114. *Deciding if a right-angled Artin group is free-by-free is an NP-complete problem.* Preliminary report.

We show that deciding if a right-angled Artin group is free-by-free is an NP-complete problem. The work is based on an earlier result by Susan Hermiller and the third author stating that the right-angled Artin group $A\Gamma$ defined by the graph Γ is free-by-free if and only if Γ is 2-breakable (a graph Γ is 2-brekable if there exists an independent set D of vertices in Γ such that every cycle in Γ contains as least two vertices from D). We reduce the 3SAT Problem to the problem of deciding if a given graph is 2-breakable (in fact, k-breakable, for any fixed $k \geq 1$).

This is a joint work with David Carroll and Benjamin Francisco. (Received July 18, 2017)

22 ► Topological groups, Lie groups

1131-22-182 **Markus Hunziker*** (markus_hunziker@baylor.edu). *Posets, classical invariant theory, and highest weight Harish-Chandra modules.* Preliminary report.

In this expository talk, I will explain how certain posets associated to cominuscule flag varieties play a central role in the solution of several old problems in classical invariant theory and representation theory. (Received July 14, 2017)

1131-22-241 **Laura Escobar*** (lescobar@illinois.edu), Urbana, IL 61801, and **Benjamin J. Wyser** and **Alexander Yong**. *K-orbit closures and Barbasch-Evens-Magyar Varieties.* Preliminary report.

We define the Barbasch-Evens-Magyar varieties as a fiber product of certain flag varieties. They are isomorphic to the manifolds of D. Barbasch-S. Evens, which provide desingularizations of symmetric orbit closures. This parallels P. Magyar's description of the Bott-Samelson variety. We analyze the moment polytope, which we

connect to the moment polytope of a Bott-Samelson variety. Joint work with Benjamin J. Wyser and Alexander Yong (Received July 16, 2017)

1131-22-304 **David Armour** and **Markus Hunziker*** (markus_hunziker@baylor.edu). *Category O, Howe duality, and a wonderful correspondence for Cohen–Macaulay modules of covariants.* Preliminary report.

We introduce a new notion—similarity of blocks—in parabolic category O. We then illustrate the usefulness of this notion in the context of Howe duality. Our main result is an explicit bijective correspondence in classical dual pair settings between the set of modules of covariants that are Cohen–Macaulay and a distinguished set of finite-dimensional representations of a related Lie group. (Received July 17, 2017)

1131-22-349 **Roger Zierau*** (roger.zierau@okstate.edu). *Computing Associated Cycles.* Preliminary report.

Associated cycles of Harish-Chandra modules play an important role in the representation theory of real reductive Lie groups. Suppose $G_{\mathbb{R}}$ is a real form of a complex reductive group G and K is the complexification of a maximal compact subgroup of $G_{\mathbb{R}}$. The associated cycle gives, in some sense, an asymptotic measure of the K-types of a Harish-Chandra module, it also gives information about the global character of an admissible representation of $G_{\mathbb{R}}$. The associated cycle is of the form

$$AC(X) = \sum m_{\mathcal{O}} \cdot \overline{\mathcal{O}},$$

where the $\mathcal{O}$ are nilpotent K-orbits in $(\mathfrak{g}/\mathfrak{k})^*$ and the $m_{\mathcal{O}}$ are nonnegative integers. This lecture will discuss methods to compute the associated cycle. The eventual goal is a general algorithm. Examples will be given. (Received July 18, 2017)

1131-22-370 **Michael P Cohen*** (michael.cohen@ndsu.edu), 1600 Edmund Ave, St Paul, MN 55104. *On the large-scale geometry of diffeomorphism groups of* 1*-manifolds.*

I'll introduce a relatively new area of research advanced by Rosendal: the coarse geometry of topological groups, which unifies and generalizes the classical fields of geometric group theory of countable groups, and coarse geometry of Banach spaces. I'll define the notion of coarse boundedness, and characterize this property in the special context of the C^k-diffeomorphism groups of one-dimensional compact manifolds (the interval and the circle). For $k = 1$, our characterization implies that the diffeomorphism group is coarsely equivalent, via a natural mapping, to the classical space $C[0, 1]$. I'll pose some questions and open problems in this area. (Received July 18, 2017)

1131-22-374 **Laura Rider*** (laurajoy@uga.edu), Athens, GA 30601, and **Amber Russell**. *Formality for the nilpotent cone and the generalized Springer correspondence.* Preliminary report.

The Springer correspondence attaches to each irreducible representation of the Weyl group some geometric information (in the form of perverse sheaves) from the nilpotent cone. In my talk, I'll give a brief introduction to the Springer correspondence, and then explain mixed/derived versions of the correspondence. As time allows, I'll also discuss Lusztig's generalized Springer correspondence and recent progress towards mixed/derived versions of the generalized Springer correspondence. (Received July 18, 2017)

26 ► Real functions

1131-26-61 **Pieter C Allaart*** (allaart@unt.edu), Mathematics Department, 1155 Union Cir #311430, Denton, TX 76203-5017. *Differentiability and Hölder regularity of a class of self-affine functions.*

In 1973, P. Lax published a surprising theorem about the differentiability of Pólya's space-filling curve. In 2006, H. Okamoto introduced a very different one-parameter family of functions, whose differentiability structure is nonetheless quite similar to that of the Pólya curve. In this talk I will introduce a large class of self-affine functions that includes both of the above examples. I will present a common generalization of Lax' and Okamoto's theorems, and give the pointwise Hölder (or multifractal) spectrum of functions in this class. (Received June 29, 2017)

28 ► Measure and integration

1131-28-17 **Victor M. Bogdan** and **Andrew E Bogdan*** (andrewebogdan@gmail.com). *Theory of Dirac Integral Spaces, derivation of ket and bra spaces as Hilbert spaces, relations to the theory of Lebesgue integral spaces.*

Let C be the space of complex numbers. A system $(X, F(C), M(C), L(C), \int, L_0(C))$ will be called a **Dirac Integral Space** if the following conditions are satisfied. (1) X is any abstract set. (2) $F = \{f | f : X \mapsto C\}$. (3) The subset $M \subset F$ has the property $(f_n \in M,\ f_n(x) \to f(x)\ \forall x \in X) \Rightarrow f \in M,)$ and is closed under composition with continuous functions $u : C^m \mapsto C$. i.e $(f_j \in M,\ f(x) = u(f_1(x), \ldots, f_m(x))\ \forall x \in X) \Rightarrow f \in M$. Since the map $u(z) = |z|$ is continuous, we have $|f| \in M\ \forall f \in M$ where $|f|(x) = |f(x)|\ \forall x \in X$. (4) The set $L \subset M$ is linear and it is **solid** in M, that is, if $g \in M$ and $f \in L$ and $|g| \leq |f|$, then $g \in L$. (5) The functional $\int : L \mapsto C$ is linear and $\int f \geq 0$, if $f = |f|$, and for every series with terms $f_n \in L$ such that $\sum_n \int |f_n| < \infty$ and $\sum_n |f_n(x)| < \infty \forall x \in X$ and $f(x) = \sum_n f_n(x)\ \forall x \in X$, we have $f \in L$ and $\int f = \sum_n \int f_n$. (6) The set $L_0 = \{f \in L :\ \int |f| = 0\}$ is solid in the space F of all functions.

Using the above axioms, we will develop the theory of such spaces and prove that P.A.M. Dirac's ket space is a Hilbert space. (Received June 21, 2017)

1131-28-26 **Victor Michael Bogdan*** (vmbogdan@gmail.com), 6652 Plaza Via, Apt 109, Irving, TX 75039. *An elementary approach to the Theory of Lebesgue and Dirac Integral Spaces.*

P. Dirac in *Principles of Quantum Mechanics*, published in 1930, employed intuitive concept of integrals involving complex-valued functions to describe the evolution of dynamical systems of Quantum Mechanics in probabilistic terms. A. Kolmogorov using the *Lebesgue Integration Theory* proved the *Strong Law of Large Numbers* and thus put the *Theory of Probability and Statistics* on a precise mathematical footing.

We shall present a system of axioms involving only elementary notions of set theory, limits, and continuous functions, to define Dirac and Lebesgue integral spaces as a quintuple $(F(Y), M(Y), L(Y), \int, L_0(Y))$, where Y is either C or R, from which one can derive the entire theory of such spaces, (see a note by A. Bogdan and V. Bogdan in these Notices for definition.)

We shall outline the development of the theory of such spaces and present their construction based on the results of the following two papers: W. Bogdanowicz, *A generalization of the Lebesgue-Bochner-Stieltjes integral and a new approach to the theory of integration,* Proc. Nat. Acad. Sci. USA 53 (1965): 492-498; W. Bogdanowicz, *An approach to the theory of Lebesgue-Bochner measurable functions and to the theory of measure,* Mathematische Annalen 164 (1966):251-269. (Received May 23, 2017)

1131-28-213 **Monica Torres*** (torres@math.purdue.edu), 150 N. University St., West Lafayette, IN 47907. *Gauss-Green formula for unbounded divergence-measure fields on open sets.*

Divergence-measure fields naturally appear in the field of nonlinear hyperbolic conservation laws. We obtain a Gauss-Green formula for unbounded divergence-measure fields on arbitrary open sets and their closures. The method, based on the use of distance function, allows to define the normal trace of the field as the limit of classical normal traces over smooth approximations of the given set. In the particular case of open sets with continuous boundary, one can explicitly characterize the approximating smooth sets using a regularized distance introduced by Lieberman. In addition, we show that any open set with Lipschitz boundary has indeed a Lipschitz deformable boundary in the sense of Chen-Frid, and that there exists always a regular deformation. This a joint work with Giovanni Comi and Gui-Qiang Chen. (Received July 15, 2017)

30 ► Functions of a complex variable

1131-30-22 **Mustapha Azkour*** (azkour.qmsi@gmail.com), 5 LT RIAD S/B GH3 ETG 4 APPT 28 CASABLANCA, Casablanca, Morocco. *Conjecture on the variations of the real & imaginary parts of the complex Dirichlet eta function.*

The Riemann hypothesis is a conjecture formulated in 1859 by the German mathematician Bernhard Riemann. It says that the non-trivial zeros of the Riemann zeta function have all the real part 1/2. His demonstration would improve knowledge of the distribution of primes. This conjecture is one of the most important unresolved problems of mathematics of the early twentieth century: it is one of the seven problems of the millennium. After a hard work on Riemann's hypothesis I was able to formulate a new conjecture which speaks of the variations of the complex function eta of Dirichlet, and if my conjecture is true, then Riemann's hypothesis would also be true. (Received May 20, 2017)

1131-30-413 **Kourosh Tavakoli*** (ktavakoli@okcu.edu). *On the Limit Behavior of Complex Iterated Function Systems.*

In this talk I discuss the limit behavior of complex iterated function systems. Using several examples, I'll explain the possibilities for the limits of a class of complex iterated function systems. (Received July 18, 2017)

34 ► Ordinary differential equations

1131-34-146 **Luis García Puente**, **Elizabeth Gross**, **Heather A. Harrington**, **Nicolette Meshkat** and **Anne Shiu*** (annejls@math.tamu.edu). *Identifiability of linear compartment models: the singular locus.*

This talk addresses the problem of parameter identifiability – that is, the question of whether parameters can be recovered from data – for linear compartment models. Using standard differential algebra techniques, the question of whether such a model is (generically, locally) identifiable is equivalent to asking whether the Jacobian matrix of a certain coefficient map, arising from input-output equations, is generically full rank. A formula for these input-output equations was given recently by Meshkat, Sullivant, and Eisenberg. Here we build on their results by giving a formula for the resulting coefficient maps. This formula is in terms of acyclic subgraphs of the directed graph underlying the linear compartment model. As an application, we prove that two families of linear compartment models – cycle and mammillary (star) models – are identifiable. We accomplish this by determining the defining equation for the singular locus of non-identifiable parameters. Our work helps to shed light on the open question of which linear compartment models are identifiable. (Received July 11, 2017)

1131-34-223 **Yunjiao Wang*** (wangyx@tsu.edu), 3100 Cleburne, Houston, TX 77004. *Dynamics of Coupled Feedback Loops.* Preliminary report.

Feedback loops are common motifs in biological systems. While the dynamics of a single feedback loop have been extensively studied and well understood, our knowledge on relations between the network structure of coupled feedback loops and their dynamics is very limited. In this talk, we will discuss the dynamics of certain classes of coupled feedback loops and shed light on possible relations. (Received July 15, 2017)

35 ► Partial differential equations

1131-35-32 **Joseph A. Iaia*** (iaia@unt.edu), University of North Texas, 1155 Union Circle, P.O. Box 311430, Denton, TX 76203. *Solutions of semilinear equations on exterior domains.* Preliminary report.

We prove the existence of radial solutions of $\Delta u + K(r)f(u) = 0$ such that $\lim_{r\to\infty} u(r) = 0$ on the exterior of the ball of radius $R > 0$ centered at the origin in $\mathbb{R}^N$ where f is odd with $f < 0$ on $(0, \beta)$, $f > 0$ on (β, ∞) and $K(r) \sim r^{-\alpha}$. We examine the cases when $0 < \alpha < 2(N-1)$ and $\alpha > 2(N-1)$ and also when f is superlinear, sublinear, and bounded. (Received June 06, 2017)

1131-35-33 **Janak R Joshi*** (janakrajjoshi@my.unt.edu), 2401 West Prairie st. Apt#1, Denton, TX 76201. *Existence and Nonexistence of Solutions for Sublinear Problems with Prescribed Number of Zeros on Exterior Domains.*

We prove existence of radial solutions of $\Delta u + K(r)f(u) = 0$ on the exterior of the ball of radius R centered at the origin in $\mathbb{R}^N$ such that $\lim_{r\to\infty} u(r) = 0$ if $R > 0$ is sufficiently small. We assume $f : \mathbb{R} \to \mathbb{R}$ is odd and there exists a $\beta > 0$ with $f < 0$ on $(0, \beta)$, $f > 0$ on (β, ∞) with f sublinear for large u, and $K(r) \sim r^{-\alpha}$ for large r with $\alpha > 2(N-1)$. We also prove nonexistence if $R > 0$ is sufficiently large. (Received June 08, 2017)

1131-35-35 **Jun Chen*** (chenjun@sustc.edu.cn), Department of Mathematics, Southern University of Science and Technology, No 1088,xueyuan Rd., Nanshan District, Shenzhen, Guangdong 518055, Peoples Rep of China. *Stability of transonic flows past a wedge.*

I will talk about the stability of transonic flows past a 2-D wedge governed by the full Euler equations. Given a piece-wise constant transonic flow past a straight wedge, if the incoming flow and the wedge are perturbed, there exists a unique subsonic solution in the downstream together with a perturbed shock in between. Corner singularity and asymptotic behavior of the subsonic flow are handled through elliptic estimates using weighted Hölder norms. The analysis discloses the relation between the shock polar and the regularity and asymptotic behavior of the downstream subsonic flow. (Received June 11, 2017)

1131-35-58 **Helge Kristian Jenssen** and **Charis Tsikkou*** (chtsikkou@mail.wvu.edu). *Radial solutions to the Cauchy problem for the wave equation as limits of exterior solutions.*

We consider the strategy of realizing the solution of a Cauchy problem (CP) with radial data as a limit of radial solutions to initial-boundary value problems posed on the exterior of vanishing balls centered at the origin. The goal is to gauge the effectiveness of this approach in a simple, concrete setting: the three-dimensional (3d), linear wave equation with radial Cauchy data. We are primarily interested in this as a model situation for other, possibly nonlinear, equations where neither formulae nor abstract existence results are available for the radial symmetric CP. In treating the 3d wave equation we therefore insist on robust arguments based on energy methods and strong convergence. Our findings show that while one can obtain existence of radial Cauchy solutions via exterior solutions, one should not expect such results to be optimal. We also show that external Neumann solutions yield better regularity than external Dirichlet solutions. (Received June 29, 2017)

1131-35-65 **Pierre-Emmanuel Jabin** and **Zhenfu Wang*** (zhenfuwangnju@gmail.com). *Quantitative estimates of propagation of chaos for stochastic systems with $W^{-1,\infty}$ kernels.*

We derive quantitative estimates proving the propagation of chaos for large stochastic systems of interacting particles. We obtain explicit bounds on the relative entropy between the joint law of the particles and the tensorized law at the limit. We have to develop for this new laws of large numbers at the exponential scale. But our result only requires very weak regularity on the interaction kernel in the negative Sobolev space $\dot{W}^{-1,\infty}$, thus including the Biot-Savart law and the point vortices dynamics for the 2d incompressible Navier-Stokes. Joint work with P.E. Jabin (Received June 30, 2017)

1131-35-67 **Thomas A Ivey*** (iveyt@cofc.edu), Department of Mathematics, College of Charleston, and **Jeanne Clelland**, Department of Mathematics, University of Colorado, Boulder. *Toward a classification of Bäcklund transformations of sine-Gordon type.* Preliminary report.

We consider the problem of classifying Backlund transformations between pairs of second-order PDEs for one function of two variables, assuming that the equations are wavelike and autonomous, i.e., of the form

$$u_{xy} = f(u, u_x, u_y), \qquad v_{xy} = g(v, v_x, v_y),$$

and the transformation is quasilinear, i.e., of the form

$$u_x = F_1(u, v)v_x + F_0(u, v), \qquad v_y = G_1(u, v)u_y + G_0(u, v).$$

The condition that these equations take solutions of one equation to solutions of the other leads to an overdetermined PDE system for the coefficients F_0, F_1, G_0, G_1.

The analysis of this system is quite complicated, branching into several cases depending on the functional dependence of F_1 and G_1. The sine-Gordon transformation belongs to the branch where these are both constant; at the other extreme, when F_1 and G_1 are functionally independent, we have discovered what appears to be a new example of a PDE possessing a 1-parameter family of auto-Bäcklund transformations (i.e., transformations that take solutions to solutions for the same PDE). Such transformations are typical of completely integrable PDE, and we explore the question of whether this equation enjoys additional features associated with integrability. (Received June 30, 2017)

1131-35-85 **Jonathan Bell*** (jbell@umbc.edu) and **S. Avdonin**. *Inverse Problems for Neuronal Cable Models on Graphs.*

For a parabolic equation defined on a tree graph domain, a dynamic Neumann-to-Dirichlet map associated with the boundary vertices can be used to recover the topology of the graph, length of the edges, and unknown coefficients and source terms in the equation. The motivation for this investigation is that the parabolic equation comes from a (linear) neuronal cable equation defined on the dendritic tree of a neuron, and the inverse problem concerns parameter identification of k unknown distributed conductance parameters. The talk is based on joint work with Sergei Avdonin (University of Alaska, Fairbanks, AK) (Received July 05, 2017)

1131-35-87 **Kazuo Yamazaki***, Department of Mathematics, University of Rochester, Rochester, NY 14620. *Recent developments on magnetohydrodynamics and related systems.*

This talk discusses some recent developments on the magnetohydrodynamics (MHD) and related systems for both deterministic and stochastic perspectives. The equations of interest include the MHD system, Navier-Stokes equations, micropolar and magneto-micropolar fluid systems, MHD-Hall system and Boussinesq system. The type of results to be discussed may include well-posedness and ergodicity, etc. (Received July 05, 2017)

1131-35-95 **John Holmes*** (holmes.782@osu.edu), Columbus, OH 43210. *A note on the compressible Euler equations.*

Local in time existence, uniqueness and continuous dependence on the initial data (Hadamard well-posedness) for the Cauchy problem for the compressible Euler equations is well known in Sobolev spaces, H^s, of high enough order. It is also known that global in time well-posedness fails for general initial data, and this failure is characterized by the "blow-up" of the gradient of the solution in the sup-norm. We further sharpen the well-posedness result by showing that the data–to–solution map for the compressible Euler equations is not better than continuous. In particular, we consider two families of solutions with smooth initial data which converge to each other in H^s, and we show that they remain bounded away from each other at any positive time. (Received July 06, 2017)

1131-35-102 **Lei Li*** (leili@math.duke.edu), 120 Science Drive, Durham, NC , and **Jian-Guo Liu**. *p-Euler equations and p-Navier-Stokes equations.*

We propose new systems of equations which we call p-Euler equations and p-Navier-Stokes equations. p-Euler equations are derived as the Euler-Lagrange equations for the action represented by the Benamou-Brenier characterization of Wasserstein-p distances, with incompressibility constraint. p-Euler equations have similar structures with the usual Euler equations but the 'momentum' is the signed $(p-1)$-th power of the velocity. By adding diffusion presented by γ-Laplacian of the velocity, we obtain what we call p-Navier-Stokes equations. We show the global existence of weak solutions for the p-Navier-Stokes equations in $\mathbb{R}^d$ for $\gamma = p$ and $p \geq d \geq 2$ through a compactness criterion. (Received July 07, 2017)

1131-35-106 **Geng Chen***, Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Recent progress on 1-d compressible Euler equations.*

The global-in-time existence of large BV solution for 1-d isentropic compressible Euler equations (p-system) is a long-standing open problem. It is reasonable to divide the problem into two sub-problems: How to find a time dependent lower bound on density for the solution, and how to find the global BV bound of the solution in $0 < t < T$ when we assume that the density is bounded away from zero in $0 < t < T$. In this talk, we will discuss the recent progress on both of these two problems. The talk includes joint work with Alberto Bressan and Qingtian Zhang. (Received July 07, 2017)

1131-35-107 **Cheng Yu*** (yucheng@math.utexas.edu), Austin, TX 78717. *Energy conservation for the fluid equations with variable density.*

In this talk, I will talk on the energy conservation for the compressible Navier-Stokes equations and the inhomogeneous Euler equations. (Received July 07, 2017)

1131-35-108 **Jiahong Wu*** (jiahong.wu@okstate.edu), Department of Mathematics, 401 Mathematical Sciences, Oklahoma State University, Stillwater, OK 74078. *Stability results for the 2D Boussinesq equations with partial dissipation.*

This talk presents three main results: first, the linear stability of the shear flow for the 2D incompressible Boussinesq equations with vertical dissipation (joint work with Lizheng Tao); second, the linear stability of a temperature equilibrium for the 2D Boussinesq equations with only velocity dissipation (joint work with Charles Doering, Kun Zhao and Xiaoming Zheng); and third, the linear stability of the 2D Boussinesq equations with only velocity dissipation near the shear flow and a temperature equilibrium. (Received July 07, 2017)

1131-35-109 **Jiahong Wu*** (jiahong.wu@okstate.edu), Department of Mathematics, 401 Mathematical Sciences, Oklahoma State University, Stillwater, OK 74078. *PDEs related to fluids with partial or fractional dissipation.*

There have been substantial recent developments on several partial differential equations from fluid dynamics with partial or fractional dissipation. This talk summarizes results on the global existence and regularity problem for the 3D Navier-Stokes equations with partial hyperdissipation, the surface quasi-geostrophic equation, the 2D Boussinesq equations with partial or fractional dissipation and the 2D magnetohydrodynamic equations with partial or fractional dissipation. (Received July 07, 2017)

1131-35-160 **Dat Cao***, Department of Mathematics and Statistics, Texas Tech University, Box 41042, Lubbock, TX 79409, **Akif Ibraguimov**, Department of Mathematics and Statistics, Texas Tech University, Box 41042, Lubbock, TX 79409, and **Alexander I. Nazarov**, St. Petersburg, Department of Steklov Institute, Fontanka 27, St.Petersburg, 19102, Russia. *Mixed boundary value problems for Degenerate elliptic equations at infinity.*

We study qualitative properties of the solutions of the Zaremba type problem in unbounded domain with respect to the degenerate elliptic equation at infinity in non-divergent form. Main result is Phragmén-Lindelöf type principle on growth and decay of the solution in the domain which is narrowing at infinity w.r.t. designated direction x_1. Equation is considered to be elliptic in the finite part of the domain but may be degenerate at infinity. Main result formulated in term of the so called s-capacity of the Dirichlet portion of the boundary, with Neumann boundary satisfying certain "admissibility" condition. (Received July 12, 2017)

1131-35-169 **Akif Ibragimov*** (akif.ibraguimov@ttu.edu), Lubbock, TX 79366, and **Alexander Grigoryan**, Bielefeld, Germany. *New Proof of Mazya's Criteria for Regularity of Zaremba Problem at Infinity.*

Paper dedicated to the Zaremba type problem in unbounded domain D, containing origin, with respect to operator $L = \nabla \cdot A(x) \cdot \nabla$ (Here $A(x)$ symmetric posittvly defined matrix with measurable coefficients). Main result is criteria of regularity at infinity, which first was proved by Mazya. We consider domain oriented along x_1 axis with "one exit" $x_1 \to +\infty$. Next we assumed that Neumann boundary $\Gamma_N$satisfies isoperimetric condition in each finite layer $\tau_j < x_1 < \tau_{j+1}$ uniformly. Then using methods developed by Landis , we proved criteria of regularity at infinity in term of relative potential of the portion of Dirthlet boundary $H_j = \Gamma_D \cap \{\tau_j < x_1 < \tau_{j+1}\}$. Let relative potential $U_j(x)$ defined as: $LU_j(x) = 0$ in D, $U_j(0) = 0$, $U_j|_{H_j} = 1$, $\frac{\partial U_j}{\partial \nu}|_{\Gamma_N} = 0$. Then for regularity at infinity of the solution of Zaremba's problem it is necessary and sufficient that

$$\lim_{N\to\infty} \lim_{x_1\to\infty} \sum_{j=1}^{N} U_j(x) = \infty.$$

(Received July 12, 2017)

1131-35-172 **Akif Ibragimov*** (akif.ibraguimov@ttu.edu) and **Vakhtang Purkadze**. *Asymptotic stability of the system of two sin-Gordon type equations.*

Time-infinity behavior of generalized system of sin-Gordon equations bounded domain for mixed boundary value boundary condition is investigated. System which model coupled pendulums class processes with diffusion has a form:

$$u_{tt} - \nabla \cdot D\nabla u + a \sin u = -A(u_t - v_t)$$
$$\epsilon(v_{tt} - \nabla \cdot D\nabla v + a \sin v) = -A(v_t - u_t)$$

For this system under some boundary condition Lyapounov type functional was constructed, and it was shown that for some constrain on initial Data this functional exponentially decay. For scalar equation similar problem studied by R.W. Dickey,(see SIAM, Vol.30,N0.2,pp 248-262.) (Received July 13, 2017)

1131-35-214 **Tam Do***, 3620 S. Vermont Ave, Los Angeles, CA 90089. *Vorticity Gradient Growth for the Axisymmetric 3D Euler Equations Without Swirl.* Preliminary report.

In the 2D Euler Equations, it is known that the L^∞ norm of the gradient of vorticity can grow at most double exponentially in time. This bound has been proven to be sharp in recent years by Kiselev and Sverak on the unit disc and extended by Xu to bounded domains with symmetry axis. We examine the possibility of gradient growth in the 3D axisymmetric setting in flows without swirl component. (Received July 15, 2017)

1131-35-220 **Du Pham*** (du.pham@utsa.edu), Mathematics Department, University of Texas at San Antonio, One UTSA Circle, San Antonio, TX 78249. *Existence and Uniqueness Results for Shigesada-Kawasaki-Teramoto Equations.*

In this talk, we present new results of existence and uniqueness of weak solutions to the Shigesada-Kawasaki-Teramoto (SKT) systems. The existence result is established using maximum principles, finite differences in time and compactness results. Our proof of uniqueness is accomplished using the adjoint problem argument. All these results are valid in space dimension $d \leq 4$. (Received July 15, 2017)

1131-35-226 **Baofeng Feng*** (baofeng.feng@utrgv.edu), 213 Baylor Ave, McAllen, TX 78504, and **Yasuhiro Ohta**. *Semi-discrete analogues of the complex short pulse and coupled complex short pulse equations based on the KP hierarchy reduction.*

Based on the KP hierarchy reduction method, we construct integrable semi discretizations of the complex short pulse (CSP) and the coupled complex short pulse (CCSP) equations, then apply them for the numerical

simulations. Starting from the tau functions of the Kadomtsev-Petviashvili (KP) hierarchy with singular shift points, we firstly derive a set of bilinear equations. Then by dimension and complex conjugate reductions, the integrable semi-discrete analogues of both the CSP and CCSP equations are constructed and their multi-soliton solutions in the form of determinants are provided. In the last, we will show the numerical results of soliton interactions by apply these semi-discretizations as a self-adaptive moving mesh method. (Received July 15, 2017)

1131-35-228 **Lizheng Tao*** (leedstao@ucr.edu) and **Jiahong Wu**. *Linear Stability of 2D Boussinesq Equations around the Couette Flow.*

In this talk, we are going to discuss the recent work on the linear stability problem for the 2D Boussinesq Equations around the Couette Flow. This work uses the Hypo-coercivity theory and other methods. (Received July 16, 2017)

1131-35-251 **Alejandro B Aceves*** (aaceves@smu.edu), Department of Mathematics, Clements Hall 208, Box 0156, Southern Methodist University, Dallas, TX 75275. *Rogue waves in the integrable Thirring model.*

Rogue waves are solutions of nonlinear integrable systems with the property of being localized both in time and space. Most of the recent work on rogue waves have dealt with the nonlinear Schroedinger equation (NLSE). For the NLSE, both theoretical results and experimental realizations in nonlinear optical fibers have drawn much attention as they may also help understand such waves observed in the ocean.

While one would expect rogue waves should be present in other integrable systems, not much is known to date. This work presents rogue wave solutions of the integrable massive Thirring model (MTM). These spatio/temporal localized solutions were obtained using the Darboux transformation. We discuss how these solutions may be of relevance to the propagation of optical pulses in a fiber Bragg grating and the formation of rogue waves in the ocean for a periodic (as opposed to flat) bottom.

This work is in collaboration with Antonio Degasperis (Universita di Roma) and Stefan Wabnitz (Universita di Brescia) (Received July 17, 2017)

1131-35-273 **Changhui Tan*** (ctan@rice.edu). *Global regularity for compressible Euler equations with alignment.*

The Euler-Alignment system arises as the macroscopic description of self-organized dynamics, featuring the flocking behavior, which is commonly observed in complex biological systems. In this talk, we discuss the global wellposedness theory for Euler-Alignment system. We show a critical threshold phenomenon, which says global regularity depends on initial configurations. With subcritical initial data, the system has a global strong solution, and it converges to a flock. On the other hand, supercritical initial data will lead to a finite time break down of the system. We also show a surprising result when the alignment is singular: global regularity is obtained for all initial conditions. (Received July 17, 2017)

1131-35-291 **Jacob Bedrossian** and **Siming He*** (simhe@math.umd.edu), Department of Mathematics, 4176 Campus Drive - William E. Kirwan Hall, room 2117, College Park, MD 20742. *Suppression of blow-up in Patlak-Keller-Segel via shear flows.*

In this talk, I will present a recent result with Jacob Bedrossian on applying additional shear flow to suppress chemotactic blow-up in parabolic-elliptic Keller-Segel System with super-critical mass in two and three dimensions. (Received July 17, 2017)

1131-35-298 **Zhaosheng Feng*** (zhaosheng.feng@utrgv.edu), 1201 University Drive, Mcallen, TX 78539. *Dynamics of a diffusive plant invasion model.*

In this talk, we consider a diffusive plant invasion model with delay under the homogeneous Neumann boundary condition. We investigate the Hopf bifurcation of this model and obtain some criteria by analyzing the associated characteristic equation and by taking tau as the bifurcation parameter. Under special circumstance, we also consider the system's discontinuous Hopf bifurcation. Then we explore the existence and non-existence of nonconstant positive steady states of this model through considering the effect of large diffusivity. Simulations demonstrate that the numerically observed behaviors are in good agreement with the theoretically proposed results. (Received July 17, 2017)

1131-35-299 **Gui-Qiang Chen**, **Apala Majumdar**, **Dehua Wang** and **Rongfang Zhang*** (roz14@pitt.edu). *Global Existence and Regularity for the Active Liquid Crystal System.*

We study the hydrodynamics of active liquid crystals in the Beris-Edwards hydrodynamic framework with the Landau-de Gennes Q-tensor order parameter to describe liquid crystalline ordering. For the incompressible case,

the existence of global weak solutions in two and three spatial dimensions is established and the higher regularity of the weak solutions and the weak-strong uniqueness are also obtained by the Littlewood-Paley decomposition in dimension two. The existence of global weak solutions for the inhomogeneous case and compressible case is also obtained. (Received July 17, 2017)

1131-35-303 **Solomon Manukure*** (smanukure@mail.usf.edu), The University of Texas at Austin, Department of Mathematics, RLM 8.100, 2515 Speedway Stop C1200, Austin, TX 78712. *Bi-integrable Couplings and Bi-Hamiltonian Formulations of Soliton Hierarchies.*

Zero curvature equations associated with simple Lie algebras generate classical integrable systems, and the case of semisimple Lie algebras generate noncoupled systems of classical integrable systems. If the associated Lie algebra is non-semisimple, zero curvature equations generate so-called integrable couplings, which are triangular coupled systems of classical integrable systems. In this talk, we discuss bi-integrable couplings for a soliton hierarchy associated with a non-semisimple loop algebra and demonstrate the Liouville integrability of this hierarchy by showing that it posses a bi-Hamiltonian structure. (Received July 17, 2017)

1131-35-309 **Anna L Mazzucato*** (alm24@psu.edu). *Vorticity concentration in the vanishing viscosity limit.*

I will discuss concentration of vorticity at the boundary as a vortex-sheet in the limit of vanishing viscosity in bounded domains under no-slip boundary conditions. (Received July 17, 2017)

1131-35-320 **Zhaosheng Feng*** (zhaosheng.feng@utrgv.edu), 1201 University Drive, Mcallen, TX 78539. *Approximate Solutions to the Korteweg-de Vries-Burgers Equation.*

In this talk, we develop a connection between the Abel equation of the first kind, an ordinary differential equation that is cubic in the unknown function, and the Korteweg-de Vries-Burgers equation, a partial differential equation that describes the propagation of waves on liquid-filled elastic tubes. We convert the problem into an equivalent integral equation by using the Abel transformation with the initial condition. By virtue of the integral equation and the Banach Contraction Mapping Principle we derive the asymptotic expansion of bounded solutions in the Banach space, and use the asymptotic formula to construct approximate solutions to the Korteweg-de Vries-Burgers equation. (Received July 17, 2017)

1131-35-328 **Kun Zhao*** (kzhao@tulane.edu). *Analysis of a Dissipative Hyperbolic System arising from Chemotaxis Research.*

We present a group of recent results concerning the rigorous analysis of a nonlinear PDE model arising from biosciences, which has primary applications in chemotaxis research. In particular, global well-posedness, long-time asymptotic behavior, diffusion limits, and boundary layer formation of classical solutions will be discussed. (Received July 18, 2017)

1131-35-329 **Kun Zhao*** (kzhao@tulane.edu). *Global Well-posedness of the Cahn-Hilliard-Brinkman Equations in Critical Space.*

The Cahn-Hilliard-Brinkman equations is a coupled PDE system describing phase separation of binary fluids in porous media. A heuristic argument shows that the global well-posedness is critical in $\mathbb{R}^4$ in the sense of scaling-invariance against free energy, while the problem is sub-critical in $\mathbb{R}^d$ for $d = 1, 2, 3$. In this talk, I will present some recent results concerning the global well-posedness and long-time behavior of classical solutions to an initial-boundary value problem of the model in $\mathbb{R}^4$. (Received July 18, 2017)

1131-35-341 **Timothy P Carson*** (tcarson@math.utexas.edu). *Recovery from some pinched metrics under Ricci flow.*

We will present a description of a Ricci flow through a singularity. The flow changes the topology of a neighborhood from $\mathbb{R}^{p+1} \times S^q$ to $\mathbb{R}^p \times S^{q+1}$. We make a symmetry assumption which reduces Ricci flow to a reaction-diffusion equation that we can get a grip on. Such reaction-diffusion equations have been studied, but Ricci flow introduces a different boundary condition. We will compare the situation to that with the usual boundary conditions, as well as to other conjectured or proven Ricci flows through singularities. (Received July 18, 2017)

1131-35-343 **Christopher Henderson*** (henderson@math.uchicago.edu). *The influence of advection on propagation in a reaction-diffusion equation.*

The long-time behavior of reaction-diffusion equations, which, for example, model temperature change in a fluid undergoing reaction or the evolution of a population density, is quite well understood in situations with rigid structure (e.g. homogeneous or periodic coefficients). Less well-understood, however, is the setting where

advection is coupled to the system, despite this being not only physically reasonable but exhibiting different long-time behavior. In this talk, I will discuss some such situations as well as a toy model for these. I will introduce the main tools to study these equations and then obtain various bounds on the propagation speeds depending on the parameters in the model. This is a joint work with François Hamel. (Received July 18, 2017)

1131-35-344 **Tau Shean Lim*** (taushean@math.duke.edu), Mathematics Department, Duke University, Durham, NC 27708. *Traveling fronts for reaction-diffusion equations with ignition reactions and Levy diffusion.*

We study traveling front solutions for one-dimensional reaction-diffusion equations with homogeneous ignition reactions f and diffusion operators $\mathcal{L}$ generated by Lévy processes $\{X_t\}_{t\geq 0}$ with symmetric jumps. Existence and uniqueness of fronts are well-known in the case of classical diffusion $\mathcal{L} = \partial_{xx}$ and some non-local diffusion operators $\mathcal{L}U = \nu * U - U$, where ν is a probability measure on $\mathbb{R}$. In this talk, we extend these results to general Lévy operators, showing that a weak diffusivity in the underlying process, in the sense that $E^0|X_1| < \infty$, gives rise to a unique (up to translation) traveling front. We also prove that our result is sharp, showing that no traveling front exists when $E^0|X_1| = \infty$. (Received July 18, 2017)

1131-35-357 **Azmy S. Ackleh**, **X Li*** (lix@uhd.edu) and **B Ma**. *Parameter Estimation in a Size-Structured Population Model with Distributed States-at-Birth.*

A least-square method is developed for estimating parameters in a size-structured population model with distributed states-at-birth from field data. First and second order finite difference schemes for approximating the nonlinear-nonlocal partial differential equation model are utilized in the least-squares problem. Convergence results for the computed parameters are established. Numerical results demonstrating the efficiency of the technique are provided. (Received July 18, 2017)

1131-35-364 **Benjamin Pineau**, **Chuong V. Tran** and **Xinwei Yu*** (xinwei2@ualberta.ca), 632 CAB, University of Alberta, Edmonton, Alberta T6G2G1, Canada. *Some new Prodi-Serrin type conditions for the 3D Navier-Stokes equations.*

In this talk I will present several new families of Prodi-Serrin type conditions which guarantee the smoothness of weak solutions for the 3D Navier-Stokes equations. These conditions involve either one of the quantities pressure, velocity, gradient of velocity, or their mixtures, and are in the form of space-time bounds on the Lebesgue, Lorentz, or Orlicz norms. This is joint work with Prof. Chuong V. Tran and Mr. Benjamin Pineau. (Received July 18, 2017)

1131-35-367 **Dean Baskin***, Department of Mathematics, Texas A&M University, Mailstop 3368, College Station, TX 77843. *The radiation field on product cones.* Preliminary report.

In this talk I will describe recent joint work with Jeremy Marzuola (building on work with Andras Vasy and Jared Wunsch) describing the long-time behavior of the radiation field on product cones. We find asymptotic expansions for solutions for solutions of the wave equation in all asymptotic regimes and find the exponents seen in the expansion for the radiation field (the pattern seen by a distant observer). These exponents are precisely the resonances of the Laplacian on a hyperbolic cone, can be computed explicitly, and agree with the expansion found by Cheeger and Taylor inside the light cone (Received July 18, 2017)

1131-35-383 **Eun Heui Kim*** (eunheui.kim@csulb.edu). *Transonic problems in multidimensional conservation laws.*

We discuss the recent progress in multidimensional conservation laws. In particular we consider self-similar two dimensional Riemann problems where the problems are transonic, meaning, hyperbolic in far field and mixed type near the origin. We discuss existence and numerical results on a reduced system, the nonlinear wave system, for certain configurations. (Received July 18, 2017)

1131-35-426 **Thomas Y Hou** (hou@cms.caltech.edu), **Tianling Jin** and **Pengfei Liu*** (plliu@caltech.edu). *POTENTIAL SINGULARITY FOR A FAMILY OF MODELS OF THE AXISYMMETRIC INCOMPRESSIBLE FLOW.*

We study a family of models for the incompressible axisymmetric Euler and Navier-Stokes equations. The models are derived by changing the strength of the convection terms in the equations written using a set of transformed variables. The models share several regularity results with the Euler and Navier-Stokes equations, including an energy identity, the BKM criterion and the Prodi-Serrin criterion. The inviscid models with weak convection are numerically observed to develop stable self-similar singularity with the singular region traveling along the symmetric axis, and such singularity scenario does not seem to persist for strong convection. (Received July 19, 2017)

37 ► Dynamical systems and ergodic theory

1131-37-8 **Kevin M Pilgrim*** (pilgrim@indiana.edu), Dept. Math., Indiana University, Rawles Hall, 831 E. 3rd St., Bloomington, IN 47405. *Semigroups of branched mapping classes: dynamics and geometry.* Preliminary report.

Suppose $P \subset S^2$ is a finite subset of the sphere. The pure mapping class group $\mathrm{PMod}(S^2, P)$ is the countable group of orientation-preserving homeomorphisms $f : (S^2, P) \to (S^2, P)$ with $f|P = \mathrm{id}_P$, up to isotopy through homeomorphisms fixing P. If we allow f to be a branched covering whose branch values are contained in P, we obtain a countable semigroup. The study of this semigroup has rich connections to one- and several-variable complex dynamics, to Teichmüller theory, and to the theory of self-similar groups. I will introduce the subject and discuss some recent developments. (Received April 10, 2017)

1131-37-13 **Chris Connell*** (connell@indiana.edu), **Thang Nguyen** (tnguyen@nyu.edu) and **Ralf Spatzier** (spatzier@umich.edu). *Lower hyperbolic rank rigidity for quarter-pinched negatively curved manifolds.*

A Riemannian manifold M has higher hyperbolic rank if every geodesic has a perpendicular Jacobi field making sectional curvature -1 with the geodesic. If in addition, the sectional curvatures of M lie in the interval $[-1, -\frac{1}{4}]$, and M is closed, we show that M is a locally symmetric space of rank one. Similar rigidity results hold for the maximal lyapunov exponent of an ergodic invariant measure of full support. This partially extends work by Constantine for non-positive curvature. It also forms a partial converse to Hamenstädt's hyperbolic rank rigidity result for sectional curvatures ≤ -1, and complements well-known results on Euclidean and spherical rank rigidity. (Received May 07, 2017)

1131-37-20 **Nandor J Simanyi*** (simanyi@uab.edu), 1300 University Blvd., Suite 452, Birmingham, AL 35294, and **Caleb C Moxley** (ccmoxley@bsc.edu), 900 Arkadelphia Road, Birmingham, AL 35254. *Panorama of Homotopical Complexity of 3D scattering billiards.*

We study the homotopical rotation vectors and the homotopical rotation sets for several cylindric billiard flows on the 3D unit flat torus.

The natural habitat for these objects is the infinite cone erected upon the Cantor set Ends(G) of all ends of the hyperbolic group G of the configuration space. An element of G describes the direction in (the Cayley graph of) the group G in which the considered trajectory escapes to infinity, whereas the height function s of the cone gives us the average speed at which this escape takes place.

The main results obtained so far, jointly with Dr. Caleb Moxley, are radial upper and lower bounds for the star-shaped rotation sets of these models.

Furthermore, we prove the convexity (star-shaped property) of the set AR of constructible rotation vectors, and that the set of rotation vectors of periodic orbits is dense in AR. We also provide effective lower and upper bounds for the topological entropy of the studied billiard flows. (Received May 18, 2017)

1131-37-55 **Aaron Hill*** (aaron.hill@louisville.edu) and **Su Gao**. *Disjointness and isomorphism between rank-1 transformations.* Preliminary report.

We give sufficient conditions for two rank-1 transformations to be disjoint. We use this to characterize both isomorphism and disjointness for commensurate pairs of bounded rank-one transformations. We may also discuss results about other related properties, such as minimal self-joinings. (Received June 27, 2017)

1131-37-59 **Christian Wolf*** (cwolf@ccny.cuny.edu), New York, NY 10031. *On the computability of rotation sets and their entropies.*

Given a continuous dynamical system $f : X \to X$ on a compact metric space X and an m-dimensional continuous potential $\Phi : X \to R^m$, the (generalized) rotation set $R(\Phi)$ is defined as the set of all μ-integrals of Φ, where μ runs over all invariant probability measures. Analogous to the classical topological entropy, one can associate the localized entropy $H(w)$ to each $w \in R(\Phi)$. In this talk, we discuss the computability of rotation sets and localized entropy functions by deriving conditions that imply their computability. We then apply our results to study to the case of subshifts of finite type. We prove that $R(\Phi)$ is computable and that $H(w)$ is computable in the interior of the rotation set. Finally, we discuss an explicit example that shows that, in general, H is not continuous on the boundary of the rotation set, when considered as a function of Φ and w. This suggests that, in general, H is not computable at the boundary of rotation sets. This is a joint work with Michael Burr and Martin Schmoll. (Received June 29, 2017)

1131-37-78 **Joseph Max Rosenblatt*** (joserose@iupui.edu), Department of Mathematical Sciences, 402 N. Blackford, IUPUI, Indianapolis, IN 46202. *Local behavior of convergence for stochastic processes in dynamical systems.* Preliminary report.

Details about the local behavior of maps and functions in ergodic dynamical systems are the focus of this talk. We consider processes that are not universally convergent for all ergodic maps and all integrable functions. In this situation, we describe for a variety of examples how when fixing the map the nature of the function affects the convergence of the process. At the same time, when fixing the function, we can describe how the nature of the map affects the convergence of the process in a variety of examples. These results range from ones that hold generically to ones that hold only rarely. (Received July 04, 2017)

1131-37-80 **Alan Haynes*** (haynes@math.uh.edu), **Michael Kelly** and **Henna Koivusalo**. *Constructing bounded remainder sets of all allowable volumes in any dimension.*

In this talk we will discuss the problem of constructing bounded remainder sets for rotations of a d-dimensional torus. This is an important topic which has been studied for nearly 100 years, and, until recently, was only adequately understood in dimensions 1 and 2. However, in just the last few years, work by several authors has led to constructions of bounded remainder sets for irrational rotations in any dimension, of all allowable volumes. In this talk we will explain, in retrospect, how many of these results can easily be obtained from a simple geometric argument which was previously employed by Duneau and Oguey in the study of deformation properties of mathematical models for quasicrystals. (Received July 05, 2017)

1131-37-84 **Kevin M Pilgrim*** (pilgrim@indiana.edu), Department of Mathematics, Rawles Hall, 831 E. 3rd St., Indiana University, Bloomington, IN 47405, and **Dylan P Thurston** (dpthurst@indiana.edu), Department of Mathematics, Rawles Hall, 831 E. 3rd St., Indiana University, Bloomington, IN 47405. *Graph energies and Ahlfors-regular conformal dimension.* Preliminary report.

For a hyperbolic post-critically finite rational map, we show that the critical exponent for the asymptotic graph energy introduced by the second author agrees with the Ahlfors-regular conformal dimension of the Julia set. (Received July 05, 2017)

1131-37-91 **Hiroki Sumi*** (sumi@math.h.kyoto-u.ac.jp), Grad. Sch. of Human and Environmental Studies, Kyoto University, Yoshida-Nihonmatsu-cho, Sakyo-ku, Kyoto, 6068501, Japan. *Finding Roots of Any Polynomial by Random Relaxed Newton's Methods.* Preliminary report.

We develop the theory of random holomorphic dynamics and apply it to finding roots of any complex polynomial by random relaxed Newton's methods. More precisely, for any polynomial g of degree two or more, let $N_{g,\lambda}(z) = z - \lambda \frac{g(z)}{g'(z)}$, where z is a point in the Riemann sphere and $\lambda \in \{\lambda \in \mathbb{C} \mid |\lambda - 1| < r\} (1/2 < r < 1)$ and we consider the random dynamical system on the Riemann sphere such that at every step we choose $\lambda \in \{\lambda \in \mathbb{C} \mid |\lambda - 1| < r\}$ according to the uniform distribution, and map the point under $N_{g,\lambda}$. We show that for any polynomial g of degree two or more, for any initial value z in the complex plane which is not a root of g', the random orbit starting with z tends to a root of g almost surely, which is the virtue of the effect of randomness. In fact, such a statement cannot hold in the deterministic relaxed Newton's method and any other deterministic complex analytic iterative schemes to find roots of polynomials (M. Hurley ETDS 1986, C. McMullen Ann. Math. 1987). Thus the above result deals with a randomness-induced phenomenon. For the preprint, see https://arxiv.org/abs/1608.05230. (Received July 06, 2017)

1131-37-115 **Qingwen Hu***, 800 W. Campbell Road, FO. 35, Richardson, TX 75080. *Global Hopf bifurcation for a model of regulatory dynamics with state-dependent delay.*

We begin with a short introduction to differential equations with state-dependent delay. Motivated by modeling regulatory dynamics, we develop a global Hopf bifurcation theory for differential equations with a state-dependent delay governed by an algebraic equation, using the S^1-equivariant degree. We apply the global Hopf bifurcation theory to the prototype model of genetic regulatory dynamics with threshold type state-dependent delay vanishing at the stationary state, for a description of the global continuation of the periodic oscillations. (Received July 09, 2017)

1131-37-116 **Vladimir Dragovic*** (vladimir.dragovic@utdallas.edu), The University of Texas at Dallas, 800 W. Campbell Road, FO 35, Richardson, TX 75080. *Pseudo-integrable billiards and their topological, dynamical, and arithmetic properties.*

We present a recent class of billiard systems in the plane, with boundaries formed by finitely many arcs of confocal conics such that they contain some reflex angles. Fundamental dynamical, topological, geometric, and arithmetic

properties of such billiards are studied. The novelty, caused by reflex angles on boundary, induces invariant leaves of higher genera and dynamical behavior different from Liouville–Arnold's Theorem. The billiard flow generates a measurable foliation defined by a closed 1-form w. Using the closed form, a transformation of the given billiard table to a rectangular cylinder is constructed and a trajectory equivalence between corresponding billiards has been established. A local version of Poncelet Theorem is formulated and necessary algebro-geometric conditions for periodicity are presented. It is proved that the dynamics depends on arithmetic of rotation numbers, but not on geometry of a confocal pencil. Examples of billiard trajectories having a fixed circle concentric with the boundary semicircles as the caustic, such that the rotation numbers with respect to the half-circles are different pairs of numbers r1 and r2 respectively, are presented. This presentation is based on joint works with Milena Radnovic. (Received July 09, 2017)

1131-37-124 **Bryna Kra**, **Nimish Shah** and **Wenbo Sun*** (sun.1991@osu.edu), 364 W Lane Ave Apt 315, Columbus, OH 43201. *Equidistribution of dilated curves.*

Consider a light source located in a polygon room. It is a classic question whether the whole room is illuminated by the light. This question was recently settled by Leliévre, Monteil and Weiss when the room is a translation surface. In this talk, we study the variation on the illumination problem introduced by Chaika and Hubert in the context of closed curves on nilmanifolds. We give necessary and sufficient conditions for a nilmanifold being illuminated by a curve. (Received July 10, 2017)

1131-37-132 **Boris Kalinin*** (kalinin@psu.edu) and **Victoria Sadovskaya** (sadovskaya@psu.edu). *Normal forms for non-uniform contractions.*

Let f be a measure-preserving transformation of a Lebesgue space (X, μ) and let F be its extension to a bundle $E = X \times \mathbb{R}^m$ by smooth fiber maps $F_x : E_x \to E_{fx}$ so that the derivative of F at the zero section has negative Lyapunov exponents. We construct a measurable system of smooth coordinate changes H_x on E_x for μ-a.e. x so that the maps $P_x = H_{fx} \circ F_x \circ H_x^{-1}$ are sub-resonance polynomials in a finite dimensional Lie group. Our construction shows that such H_x and P_x are unique up to a sub-resonance polynomial. As a consequence, we obtain the centralizer theorem that the coordinate change H also conjugates any commuting extension to a polynomial extension of the same type. We apply our results to a measure-preserving diffeomorphism f with a non-uniformly contracting invariant foliation W. We construct a measurable system of smooth coordinate changes $H_x : W_x \to T_x W$ such that the maps $H_{fx} \circ f \circ H_x^{-1}$ are polynomials of sub-resonance type. Moreover, we show that for almost every leaf the coordinate changes exist at each point on the leaf and give a coherent atlas with transition maps in a finite dimensional Lie group. (Received July 10, 2017)

1131-37-134 **Yuncheng You*** (you@mail.usf.edu), 4202 East Fowler Avenue, Tampa, FL 33620. *Stochastic Viral Dynamics with Beddington-DeAngelis Response.*

Stochastic viral dynamics modeled by stochastic differential equations with Beddington-DeAngelis functional response and driven by white noise will be presented. The stochastic positive invariance and the existence of stationary distribution are proved. Through estimation of the pathwise and asymptotic moment upper bounds, the moment Lyapunov exponent is shown to be nonpositive when the noise intensities are relatively small. Then the persistence and extinction will be discussed. (Received July 11, 2017)

1131-37-135 **Meagan Carney**, 3551 Cullen Blvd., Houston, TX 77204, and **Matthew Nicol***, 3551 Cullen Blvd., Houston, TX 77204. *Dynamical Borel-Cantelli lemmas and rates of growth of Birkhoff sums of non-integrable observables on chaotic dynamical systems.*

We consider implications of dynamical Borel-Cantelli lemmas for rates of growth of Birkhoff sums of non-integrable observables $\phi(x) = d(x, q)^{-k}$, $k > 0$, on ergodic dynamical systems (T, X, μ) where $\mu(X) = 1$. Some general results are given as well as some more concrete examples involving non-uniformly expanding maps, intermittent type maps as well as uniformly hyperbolic systems. (Received July 11, 2017)

1131-37-136 **Meagan Carney** and **Matthew Nicol***, Department of Mathematics, 3551 Cullen Blvd., Houston, TX 77204, and **Hongkun Zhang**. *The Compound Poisson law for hitting times to periodic orbits in two-dimensional hyperbolic systems.* Preliminary report.

We show that a compound Poisson distribution holds for scaled exceedances of observables ϕ uniquely maximized at a periodic point ζ in a variety of two-dimensional hyperbolic dynamical systems with singularities (M, T, μ), including the billiard maps of Sinai dispersing billiards in both the finite and infinite horizon case. The observable we consider is of form $\phi(z) = -\ln d(z, \zeta)$ where d is a metric defined in terms of the stable and unstable foliation. The compound Poisson process we obtain is a Pólya-Aeppli distibution of index θ. We calculate θ in terms of the derivative of the map T. These results generalize to a broader class of functions maximized at ζ, though the formulas regarding the parameters in the distribution need to be modified. (Received July 11, 2017)

1131-37-137 **Patrick Shipman*** (shipman@math.colostate.edu), 1874 Campus Delivery, Colorado State University, Fort Collins, CO 80523. *Optimally Topologically Transitive Orbits in Two-dimensional Discrete Dynamical Systems.* Preliminary report.

Every orbit of a rigid rotation of a circle by a fixed irrational angle is dense. However, the apparent uniformity of the distribution of iterates after a finite number of iterations appears strikingly different for various choices of a rotation angle. Motivated by this observation, we introduce a scalar function on the orbits of a discrete dynamical system defined on a bounded metric space, called the linear limit density, which we interpret as a measure of an orbit's approach to density. Any discrete dynamical system defined by an orientation-preserving diffeomorphism of the circle has an orbit with a larger linear limit density than any orbit of the rigid rotation by the golden number. We determine linear limit densities of orbits of two-dimensional discrete dynamical systems and random walks. (Received July 11, 2017)

1131-37-138 **Vladimir Dragovic*** (vladimir.dragovic@utdallas.edu), The University of Texas at Dallas, 800 W. Campbell Road, FO 35, Richardson, TX 75080. *Discriminantly separable polynomials, Kowalevski top, and quad-graphs.*

The talk consists of two parts. Both parts consider pencils of quadrics and integrable quad-graphs. In the first part, the class of discriminantly separable polynomials in three variables of degree two in each, which we introduced recently, is classified and connected with pencils of conics. The relationship with the classical Kowalevski top is presented. Then, this class of polynomials is connected to the integrable quad-graphs in the sense of Adler, Bobenko and Suris. In the second part, we start with the billiard algebra, associated with billiard systems within pencils of quadrics. Our recent "the six-pointed star theorem", which was derived as an operational consistency for the billiard algebra operation, is interpreted also as a consistency condition for a line congruence. The results from the first part are joint with Katarina Kukic, and from the second part with Milena Radnovic. (Received July 11, 2017)

1131-37-142 **Tushar Das*** (tdas@uwlax.edu). *Does every expanding repeller have an ergodic invariant measure of full Hausdorff dimension?*

We construct a a self-affine sponge in $\mathbb{R}^3$ coming from an affine iterated function system whose coordinate subspace projections satisfy the strong separation condition, and whose dynamical dimension, i.e. the supremum of the Hausdorff dimensions of its invariant measures, is strictly less than its Hausdorff dimension. More generally, we prove a variational principle that computes the Hausdorff and dynamical dimensions of a large class of self-affine sponges. We end with several open questions that arise naturally in the wake of our results. This work is joint with David Simmons (York). (Received July 11, 2017)

1131-37-154 **William Ott*** (ott@math.uh.edu) and **Zijie Zhou**. *The effect of projections on fractal sets and measures in Banach spaces.*

Motivated by infinite-dimensional dynamical systems, we address how nonlinear maps affect dimension for sets and measures in Banach spaces. More precisely, suppose A is a compact subset of a Banach space $\mathcal{B}$. For a *typical* C^1 map $f : \mathcal{B} \to \mathbb{R}^m$, what is the relationship between the Hausdorff dimension of A and that of $f(A)$?

Here, we show that a typical C^1 map preserves the Hausdorff dimension of A, up to a factor that involves the *dual thickness* of A. This result answers a question posed by James Robinson. We conclude by comparing the Banach space result to what is known when $\mathcal{B}$ is a Hilbert space. (Received July 12, 2017)

1131-37-178 **Vasileios Chousionis*** (vasileios.chousionis@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269-3, and **Jeremy Tyson** and **Mariusz Urbanski**. *Conformal graph directed Markov systems on Carnot groups.*

We develop a comprehensive theory of conformal graph directed Markov systems in the non-Riemannian setting of Carnot groups equipped with a sub-Riemannian metric. Using thermodynamic formalism we show that the limit set of a Carnot conformal GDMS has Hausdorff dimension given by Bowen's parameter, and we study finer properties of the corresponding conformal measures. We illustrate our results for a variety of examples including Iwasawa continued fractions as well as Kleinian and Schottky groups associated to the non-real classical rank one hyperbolic spaces. Joint work with J. Tyson and M. Urbanski. (Received July 13, 2017)

1131-37-185 **Mark David Comerford*** (mcomerford@math.uri.edu), 5 Lippitt Road, Room 200, Kingston, RI 02881. *Neutral Fixed Points in non-Autonomous Iteration.*

Although the concept of periodicity does not exist as such in non-autonomous iteration, properties of neutral fixed points are extremely useful in constructing interesting examples in non-autonomous polynomial dynamics. We exhibit a number of increasingly complex examples, from polynomial sequences where all the critical points escape but yet there are bounded Fatou components, to Julia sets of positive area which admit an invariant

sequence of measurable line fields. We conclude with work in progress showing that one can construct a sequence of polynomials with a Fatou component on which every univalent function from the classical Schlicht class on the unit disc is a limit function. (Received July 14, 2017)

1131-37-227 **Tamara Kucherenko***, (tkucherenko@ccny.cuny.edu), The City College of New York, and **Daniel J. Thompson**, Ohio State University. *Measures of maximal entropy for suspension flows over the full shift.*

We consider suspension flows with continuous roof function over the full shift Σ on a finite alphabet. For any non-trivial subshift of finite type $Y \subset \Sigma$, we show there exists a roof function such that the measure(s) of maximal entropy for the suspension flow over Σ are exactly the lifts of the measure(s) of maximal entropy for Y. Here, non-trivial means that Y contains infinitely many points. In the case when Y is transitive, this gives a unique measure of maximal entropy for the flow which is not fully supported. If Y has more than one transitive component, all with the same entropy, this gives explicit examples of suspension flows over the full shift with multiple measures of maximal entropy. This contrasts with the case of a Hölder continuous roof function where it is well known the measure of maximal entropy is unique and fully supported. (Received July 15, 2017)

1131-37-236 **Mrinal Kanti Roychowdhury***, 1201 West University Drive, Edinburg, TX 78539. *Quantization for Probability Distributions.*

The basic goal of quantization for probability distributions is to reduce the number of values, which is typically uncountable, describing a probability distribution to some finite set and thus approximation of a continuous probability distribution by a discrete distribution. I will talk about it. (Received July 16, 2017)

1131-37-237 **Sergey Bezuglyi*** (sergii-bezuglyi@uiowa.edu), **Olena Karpel** and **Jan Kwiatkowski**. *Exact number of ergodic measures for Bratteli diagrams.*

We study the simplex $M_1(B)$ of probability measures on a Bratteli diagram B which are invariant with respect to the tail equivalence relation. We prove a criterion of unique ergodicity of a Bratteli diagram. In case when a finite rank k Bratteli diagram B has $l \leq k$ ergodic invariant measures, we describe the structures of the diagram and the subdiagrams which support these measures. We find conditions under which the extension of a measure from a uniquely ergodic subdiagram is a finite ergodic measure. (Received July 16, 2017)

1131-37-239 **Tomoki Ohsawa*** (tomoki@utdallas.edu), 800 W Campbell Rd, Richardson, TX 75080-3021. *Hamiltonian Dynamics of Semiclassical Wave Packets.*

It is well known that both classical and quantum mechanical systems are described as Hamiltonian systems: finite-dimensional one for the former, and infinite-dimensional for the latter with respect to appropriate symplectic structures. I will show how to exploit such geometric structures to formulate semiclassical dynamics—the transition regime between quantum and classical mechanics—from the symplectic-geometric point of view. Of particular interest is the semiclassical wave packets of Hagedorn. I will explain how one can formulate the dynamics of the wave packets from the symplectic/Hamiltonian point of view. (Received July 16, 2017)

1131-37-248 **Jane Hawkins*** (jmh@math.unc.edu), Mathematics Dept., CB #3250, University of N. Carolina at Chapel Hill, Chapel Hill, NC 27599. *Rational maps commuting with the antipodal map: dianalytic maps of the real projective plane.*

We give an overview of properties of rational maps which commute with the antipodal map of the sphere. We discuss the dynamical properties, some Julia and Fatou sets that can occur, and we look at some parameter spaces. Many of the results appear in recent papers or preprints by the author and others. In particular we show some experimental results about Herman rings with Michelle Randolph and the properties these maps induce on the real projective plane. (Received July 16, 2017)

1131-37-252 **Jason Atnip*** (jason.atnip@unt.edu). *Dimensions of Meromorphic Functions of Finite Order.*

In this talk we discuss two classes of meromorphic functions of finite order previously studied by Mayer and by Kotus and Urbański. In particular we estimate a lower bound for Hausdorff dimension of the Julia set and the set of escaping points for non-autonomous additive and affine perturbations of functions from these classes. For certain systems we are also able to provide an upper bound for the dimension of the escaping set. We accomplish this by constructing non-autonomous graph directed Markov systems, which sit inside of the aforementioned non-autonomous Julia sets. We also give estimates for the eventual and eventual hyperbolic dimensions of the these non-autonomous perturbations. (Received July 17, 2017)

1131-37-257 **Sean Bauer** and **Nikola P Petrov*** (npetrov@ou.edu), Department of Mathematics, University of Oklahoma, 601 Elm Ave, Norman, OK 73019. *KAM tori for presymplectic vector fields.*

Given a vector field on a (pre)symlpectic manifold that preserves the (pre)symplectic structure, we construct a submanifold (namely, a torus) that is invariant with respect to the flow of the vector field. We use a recently developed method of proof that relies heavily on the geometry of the system, does not assume that the system is close to integrable, and does not rely on using action-angle variables. The proof has an a posteriori format, the invariant torus is constructed by using a Newton method in a space of functions, starting from a torus that is approximately invariant. This is a joint research with Sean Bauer. (Received July 17, 2017)

1131-37-290 **Volodymyr Nekrashevych*** (nekrash@math.tamu.edu), Dept of Mathematics, College Station, TX 77843. *Julia sets with local cut points and amenable groups.* Preliminary report.

We will discuss how topological properties of the Julia set of a complex rational function can be used to prove amenability of the iterated monodromy groups. Namely, we will show that if the Julia set is "gasket like", then the iterated monodromy group is amenable. This is a joint work with K. Pilgrim and D. Thurston. (Received July 17, 2017)

1131-37-297 **Jonathan E Rubin*** (jonrubin@pitt.edu), Department of Mathematics, University of Pittsburgh, 301 Thackeray Hall, Pittsburgh, PA 15260. *Inspired by breathing: mechanisms for mixed-mode oscillations and related dynamics.*

In mammals, respiration emerges from the dynamics of a central pattern generator (CPG) in the brainstem. Understanding the rhythmic dynamics of the respiratory CPG leads to a wide range of interesting mathematical problems involving topics such as multiple timescales, network interactions, and closed-loop control. In multi-timescale oscillatory systems with two or more slow variables, it is somewhat natural to expect mixed-mode oscillations (MMOs) involving alternations of small- and large-amplitude oscillations. In this talk, I will survey some of our recent results, inspired by respiratory modeling to differing degrees, about dynamics related to MMOs and about some non-standard MMO mechanisms. It is my hope that these ideas will be interesting and useful to audience members working on differential equation models for a range of complex biological systems. (Received July 17, 2017)

1131-37-306 **Anna Zdunik*** (a.zdunik@mimuw.edu.pl), ul. Banacha 2, 02-097 Warszawa, Poland. *Random function systems on the circle.*

The talk will be devoted to ergodic properties of Iterated Function Systems of homeomorphisms on the circle. We show in particular that such systems, under very weak conditions, satisfy the Law of Large Numbers and Central Limit Theorem. This is a joint work with Tomasz Szarek. (Received July 17, 2017)

1131-37-358 **Timothy C Wilson*** (timothywilson@my.unt.edu). *Continuity of Hausdorff Dimension in Hyperbolic Polynomials.*

We consider a family of hyperbolic polynomials $P_\lambda : \mathbb{C} \to \mathbb{C}$ defined by $P_\lambda(z) = \lambda z^{d+1} + P(z)$ where $P(z)$ is hyperbolic polynomial of degree d. Let $J(P_\lambda)$ be the Julia set of P_λ. Our main result is that the function $\lambda \mapsto h_\lambda := HD(J(P_\lambda)), \lambda \in [0, \epsilon)$ is continuous at the point 0. The main tools we use are the associated conformal measures. (Received July 18, 2017)

1131-37-376 **Matthew Nicol**, **Andrew Torok*** (torok@math.uh.edu) and **Sandro Vaienti**. *Central limit theorems for sequential and random intermittent dynamical systems.*

We establish self-norming central limit theorems for non-stationary time series arising as observations on sequential maps possessing an indifferent fixed point (and polynomial decay of correlations). These transformations are obtained by perturbing the slope in the Pomeau-Manneville map. We also obtain quenched central limit theorems for random compositions of these maps. (Received July 18, 2017)

1131-37-381 **Marco Antonio López*** (marco.lopez@unt.edu) and **Mariusz Urbański** (mariusz.urbanski@unt.edu). *Shrinking Targets and Non-Autonomous Systems.*

The "shrinking target problem" refers to the study of the set of points in a metric space whose orbit under a dynamical system hit a ball of shrinking radius infnitely often. In our work we focus on establishing Bowen's dimension formula for shrinking target sets in the context of non-autonomous iterated function systems. In special cases, such shrinking target sets arise in Diophantine approximation. (Received July 18, 2017)

1131-37-386 **Dmitry Kleinbock*** (kleinboc@brandeis.edu), Department of Mathematics, Brandeis University, Waltham, MA 02454, and **Nick Wadleigh**, Department of Mathematics, Brandeis University, Waltham, MA 02454. *Shrinking targets on homogeneous spaces and improving Dirichlet's Theorem.*

Optimal results on the metric theory for improvements to Dirichlet's Theorem are obtained in the one-dimensional case. For simultaneous approximation the problem is open. I will describe reduction of the problem to dynamics both in one-dimensional case (via continued fractions) and for higher dimensions (via diagonal flows on the space of lattices). If time allows I'll speak about an inhomogeneous version which happens to be easier than the homogeneous one. (Received July 18, 2017)

1131-37-421 **Giulio Tiozzo*** (tiozzo@math.utoronto.ca), 40 St George St, Toronto, ON , Canada. *On the local Hoelder exponent of the entropy function.*

A question for your real analysis students: can you find a function whose local Hoelder exponent at any point equals the *value* of the function? It turns out that such functions arise quite naturally from dynamical systems, and we will see an example which comes from real unimodal maps. The proof is elementary and relies on the symbolic dynamics. (Received July 19, 2017)

43 ► Abstract harmonic analysis

1131-43-164 **W Spencer Leslie*** (lesliew@bc.edu). *A Generalized Theta lifting and CAP Representations.*

Theta representations are fundamental automorphic representations on covers of reductive groups which generalize Jacobi's theta function, as well as the oscillator (Weil) representation used in the theory of the theta correspondence. In this talk, we study the theta representation on the four-fold cover of the symplectic group, and use it to construct a new lifting of automorphic forms on covering groups. This construction fits nicely into a conjectured extension of Arthur's conjectures to covering groups, and produces the first examples of CAP representations on higher covers. (Received July 12, 2017)

1131-43-424 **Krystal Taylor*** (taylor.2952@osu.edu), Ohio State, and **Karoly Simon** (karoly.simon51@gmail.com). *Interior, Dimension, and Measure of Algebraic Sums of Planar Sets and Curves.*

Recently considerable attention has been paid to the study of the arithmetic sums of two planar sets $A + G := \{a + g : a \in A, g \in G\}$. We focus on the case when G is a piecewise C2 curve, in particular when G is the unit circle. In this case there is a natural guess what the size (Hausdorff dimension, Lebesgue measure) of $A + G$ should be. We verify this under some simple natural assumptions. We also address the more difficult question: under which condition does the set $A + G$ has non-empty interior? (Received July 19, 2017)

45 ► Integral equations

1131-45-325 **Lichen Zhao*** (zhaolichen3@nwu.edu.cn). *Several Localized Waves Induced by Linear Interference between a Nonlinear Plane Wave and Bright Solitons.*

We investigate linear interference effects between a nonlinear plane wave and bright solitons, which are admitted by pair-transition coupled two-component Bose-Einstein condensate. We demonstrate the interference effects can induce several localized waves possessing distinctive wave structures, mainly including anti-dark soliton, W-shaped soliton, multi-peak soliton, Kuznetsov-Ma like breather, and multi-peak breather. Especially, the explicit conditions for them are clari ed by a phase diagram based on the linear interference properties. Furthermore, the interactions between these localized waves are discussed. The detailed analysis indicate that soliton-soliton interaction induced phase shift brings the collision between these localized waves be inelastic for soliton involving collision, and be elastic for breathers. These characters come from that the pro le of solitons depend on relative phase between bright soliton and plane wave, and the pro le of breathers do not depend on the relative phase. These results would motivate more discussions on linear interference between other nonlinear waves. Especially, the soliton or breather obtained here is proven to be not related with modulational instability. The underlying reasons are discussed in detail. (Received July 18, 2017)

46 ► Functional analysis

1131-46-7 **Oriehi E. D. Anyaiwe*** (destinyanyaiwe@gmail.com) and **Chika Moore** (dogoodmoore@yahoo.com). *Iterative Solutions for Variational Inclusions Problems in Banach Spaces.* Preliminary report.

Variational inclusion problems has become the apparatus that is generally used to constrain sundry mathematical equations in other to guarantee the uniqueness and existence of their solutions. The existence of these solutions was earlier studied and proven for uniform Banach Spaces using accretive operators. In this study, we extend the conditions to hold for arbitrary Banach Spaces using uniform accretive operators. (Received April 10, 2017)

1131-46-101 **Daniel Freeman*** (dfreema7@slu.edu) and **Darrin Speegle**. *The discretization problem for continuous frames and coherent states.*

Functions on $L_2([0,1])$ can be analyzed continuously through the Fourier transform or discretely through Fourier series and sampling the Fourier transform only at the integers. We consider what other continuous representations can be sampled to obtain discrete representations. Using the results of Marcus-Spielman-Srivastava in their solution of the Kadison-Singer problem, we give a complete characterization of when a continuous frame for a Hilbert space may be sampled to obtain a discrete frame. In particular, every bounded continuous frame may be sampled to obtain a discrete frame. This solves the discretization problem as posed by Ali, Antoine, and Gazeau in their physics textbook: Coherent States, Wavelets, and Their Generalizations. (Received July 07, 2017)

1131-46-150 **Tao Mei*** (tao_mei@baylor.edu), One bear place, Waco, TX 77433, and **quanhua Xu**. *Mikhlin's Multiplier Theory and Unconditional Subsequence Property for Noncommutative Lp Spaces associated with Free Group von Neumann algebras.* Preliminary report.

We prove an analogue of the classical Mikhlin Fourier multiplier theorem for free groups. This implies several analytic properties, including the Unconditional Subsequence Property, for the associated noncommutative Lp spaces. This talk is based on a joint work with Quanhua Xu. (Received July 12, 2017)

1131-46-173 **Florent Pierre Baudier*** (florent@math.tamu.edu), Texas A&M University, College Station, TX 77843, and **Gilles Lancien** and **Thomas Schlumprecht**. *A new concentration inequality and its applications to coarse geometry.*

A new concentration inequality for Lipschitz maps on the infinite Hamming graphs and taking values in Tsirelson's original space will be discussed. This concentration inequality is then used to disprove the conjecture that the separable infinite dimensional Hilbert space coarsely embeds into every infinite dimensional Banach space. This question arose from the work of G. Yu in the late 90's about the coarse geometric Novikov conjecture. A rigidity result pertaining to the spreading model set for Banach spaces coarsely embeddable into Tsirelson's original space will also be discussed.

Joint work with G. Lancien and Th. Schlumprecht (Received July 13, 2017)

1131-46-206 **Cory Krause*** (corykrause@my.unt.edu). *Some partial results on the ℓ_p spreading model problem.* Preliminary report.

In the study of the asymptotic structure of Banach spaces, strong assumptions concerning the asymptotic geometry of a space may imply facts about the original geometry. Spreading models are one common tool in this regard. For example, assume that X is a space with a basis (x_i) such that every spreading model of a normalized block sequence of (x_i) is 1-equivalent to some fixed basic sequence (e_i). Does X contain $[e_i]$ isomorphically? The answer to this question is known to be yes whenever (e_i) is the unit vector basis of ℓ_1 or c_0. It has been asked if the same is true of ℓ_p for $1 < p < \infty$. We present some partial results on this question including a positive result under the additional assumption that all the normalized block sequences give rise to spreading models without passing to subsequences. (Received July 14, 2017)

1131-46-207 **Petr Hajek** (hajek@math.cas.cz), Czech Technical University in Prague, Zikova 4, 160 00, Prague, TX 160 00, and **Thomas B Schlumprecht*** (schlump@math.tamu.edu), Department of Mathematocs, Texas A&M University, College Station, TX 77845. *On coarse embeddings into $c_0(\Gamma)$.*

Let λ be a large enough cardinal number (assuming the Generalized Continuum Hypothesis it suffices to let $\lambda = \aleph_\omega$). If X is a Banach space with $\mathrm{dens}(X) \geq \lambda$, which admits a coarse (or uniform) embedding into any $c_0(\Gamma)$, then X fails to have nontrivial cotype, i.e. X contains ℓ_∞^n C-uniformly for every $C > 1$. In the special case when X has a symmetric basis, we may even conclude that it is linearly isomorphic with $c_0(\mathrm{dens} X)$. (Received July 14, 2017)

1131-46-242 **Ryan M Causey** and **Stephen J Dilworth*** (dilworth@math.sc.edu). *Almost Isometric Constants for Partial Unconditionality.*

We discuss optimal constants of certain projections on subsequences of weakly null sequences. Positive results yield constants arbitrarily close to 1 for Schreier type projections, and arbitrarily close to 1 for Elton type projections under the assumption that the weakly null sequence admits no subsequence generating a c_0 spreading model. As an application, we prove that a weakly null sequence admitting a spreading model not equivalent to the c_0 basis has a quasi-greedy subsequence with quasi-greedy constant arbitrarily close to 1. (Received July 16, 2017)

1131-46-266 **Andrew T Swift*** (ats0@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *A coding of bundle graphs.*

In this talk, it will be shown how a large family of bundle graphs; including the countably-branching diamond, Laakso, and parasol graphs; can be coded with finite sequences. This enables easier and more general proofs of some known embeddability results, including an embedding of countably-branching Laakso and parasol graphs into L_1 with distortion 2. (Received July 17, 2017)

1131-46-307 **Keaton Hamm*** (keaton.hamm@vanderbilt.edu). *Approximation and Quasi Shift-Invariant Spaces.*

We will discuss the structure of subspaces of $L_p(\mathbb{R}^n)$ of the form $V_p(\phi, X) := \overline{\text{span}}^{L_p}\{\phi(\cdot - x_n)\}$, where $X := (x_n)$ is a quasi-uniform sequence in $\mathbb{R}^n$. Such subspaces are called quasi shift-invariant spaces after Gröchenig and Stöckler. In addition to structural considerations, some applications to function interpolation and sampling theory will be discussed. (Received July 17, 2017)

1131-46-335 **Pavlos Motakis***, Department of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Daniele Puglisi** and **Andreas Tolias**. *Spaces of compact diagonal operators as Calkin algebras of Banach spaces.*

The Calkin algebra of a Banach space Z is the unital Banach algebra $\mathcal{C}al(Z)$ defined as the quotient $\mathcal{L}(Z)/\mathcal{K}(Z)$ of the algebra of all bounded linear operators on Z over the ideal of all compact ones. We investigate the question of what types of unital algebras can occur as Calkin algebras. Given a Banach space X with a Schauder basis we denote by $\mathcal{K}_{\text{diag}}(X)$ the space of all compact and diagonal operators on X. We prove that there exists a Banach space $\mathfrak{X}_X$ so that the Calkin algebra of $\mathfrak{X}_X$ is isomorphic, as a Banach algebra, to $\mathcal{K}_{\text{diag}}(X) \oplus \mathbb{R}I$. This yields Banach spaces with interesting Calkin algebras, e.g., James' quasi reflexive Banach space and even a hereditarily indecomposable Banach algebra constructed by S. A. Argyros, I. Deliyanni, and A. Tolias. The space $\mathfrak{X}_X$ is of the form $(\sum \oplus X_k)$ where each X_k is a version of the Argyros-Haydon space and the outside norm is a modified Argyros-Haydon sum incorporating the norm of the space X. (Received July 18, 2017)

1131-46-351 **Bruno de Mendonça Braga*** (demendoncabraga@gmail.com) and **Andrew Swift**. *Coarse embeddings into superstable spaces.*

Krivine and Maurey proved in 1981 that every stable Banach space contains almost isometric copies of ℓ_p, for some $p \in [1, \infty)$. In 1983, Raynaud showed that if a Banach space uniformly embeds into a superstable Banach space, then X must contain an isomorphic copy of ℓ_p, for some $p \in [1, \infty)$. In this talk, I present a joint work with A. Swift in which we show that if a Banach space coarsely embeds into a superstable Banach space, then X has a spreading model isomorphic to ℓ_p, for some $p \in [1, \infty)$. In particular, we obtain that there exist reflexive Banach spaces which do not coarsely embed into any superstable Banach space. (Received July 18, 2017)

1131-46-355 **Ben Wallis*** (benwallis@live.com), Dekalb, IL 60115, and **Fernando Albiac** and **Jose L Ansorena**. *Garling sequence spaces.*

We introduce and investigate a new class of separable Banach spaces modeled after an example of Garling from 1968. For each $1 \leq p < \infty$ and each nonincreasing weight $w \in c_0 \setminus \ell_1$ we exhibit an ℓ_p-saturated, complementably homogeneous, and uniformly subprojective Banach space $g(w, p)$. We also show that $g(w, p)$ admits a unique subsymmetric basis despite the fact that for a wide class of weights it does not admit a symmetric basis. This provides the first known examples of Banach spaces where those two properties coexist. (Received July 18, 2017)

1131-46-356 **J. Alejandro Chávez-Domínguez*** (jachavezd@math.ou.edu), Norman, OK 73019. *An Ando-Choi-Effros lifting theorem respecting subspaces.*

We prove a version of the Ando-Choi-Effros lifting theorem respecting subspaces, which in turn relies on Oja's principle of local reflexivity respecting subspaces. To achieve this, we first develop a theory of pairs of M-ideals. As a first consequence we get a version respecting subspaces of the Michael-Pełczyński extension theorem. Other

applications are related to linear and Lipschitz bounded approximation properties for a pair consisting of a Banach space and a subspace. We show that in the separable case, the BAP for such a pair is equivalent to the simultaneous splitting of an associated pair of short exact sequences given by a construction of Lusky. We define a Lipschitz version of the BAP for pairs, and study its relationship to the (linear) BAP for pairs. The two properties are not equivalent in general, but they are when the pair has an additional Lipschitz-lifting property in the style of Godefroy and Kalton. We also characterize, in the separable case, those pairs of a metric space and a subset whose corresponding pair of Lipschitz-free spaces has the BAP. (Received July 18, 2017)

49 ► Calculus of variations and optimal control; optimization

1131-49-83 **Vakhtang Putkaradze*** (putkarad@ualberta.ca), University of Alberta, CAB 632, Edmonton, Alberta T6G2G1, Canada. *Variational approach to fluid-structure interactions: friction, constraints, Darcy's law and poromechanics.*

This work is motivated by the study of mechanics of elastic porous media filled with fluid. Using a variational geometric approach coupled with the Lagrange-d'Alembert's method for friction forces, we derive the equations of motion for both the elastic media and the fluid inside the media. We then study some simplified cases such as a pendulum with a moving viscous droplet. We show that the analogue of Darcy's law in these simplified models comes from the short-term convergence to a 'constraint manifold' in a singular perturbation problem, and the following long-term dynamics on that manifold. The resulting Darcy's law can reduce to either holonomic or non-holonomic constraint for the motion, depending the physical realization. We also demonstrate that care must be taken in formulating Darcy's law as the long-term dynamics can change drastically for small perturbations of the system. We discuss the relevance of these results for poromechanics and consider some simplified physical cases of the porous media motion.

This is a joint work with Akif Ibraguimov (Texas Tech) and Dmitry Zenkov (NCSU). The work was partially supported by NSERC Discovery grant and the University of Alberta. (Received July 05, 2017)

1131-49-148 **Ryan W Matzke*** (matzk053@umn.edu), **Dmitriy Bilyk** and **Feng Dai**. *Stolarsky Principle and Energy Optimization on the Sphere.*

The classical Stolarsky Invariance Principle connects the L^2 discrepancy of a finite point set on the sphere to the pairwise sum of Euclidean distances between the points. By extending this result to arbitrary measures and arbitrary notions of discrepancy, we can approach an array of problems of energy optimization from the stand point of discrepancy theory. In particular, we can determine the maximum sum of geodesic distances between points on the sphere, and the arrangements that produce it. (Received July 11, 2017)

51 ► Geometry

1131-51-256 **Philip Puente*** (philippuente@my.unt.edu), 1030 Dallas DR APT 1022, Denton, TX 76205. *Crystallographic complex reflection groups and the Braid Conjecture.*

Crystallographic complex reflection groups are generated by reflections about affine hyperplanes in complex space and stablize a full rank lattice. These analogs of affine Weyl groups have infinite order and were classified by V.L. Popov. The classical Braid Theorem (first established by E. Artin and E. Brieskorn) asserts that the Artin group of a reflection group (finite or affine Weyl) gives the fundamental group of regular orbits. In other words, the fundamental group of the space with reflecting hyperplanes removed has a presentation mimicking that of the Coxeter presentation; one need only remove relations giving generators finite order. N.V. Dung used a semi-cell construction to prove the Braid Theorem for affine Weyl groups. Malle conjectured that the Braid Theorem holds for all crystallographic complex reflection groups after constructing Coxeter-like reflection presentations. We show how to extend Dung's ideas to crystallographic complex reflection groups and then extend the Braid Theorem to some groups in the infinite family [G(r,p,n)]. The proof requires a new classification of crystallographic groups in the infinite family that fail the Steinberg Theorem. These reflection groups exhibit points with non regular orbits that lie off of the reflecting hyperplanes. (Received July 17, 2017)

1131-51-420 **James H Staff*** (james.staff@ttu.edu), Lubbock, TX 79414. *Weyl quantization of Chern-Simons theory on a torus.* Preliminary report.

This talk concerns quantum Chern-Simons theory on a torus. For suitable choices of gauge group G, rigorous analytic models for the quantum theory are determined by Weyl quantization via geometric quantization of the moduli space of flat G-connections on the torus. In the case $G = SU(2)$, R. Gelca and A. Uribe showed that this quantum model is equivalent to the Reshetikhin-Turaev model arising from quantum groups. This Weyl quantization scheme is possible whenever G is compact and simply connected. I will describe this process with the case $G = SU(3)$ and discuss the resulting model. (Received July 18, 2017)

52 ► Convex and discrete geometry

1131-52-82 **Anthony W Harrison*** (aharri60@kent.edu) and **Jenya Soprunova**. *Computing the lattice size of a lattice polygon.*

Combinatorial and geometric properites of polyhedra are often useful for answering algebraic questions about toric varieties. Determining the lattice size of a polygon is such an instance with applications to toric surfaces and error-correcting codes.

The lattice size of a lattice polygon P, denoted $\mathrm{ls}(P)$, is defined to be the smallest number n such that the image of P under an affine unimodular transformation is contained within the n-dilate of the standard 2-simplex. Castryck, Cools, and Shicho showed that there is a recursive algorithm that computes the lattice size of P by relating $\mathrm{ls}(P)$ to the lattice size of the convex hull of the interior lattice points of P.

We have developed an algorithm that computes the lattice size of P without the computational expense of determining the interior lattice points. We show that if a fixed, finite set of transformations does not yield a "smaller" image of P, then a translate of P already fits in the smallest possible dilate. This allows the determination of the lattice size by using operations that only require the vertices of P.

We also discuss a variant of the lattice size where the unit cube is used in place of the simplex. (Received July 05, 2017)

1131-52-209 **Dmitry Zakharov*** (dvzakharov@gmail.com). *Discrete differential geometry, integrability, and lattices in pseudo-Euclidean spaces.*

Discrete differential geometry aims to find appropriate discrete analogues of notions of classical differential geometry. Instead of considering manifolds and maps between them, discrete differential geometry studies lattices in R^n and other manifolds.

The theory of integrable systems studies exact solutions to nonlinear differential equations. It has long been known that many special geometries are described by integrable equations, admitting many families of exact solutions. Recent work has shown that it is often possible to discretize the geometry while preserving the integrability. In other words, there exist discrete versions of constructions of classical differential geometry, and they satisfy certain discrete integrable systems. In the continuous limit, these discrete systems converge to the integrable equations, while the lattices converge to the classical geometries.

I will demonstrate this approach by looking at the Weierstrass representation of surfaces in Euclidean and pseudo-Euclidean space. Such surfaces are defined by a solution to a Dirac equation, and an appropriate discretization of the Dirac equation defines lattices of isotropic vectors in pseudo-Euclidean space. (Received July 14, 2017)

1131-52-271 **N M Ercolani***, Department of Mathematics, 617 N. Santa Rita Avenue, University of Arizona, Tucson, AZ 85721-0089. *Discrete Surfaces and Quantum Gravity.*

The idea of describing rough or random surfaces in terms of *worldsheets* for a discretization of the Euclidean Einstein-Hilbert action in 2 dimensions goes back to Polyakov and leads to a beautiful variational problem for the probability generating functions of these combinatorial objects. In this talk we will briefly review this problem and describe its recent resolution in terms of Hopf algebras related to inverse Bessel functions. (This is joint work with Patrick Waters.) We hope to also have the time to at least pose the question of extending this subject to its Lorentzian analogue. (Received July 17, 2017)

53 ► Differential geometry

1131-53-25 **James Isenberg**, **Dan Knopf*** (danknopf@math.utexas.edu) and **Natasa Sesum**. *Non-Kahler Ricci flow singularities that converge to Kahler-Ricci solitons.*

We investigate Riemannian (non-Kähler) Ricci flow solutions that develop finite-time Type-I singularities with the property that parabolic rescalings at the singularities converge to singularity models that are shrinking Kähler–Ricci solitons. More specifically, the singularity model for these solutions is the "blowdown soliton" discovered in [FIK03]. Our results support the conjecture that the blowdown soliton is stable under Ricci flow. This work also provides the first set of rigorous examples of non-Kähler solutions of Ricci flow that become asymptotically Kähler, in suitable space-time neighborhoods of developing singularities, at rates that break scaling invariance. These results support the conjectured stability of the subspace of Kähler metrics under Ricci flow. (Received May 23, 2017)

1131-53-27 **Pushpi J Paranamana*** (pushpi.paranamana@ttu.edu), Department of Mathematics & Statistics, Texas Tech University, Lubbock, TX 79410, and **Eugenio Aulisa**, **Magdalena Toda** and **Akif Ibragimov**. *Hypersurface model of the fracture for nonlinear fluid flows.* Preliminary report.

In this work, we analyze the flow filtration process of slightly compressible fluids in porous media containing fractures with complex geometries. We model the coupled fracture-porous media system where the linear Darcy flow is considered in porous media and the nonlinear Forchheimer equation is used inside the fracture. Also, we devise a model to address the complexity of the fracture geometry which examines the flow inside fractures with variable thickness on a general manifold. The fracture is represented as the normal variation of a surface immersed in $\mathbb{R}^3$ and using Laplace Beltrami operator, we formulate an equation that describes the flow and then further simplifications were done. Using the model, pressure profile of a nonlinear flow is analyzed and compared with the actual pressure profile obtained numerically in order to validate the model. (Received May 26, 2017)

1131-53-57 **Rafael Lopez*** (rcamino@ugr.es), Departamento de Geometria y Topologia, Universidad de Granada, 18071 Granada, Spain. *Construction of new minimal and maximal surfaces: the Björling problem and duality.*

The Björling problem consists of finding a minimal surface in Euclidean space $\mathbb{E}^3$ containing a given curve and a prescribed unit normal vector to the surface along this curve. Under holomorphic assumptions, Schwarz proved local existence obtaining an expression of the parametrization of the minimal surface involving nothing but integrals and analytic continuation of the initial data. There is a similar Björling problem for zero-mean curvature spacelike surfaces (maximal surfaces) in Lorentz-Minkowski space $\mathbb{L}^3$. Although the parametrization of the surface is simple, in the literature only a few explicit parametrizations of minimal/maximal surfaces are known.

In this talk we provide new and many examples of minimal surfaces by solving the Björling problem for a large class of curves and similar constructions can be done in $\mathbb{L}^3$. Finally, we relate minimal surfaces in $\mathbb{E}^3$ to maximal surfaces in $\mathbb{L}^3$ by the correspondence known as duality and we investigate whether two congruent minimal (maximal) surfaces have congruent dual maximal (minimal) surfaces. (Received July 17, 2017)

1131-53-99 **Hung T Tran*** (htt4@cornell.edu). *Rigidity of Einstein Four-Manifolds.*

In this talk, we first discuss the existence of Einstein metrics by integrable system methods. However, not every manifold admits such a structure. Even when it does, the structure is quite rigid: the moduli space of all metrics satisfying some general conditions contains only a single point. This is a joint work with Xiaodong Cao. (Received July 07, 2017)

1131-53-100 **Hung T Tran*** (htt4@cornell.edu). *Index of Free Boundary Minimal Hypersurfaces.*

A free boundary minimal hypersurface in the unit Euclidean ball is a critical point of the volume functional among all hypersurfaces with boundaries in the unit sphere, the boundary of the ball. The Morse index gives the number of distinct admissible deformations which decrease the area to second order. In this talk, we discuss recent developments in this area and give explicit index computation for many known examples. Part of this is a joint work with Ari Stern, Detang Zhou, and Graham Smith. (Received July 07, 2017)

1131-53-112 **Magdalena D Toda*** (magda.toda@ttu.edu), Dept. Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, and **Fangyuan Zhang** (fangyuan.zhang@ttu.edu), Dept. Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Beta Barrels as Elastic Surfaces.*

This study provides a complete characterization of beta barrels as rotational elastic surfaces, and shows that the dimensions ratio completely determines their exact shape. The elastic surface models of beta barrels, as obtained by advanced numerical integration for integrable systems, have been validated by the statistical analysis performed on protein data banks. The elastic model proves itself as a clear winner over the previous beta barrel models that were tried as best-fits over the past few decades. (Received July 08, 2017)

1131-53-113 **Magdalena D Toda*** (magda.toda@ttu.edu), Department of Mathematics and Statististics, Texas Tech University, Lubbock, TX 79409-1042. *Boundary Value Problems for Generalized Willmore Equations.*

This report studies the solutions of certain boundary value problems for the generalized Willmore equation (GWE). Minimal solutions and CMC solutions of such boundary value problems are described as particular, separate subcases. Bio-physical applications are of particular interest and relevance to our study, and will be presented briefly. (Received July 08, 2017)

1131-53-114 **Shihshu Walter Wei*** (wwei@ou.edu), Department of Mathematics, 601 Elm Ave #423, The University of Oklahoma, Norman, OK 73019. *F-harmonic maps through the development of deep analytic techniques and applications.*

F-harmonic maps (where $F : [0,\infty) \to [0,\infty)$ is a C^2 nondecreasing function with $F(0) = 0$) are natural generalizations of geodesics, minimal submanifolds, harmonic maps, maximal spacelike hypersurfaces, functions of least gradient, harmonic 1-forms with integral periods, p-harmonic maps, conformal maps between equal dimensional manifolds, exponential harmonic maps, holomorphic maps between Kähler manifolds, etc. We recall a smooth map $u : M \to N$ between Riemannian manifolds M and N is said to be F-harmonic if u is a critical point of F-energy functional E_F with respect to any compactly supported variation, given by

$$E_F(u) = \int_M F(\frac{1}{2}|du|^2)\, dv$$

Here the $|du|$ denotes the Hilbert-Schmidt norm of the differential du of u and dv is the volume element of M.

We will describe the background and current work of F-harmonic maps through the development of deep analytic techniques and applications. (Received July 08, 2017)

1131-53-133 **Dami Lee*** (damilee@indiana.edu), Indiana University, 831 E 3rd St, Bloomington, IN 47405. *Geometric Realization of Cyclic Branched Covers as Infinite Regular Polyhedra.*

In this talk, we relax Coxeter-Petrie's definition of infinite regular polyhedra. With the weaker definition we are able to construct more polyhedra whose polyhedral metrics induce conformal structures. We will provide examples that are conformally equivalent to known surfaces such as Schoen's I-WP surface and Kepler's small stellated dodecahedron. If time permits, we will present one way of classifying such polyhedra. (Received July 11, 2017)

1131-53-221 **Barbara A. Shipman*** (bshipman@uta.edu), **Patrick D. Shipman** and **Stephen P. Shipman**. *Lorentz-conformal transformations and timelike surfaces of zero mean curvature.* Preliminary report.

Lorentz-conformal transformations in the plane satisfy, with sufficient smoothness, the Lorentz-Cauchy-Riemann equations and the wave equation. These maps are holomorphic with respect to a hyperbolic structure on the plane. Taking Lorentz-conformal generating functions in Weierstrass-Enneper expressions for timelike surfaces in Lorentz 3-space produces timelike surfaces with zero mean curvature. Solutions of the wave equation may be naturally extended to non-smooth functions, creating variants of timelike surfaces with non-smooth features. (Received July 15, 2017)

1131-53-240 **Tomoki Ohsawa*** (tomoki@utdallas.edu), 800 W Campbell Rd, Richardson, TX 75080-3021. *The Siegel Upper Half Space, Symplectic Reduction, and Gaussian Wave Packet.*

I will talk about the symplectic geometry behind the dynamics of the Gaussian wave packet, particularly the role of the Siegel upper half space in parametrizing the Gaussian wave packet. The Siegel upper half space is the set of symmetric complex matrices with positive-definite imaginary parts. Understanding the geometry of this space gives insights into the description of the dynamics of the Gaussian wave packet. Particularly, I will show that the Siegel upper half space is an example of the Marsden–Weinstein quotient of symplectic reduction. The result

provides a connection between two different formulations of Gaussian wave packet dynamics as Hamiltonian dynamical systems via symplectic reduction. (Received July 16, 2017)

1131-53-264 **Laney Bowden**, **Jason Cantarella**, **Andrea Haynes**, **Tom Needham** and **Clayton Shonkwiler*** (clay@shonkwiler.org), Colorado State University, Department of Mathematics, Campus Delivery 1874, Fort Collins, CO 80523, and **Aaron Shukert** and **Gavin Stewart**. *The Geometry of Polygon Space: Acute Triangles, Convex Quadrilaterals, Flag Means, and More.*

"Three Points are taken at random on an infinite Plane. Find the chance of their being the vertices of an obtuse-angled Triangle."

This is the text of Lewis Carroll's Pillow Problem #58, from 1884. This and similar problems (e.g., "what's the probability that a random quadrilateral is convex?") sparked intense debate in the 19th century as mathematics was just starting to get to grips with the basics of geometric probability.

Using Carroll's problem as motivation, I will describe an identification between the space of planar n-gons and the Grassmannian of 2-planes in $\mathbb{R}^n$ inspired by work of Hausmann and Knutson. This identification allows us to leverage the geometry of the Grassmannian to compute the exact probability that a triangle is obtuse and that a polygon is convex and to determine the most scalene triangle.

Though this work is focused on planar polygons with few edges, it provides a template for integration and clustering in the physically-relevant setting of polygons in space, which are used to model ring polymers in solution. (Received July 17, 2017)

1131-53-269 **T. Arias-Marco**, **E. Dryden**, **C. S. Gordon**, **A. Hassannezhad**, **A. Ray*** (allie.ray@trincoll.edu) and **E. Stanhope**. *The Steklov Spectrum on Orbifolds.*

The classical question "Can one hear the shape of a drum?" considers what geometric information about a differentiable manifold can be obtained by its Laplace spectrum. We modify this question to consider the Steklov spectrum on an orbifold (a mildly singular version of a manifold). In particular, we will discuss whether the Steklov spectrum can detect the presence of singular points on a compact 2-dimensional orbifold. (Received July 17, 2017)

1131-53-314 **C Robin Graham** (robin@math.washington.edu) and **Nicholas Reichert*** (nwr@uw.edu). *Higher-dimensional Willmore energies via minimal submanifold asymptotics.*

An overview of the derivation of a conformally invariant generalization of the Willmore energy for compact immersed submanifolds of even dimension in a Riemannian manifold is given. The energy arises as the coefficient of the log term in the renormalized area expansion of a minimal submanifold in a Poincare-Einstein space with prescribed boundary at infinity. Its first variation is identified as the obstruction to smoothness of the minimal submanifold. The energy is explicitly identified for the case of submanifolds of dimension four. Variational properties of this four-dimensional energy are discussed when the background is a Euclidean space or a sphere, including identifications of critical embeddings, questions of boundedness above and below for various topologies, and second variation. (Received July 17, 2017)

1131-53-354 **Lance Drager*** (lance.drager@ttu.edu), Department of Math and Stat, Texas Tech University, Lubbock, TX 79409-1042, and **Jeffrey M. Lee** and **Jack L. Follis**. *Underactuated control, parallel transport and a geometry problem.* Preliminary report.

Suppose we have a point p in a Riemannian manifold and a subspace V_0 in the tangent space at p. A curve $\gamma(t)$ starting at p will be called admissible if $\gamma'(t) \in V_t$ where V_t is the parallel translation of V_0 along γ. The problem is to find the points that can be reached along admissible curves starting at p.

If V_0 is contained in the tangent space of a totally geodesic submanifold T, then admissible curves starting a p must stay in T. Thus, our problem is related to totally geodesic submanifolds.

We will describe a setting for attacking this problem, and report on the result of applying this apparatus in the example of the three dimensional Heisenberg Group with a left invariant metric. (Received July 18, 2017)

1131-53-365 **Anusha Mangala Krishnan*** (anushakr@sas.upenn), Dept of Mathematics, David Rittenhouse Labs, 209 South 33rd Street, PHILADELPHIA, PA 19104-6395. *Cohomogeneity one Ricci flow and non negative curvature.*

We show that S^4, $\mathbb{C}P^2$, $S^2 \times S^2$ and $\mathbb{C}P^2 \# -\mathbb{C}P^2$ admit metrics of nonnegative sectional curvature which immediately lose this property under the Ricci flow. Although this was previously known for compact manifolds of dimension > 5 and for non-compact manifolds, these are the first compact 4-dimensional examples showing such behaviour, and show some limitations of the Ricci flow above dimension 3 (where non negative sectional curvature is preserved). Our approach involves studying the Ricci flow on manifolds admitting an isometric

cohomogeneity one group action. This talk is based on joint work with Renato Bettiol. (Received July 18, 2017)

1131-53-397 **Joseph Ansel Hoisington*** (jhois@math.upenn.edu), University of Pennsylvania, Mathematics Department, 209 S. 33rd St., Philadelphia, PA 19104. *Total Curvature and the Betti Numbers of a Complex Projective Manifold.*

We will show that the sum of the Betti numbers of a complex projective manifold can be estimated in terms of its total curvature, as measured by the second fundamental form of its immersion into projective space, and characterize the manifolds whose total curvature is minimal. These results extend the classic theorems of Chern and Lashof to a new setting. (Received July 18, 2017)

1131-53-398 **Ruth Gornet***, rgornet@uta.edu, and **Jeffrey McGowan**, mcgowan@ccsu.edu. *Lens spaces, isospectral on sporadic forms.*

The authors report on work in progress in expanding and correcting their previous paper 'Lens Spaces, isospectral on forms but not on functions.' Building on work of Ikeda in 'Riemannian manifolds p-isospectral but not (p + 1)-isospectral', the authors use the computer to compare the p-spectral of lens spaces. Recall that lens spaces are Riemannian manifolds that are quotients of canonical spheres by finite cyclic groups of isometries. (Received July 18, 2017)

54 ► General topology

1131-54-190 **Logan Crone**, **Lior Fishman**, **Nathaniel Hiers*** (nathanielhiers@my.unt.edu) and **Stephen Jackson**. *The 2-Rothberger Game and a Generalization of Galvin's Theorem.*

We will show that the Rothberger game $G_1(\mathcal{O},\mathcal{O})$ and the 2-Rothberger game $G_2(\mathcal{O},\mathcal{O})$ are equivalent for T_2 spaces. We will also generalize Galvin's classic theorem about the duality of the Rothberger and point-open games in two ways.

II is said to win the $\mathcal{P}$-Rothberger game (and I is said to win the $\mathcal{P}$-point open game) when II's moves form a sequence that satisfies $\mathcal{P}$. First, we will show that Galvin's Theorem holds when the Rothberger and point-open games are generalized in this way with respect to a property $\mathcal{P}$. Next, we will show that when the property $\mathcal{P}$ is coordinatewise monotone, the duality of the $\mathcal{P}$-2-Rothberger game and the $\mathcal{P}$-2-point-open game also holds. (Received July 14, 2017)

57 ► Manifolds and cell complexes

1131-57-12 **Charles Frohman*** (charles-frohman@uiowa.edu), **Joanna Kania-Bartoszynska** and **Thang Le**. *Representations of the Kauffman Bracket Skein Algebra at Roots of Unity.*

Let ζ be an nth root of unity, and F be a finite type oriented surface. The Kauffman bracket skein algebra $K_\zeta(F)$ is an algebra over the complex numbers with basis the simple diagrams on F and multiplication given by stacking and resolving crossings using the Kauffman bracket skein relations. We prove a conjecture of Bonahon and Wong about irreducible represetations of $K_\zeta(F)$.

An irreducible representation $\rho : K_\zeta(F) \to M_N(\mathbb{C})$ is a surjective homomorphism to a matrix algebra. We prove generically, the irreducible representations of $K_\zeta(F)$ are determined by their central characters, and those generic representations all have the same dimension, which is the rank of $K_\zeta(F)$ as a module over its center. (Received May 01, 2017)

1131-57-15 **Mustafa Hajij*** (mhajij@usf.edu), tampa, FL 33647. *COEFFICIENTS STABILITY OF THE COLORED JONES POLYNOMIAL AND TWIST REGIONS.*

We prove that the coefficients of the colored Jones polynomial of alternating links stabilize under increasing the number of twists in the twist regions of the link diagram. This gives us an infinite family of q-power series derived from the colored Jones polynomial parametrized by the color and the twist regions of the alternating link diagram. (Received May 07, 2017)

1131-57-53 **Tian Yang***, TAMU, college station, TX 77843. *Volume conjectures for Reshetikhin-Turaev and Turaev-Viro invariants.*

In a joint work with Qingtao Chen, we conjecture that at the root of unity $exp(2\pi i/r)$ instead of the usually considered root $exp(\pi i/r)$, the Turaev- Viro and the Reshetikhin-Turaev invariants of a hyperbolic 3-manifold grow expo- nentially with growth rates respectively the hyperbolic and the complex volume of the manifold. This

reveals a different asymptotic behavior of the relevant quantum invariants than that of Wittens invariants (that grow polynomially by the Asymp- totic Expansion Conjecture), which may indicate a different geometric interpretation of the Reshetikhin-Turaev invariants than the SU(2) Chern-Simons gauge theory. Recent progress toward these conjectures will be summarized, including a joint work with Renaud Detcherry and Effie Kalfagianni. (Received June 27, 2017)

1131-57-54 **Francis Bonahon*** (fbonahon@math.usc.edu). *Miraculous cancellations for traces of 2-by-2 matrices.*

In earlier work, Helen Wong and the author discovered unexpected central elements in the Kauffman bracket skein algebra $\mathcal{S}^q(S)$ of a surface S, when the quantum parameter q is a root of unity. The talk will place these results in a more representation theoretic framework, involving the quantum group $\mathrm{U}_q(\mathfrak{sl}_2)$ and its dual Hopf algebra SL_2^q. More precisely, the key ingredient involves certain miraculous cancellations for traces of $\mathcal{A}$-points of SL_2^q, which are 2-by-2 matrices whose entries take value in a non-commutative algebra $\mathcal{A}$. (Received June 27, 2017)

1131-57-88 **Adam M Lowrance*** (adlowrance@vassar.edu) and **Dean Spyropoulos**. *The Jones polynomial of an almost alternating link.* Preliminary report.

A link is almost alternating if it is non-alternating and has a diagram that can be transformed into an alternating diagram via one crossing change. In this talk, we discuss the Jones polynomial of an almost alternating link. We show that the Jones polynomial of an n-component almost alternating link is different from the Jones polynomial of the n component unlink. We also provide obstructions to a link being almost alternating arising from the coefficients of the Jones polynomial. (Received July 05, 2017)

1131-57-98 **Michelle Chu*** (mchu@math.utexas.edu). *Special subgroups of Bianchi groups.* Preliminary report.

Every cusped arithmetic hyperbolic 3-manifold is commensurably to the quotient of $\mathbb{H}^3$ by a Bianchi group. The Bianchi groups are the groups $\mathrm{PSL}_2(\mathcal{O}_d)$ where $\mathcal{O}_d$ is the ring of integers in the imaginary quadratic field $\mathbb{Q}(\sqrt{-d})$. Recently there has been interest in determining special subgroups of 3-manifold groups. For the Bianchi groups, we explicitly determine special congruence subgroups. (Received July 06, 2017)

1131-57-130 **Abhijit Champanerkar*** (abhijit@math.csi.cuny.edu), Department of Mathematics, 2800 Victory Blvd, Staten Island, NY 10314, **Ilya Kofman** (ikofman@math.csi.cuny.edu), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Blvd, Staten Island, NY 10314, and **Jessica Purcell** (jessica.purcell@monash.edu), School of Mathematical Sciences, 9 Rainforest Walk, Room 401, Monash University, Melbourne, VIC 3800, Australia. *Geometry of biperiodic alternating links.*

In this talk we will discuss the hyperbolic geometry of alternating link complements in the thickened torus. For links whose projection is related to a biperiodic edge-to-edge Euclidean tiling with convex regular polygons, we will describe the complete hyperbolic structure on their complements explicitly, and highlight some properties of such tilings. We will also discuss some conjectures related to determinant, volume and their limits. (Received July 17, 2017)

1131-57-139 **Jozef H. Przytycki*** (przytyc@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20 052. *Applications of partial presimplicial sets.*

We show, in my talk, three applications of partial presimplicial sets.

Let X_n be a family of sets, $n \geq 0$, R a commutative ring, RX_n the R-module with basis X_n, and $d_{i,n} = d_i : RX_n \to RX_{n-1}$ for $0 \leq i \leq n$. We say that (X_n, d_i) is a partial presimplicial set if

(1) (RX_n, d_i) is a presimplicial module, that is $d_i d_j = d_{j-1} d_i$ for $i < j$, and

(2) for any $x_n \in X_n$ we have $d_i(x_n) \in X_{n-1}$ or $d_i(x_n) = 0$.

Applications of partial presimplicial sets rest on the fact that they have easy to describe geometric realization (as a CW-complex).

We present three examples where geometric realization is of interest:

(1) Almost extreme Khovanov homology of semi-adequate links (work with Marithania Silvero).

(2) Geometric realization of comultiplication free Khovanov homology (e.g. Helme-Guizon–Rong chromatic homology of graphs). Here the conjecture is that the geometric realization is a wedge of spheres and suspensions of projective planes.

(3) Quandle homology of spindles (work of Takefumi Nosaka and Seung Yeop Yang). (Received July 11, 2017)

1131-57-232 **Carmen Caprau***, Department of Mathematics, California State University-Fresno, 5245 North Backer Avenue M/S PB 108, Fresno, CA 93740, and **Heather Dye**. *On the SO(2n) polynomial for virtual links.* Preliminary report.

We construct a state-sum formula for a one-variable polynomial invariant of virtual knots and links. When restricted to classical knots and links, the resulting invariant is the SO(2n) polynomial, that is a one-variable specialization of the Dubrovnik polynomial of unoriented classical knots and links. (Received July 16, 2017)

1131-57-245 **Mark Brittenham*** (mbrittenham2@math.unl.edu), Department of Mathematics, Avery 203, University of Nebraska, Lincoln, NE 68588-0130, and **Susan Hermiller** (hermiller@unl.edu), Department of Mathematics, Avery 203, University of Nebraska, Lincoln, NE 68588-0130. *Unknotting number and minimal crossing diagrams.*

For every knot whose unknotting number we know, there is a minimal crossing diagram for the knot so that changing one of the crossings results in a knot with lower unknotting number. It has long been hoped that this was true of every knot; this would, in principle, provide an algorithm to compute unknotting number. We report on the results of a computer search which establishes that this cannot hold in general, however; there is a knot for which no crossing change in any minimal diagram for the knot lowers unknotting number. (Received July 18, 2017)

1131-57-267 **Sujoy Mukherjee*** (sujoymukherjee@gwu.edu), **Józef H. Przytycki**, **Marithania Silvero**, **Xiao Wang** and **Seung Yeop Yang**. *Khovanov homology and torsion.*

Khovanov homology, an invariant of knots and links, is a categorification of the Jones polynomial. $\mathbb{Z}_2$ torsion in the Khovanov homology of knots and links is very common. In this talk, I will discuss recent developments regarding non-$\mathbb{Z}_2$ torsion in Khovanov homology. In particular, I will provide examples of links with large even torsion and counterexamples to parts of the PS braid conjecture. (Received July 17, 2017)

1131-57-285 **Thomas Kerler*** (kerler.2@osu.edu), The Ohio State University, Department of Mathematics, 231 West 18th Avenue, Columbus, OH 43210, and **Yu Tsumura** and **Yilong Wang**. *On Dihedral Structures in $SO(m)_2$-Fusion Catgeories and Applications to TQFT.* Preliminary report.

The fusion categories associated to quantum-$SO(m)$ at level two are important non-trivial examples of weakly integral fusion categories and, as such, have gained considerable interest in topological quantum computing. One special feature is that the zero-graded parts of these categories obey the classical fusion rules of dihedral groups. In this work we identify concrete quasi-triangular structures on the group algebras of dihedral groups whose representation categories are isomorphic to these sub-categories. We go on to discuss how and extended braided Hopf algebra structure on these dihedral group rings can be used to compute $SO(m)_2$-TQFTs combinatorially, without invoking standard categorical data such as 6-j-symbols. The hope is to gain insights in finiteness and integrality properties of TQFTs based on weakly integral categories. (Received July 17, 2017)

1131-57-288 **Louis H Kauffman*** (kauffman@uic.edu), 5530 South Shore Drive, Apt 7C, Chicago, IL 60637-1946. *Knotoids and Virtual Knot Theory.* Preliminary report.

This talk is joint work with Neslihan Gugumcu. A knotoid is a knot diagram with two ends. The ends can be in separate regions of the diagram. Equivalence is defined by Reidemeister moves that do not involve the ends of the diagram. We discuss the use of virtual knot theory to study knotoids. In particular, we define directly two invariants, the arrow polynomial and the affine index polynomial for knotoids and we use these invariants to obtain lower bounds on the complexity of knotoids. Here complexity denotes the height of a knotoid, a measure of the distance between the knotoid ends. We discuss our conjecture that the Jones polynomial (extended to knotoids) detects the unknotted knotoid. (Received July 17, 2017)

1131-57-312 **Samuel J. Lomonaco*** (lomonaco@umbc.edu), University of Marylan Baltimore County (UMBC), 1000 Hilltop Circle, Baltimore, MD 21250. *A reduction of 4-D knot theory to 3-D knot theory, and its application to the higher homotopy groups of knots.* Preliminary report.

We begin by showing how four dimensional knots [i.e., (4,2)-knots] can be represented as labelled embeddings of closed 4-valent graphs in 3-space. We then use this representation to compute the higher homotopy groups of four dimensional knots. (Received July 17, 2017)

1131-57-317 **Kate Petersen*** (petersen@math.fsu.edu). *Representations of Knot Groups.* Preliminary report.

The SL(2,C) character variety of a knot is the space of all representations of the fundamental group into SL(2,C) up to trace equivalence. The character variety carries a wealth of information about the topology of the knot

complement. I'll discuss some special representations and how they shed light on the geometry of the character variety. (Received July 17, 2017)

1131-57-318 **Jozef H. Przytycki** and **Xiao Wang*** (wangxiao@gwmail.gwu.edu). *Khovanov homology and Hochschild homology.*

Khovanov homology is a powerful invariant of links. In May of 2005, Przytycki pointed out the relation between Hochschild homology of the algebra $Z[x]/(x^2)$ and Khovanov homology of $(2, n)$-torus links. In this work, we will seek for more relation between Hochschild homology and Khovanov homology of other links. (Received July 17, 2017)

1131-57-366 **Charles D Frohman** and **Joanna Kania-Bartoszynska***, jkaniaba@nsf.gov, and **Thang Le**. *Commutativity in the Kauffman bracket skein algebra of a surface.*

Let F be an oriented, closed connected surface, possibly with some punctures. The Kauffman bracket skein algebra of F is formed by taking linear combinations of framed links embedded in a cylinder over F with coefficients in complex numbers, and dividing by the Kauffman bracket skein relations. We assume that the parameter involved in the relation is a root of unity. The multiplication comes from placing one link above another and extending linearly. We characterize the center of this algebra for any root of unity and any number of punctures (including none). We also show that for certain roots of unity a properly localized algebra of a surface with at least one puncture can be split over its center as a tensor product of two commutative subalgebras. (Received July 18, 2017)

1131-57-380 **Jeffrey M. Lee*** (jeffrey.lee@ttu.edu), Department of Math and Stat, Texas Tech University, Lubbock, TX 79409-1042, and **Lance Drager**, **Ken Richardson** and **Efton Park**. *Generalized Distributions are Spanned by Finitely Many Sections.*

Generalized subbundles of vector bundles arise in many fields. We show that such subbundles are spanned by finitely many global sections. We also show by example that the space of sections of such a subbundle may not be finitely generated (even locally) as a module over the ring of smooth functions. (Received July 18, 2017)

58 ► Global analysis, analysis on manifolds

1131-58-29 **Klaus Kirsten*** (klaus_kirsten@baylor.edu), Department of Mathematics, Waco, TX 76796, and **Yoonweon Lee** (yoonweon@inha.ac.kr), Department of Mathematics, Incheon, 402-751, South Korea. *The polynomial associated with the BFK-gluing formula of the zeta-determinant.*

Let M_1 and M_2 be two Riemannian manifolds each of which have the boundary N. Consider the Laplacian on M_1 and M_2 augmented with Dirichlet boundary conditions on N. A natural question to ask is if there is any relation between spectral properties of the Laplacian on M_1, M_2, and the Laplacian on the manifold (without boundary) $M = M_1 \cup_N M_2$. A partial answer is given by the Burghelea-Friedlander-Kappeler-gluing formula for zeta-determinants. This formula contains an (in general) unknown polynomial which is completely determined by some data on a collar neighborhood of the hypersurface N. In this talk I present results for the polynomial in terms of suitable geometric tensors on N. (Received June 01, 2017)

1131-58-117 **Nicolae Anghel*** (anghel@unt.edu), 1155 Union Circle # 311430, Denton, TX 76203. *Fredholmness vs. Spectral Discreteness for First Order Differential Operators.*

In this talk it is shown that for essentially self-adjoint first-order differential operators D, acting on sections of bundles over complete (non-compact) manifolds, Fredholmness vs. Spectral Discreteness is the same as '$\exists c > 0$, D is c-invertible at infinity' vs. '$\forall c > 0$, D is c-invertible at infinity'. An application involving the spectral theory of electromagnetic Dirac operators is then given. (Received July 09, 2017)

1131-58-229 **Shankar C. Venkataramani*** (shankar@math.arizona.edu), 617 N Santa Rita Ave, Department of Mathematics, University of Arizona, Tucson, AZ 85721, and **Toby Shearman** (tshearman@math.arizona.edu), 617 N Santa Rita Ave, Department of Mathematics, Tucson, AZ 85721. *Non-euclidean elasticity, discrete differential geometry and a generalized Sine-Gordon equation.*

Leaves, flowers and torn plastic bags are all examples of thin objects that are conjectured to have no stress-free configurations in $\mathbb{R}^3$. Non-euclidean elasticity is the study of energy driven pattern formation in such objects. I will discuss some recent geometric and numerical approaches to this problem, and discuss some of the intriguing results including –

(i) a generalization of the Sine-Gordon equation to describe "rough" hyperbolic surfaces with constant negative curvature, and (ii) the important role of regularity in quantitative versions of the Hilbert-Efimov theorem on the nonexistence of isometric immersions of the Hyperbolic plane into $\mathbb{R}^3$.

This is joint work with Toby Shearman (U. Arizona). (Received July 16, 2017)

1131-58-331 **Georges Habib** (ghabib@ul.edu.lb), Lebanese University, Faculty of Sciences II, Dept. Mathematics, P.O. Box 90656, Fanar-Matn, Lebanon, and **Ken Richardson*** (k.richardson@tcu.edu), Dept. of Mathematics, Texas Christian University, Fort Worth, TX 76129. *Homotopy invariance of cohomology and signature of a Riemannian foliation.*

We prove that any smooth foliation that admits a Riemannian foliation structure has a well-defined basic signature, and this geometrically defined invariant is actually a foliated homotopy invariant. We also show that foliated homotopic maps between Riemannian foliations induce isomorphic maps on basic Lichnerowicz cohomology, and that the Álvarez class of a Riemannian foliation is invariant under foliated homotopy equivalence. The definitions and geometric interpretations of these words will be explained. (Received July 18, 2017)

1131-58-334 **Jochen Brüning** (bruening@mathematik.hu-berlin.de), Institut für Mathematik, Humboldt Universität zu Berlin, Unter den Linden 6, D-10099 Berlin, Germany, **Franz W Kamber** (kamber@math.uiuc.edu), Dept. of Mathematics, University of Illinois, 1409 W. Green S, Urbana, IL 61801, and **Ken Richardson*** (k.richardson@tcu.edu), Dept. of Mathematics, Texas Christian University, Fort Worth, TX 76129. *New formula for the equivariant index.*

We prove a new 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. Among the applications, we obtain a new index formula for all basic Dirac operators on Riemannian foliations, a problem that was open for many years. (Received July 18, 2017)

60 ► Probability theory and stochastic processes

1131-60-14 **Chuang Xu*** (cx1@ualberta.ca), Central Academic Building (CAB) 632, Department of Math and Stats, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Best finite constrained approximations of one-dimensional probabilities.*

This paper studies best finitely supported approximations of one-dimensional probability measures with respect to the L^r-Kantorovich (or transport) distance, where either the locations or the weights of the approximations' atoms are prescribed. Necessary and sufficient optimality conditions are established, and the rate of convergence (as the number of atoms goes to infinity) is discussed. Special attention is given to the case of best uniform approximations (i.e., all atoms having equal weight). The elementary approach is based on best approximations of (monotone) L^r-functions by step functions, which is different from, and naturally complementary to, the classical Voronoi partition approach. This is a joint work with Dr. Arno Berger. (Received May 03, 2017)

1131-60-89 **Andrey Sarantsev*** (sarantsev@pstat.ucsb.edu), South Hall 5607A, University of California, Santa Barbara, CA 93106. *STABLE SYSTEMS OF COMPETING LEVY PARTICLES.*

We consider a finite system of particles on the real line. Each particle moves as a Levy process, with parameters depending on its current rank relative to other particles. We prove that this system is ergodic under natural conditions. Similar models are used for financial modeling. (Received July 05, 2017)

1131-60-120 **Lewis Bowen*** (lpbowen@math.utexas.edu), 1 University Station C1200, Austin, TX 78712. *Random interlacements and the Gaboriau-Lyons problem.*

The von Neumann-Day problem asks whether every non-amenable group contains a non-abelian free group. It was answered in the negative by Ol'shanskii in the 1980's. The measurable version is still open. I will explain a recent positive answer in the case of Bernoulli shifts. The proof uses an approximation to the random interlacement process by random collections of geometrically-killed random walk paths. (Received July 10, 2017)

1131-60-274 **N M Ercolani***, Department of Mathematics, 617 N. Santa Rita Avenue, University of Arizona, Tucson, AZ 85721-0089. *The Statistical Mechanics of Integrable Nonlinear Lattice Equations.*

There are a number of, by now, classical studies of the statistical mechanics of nonlinear wave equations (for example by Lebowitz-Rose-Speer (1989) and McKean (1995) in the case of the Cubic Schrodinger Equation). We

are currently looking at discrete analogues in the case of the Ablowitz-Ladik system with an eye to paralleling recent developments in random matrix theory that connect to the hyperbolic Brownian Carousel or Prufer Phase Stochastic Differential Equations. For ease of exposition, in this talk we will focus on the simpler setting of the quasi-periodic Toda lattice and just try to motivate and describe the basic set-up. This is joint work with Diane Holcomb and Dylan Murphy. (Received July 17, 2017)

1131-60-422 **Indika P Wickramasinghe*** (ind_pradeep@yahoo.com), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446. *Classification Technique and the Accuracy of Data Classification.*

Though the accuracy of data classification depends on various features, the classification techniques plays a major role in data classification. Using a collected dataset about credit card transactions, this study compares four different data classification techniques for higher accuracy. In this study we consider four types of popular classification techniques, namely Support Vector Machines (SVM), Principal Component Analysis (PCA), Robust Principal Component Analysis (RPCA), and Random Forest. Out of the selected classification techniques, Random Forest performs better than its counterparts. In addition, the impact of the noise on accuracy of data classification also discusses. (Received July 19, 2017)

62 ► Statistics

1131-62-42 **David Kahle*** (david_kahle@baylor.edu), One Bear Place #97140, Waco, TX 76798, and **Chris O'Neill** and **Jeff Sommars**. *m2r: Macaulay2 in R.*

R is the programming lingua franca for statisticians and, increasingly, data scientists. In this talk we communicate recent efforts to port Macaulay2 into R with the m2r R package. We include a basic demo, an overview of some of the internals and the design philosophy, and how to get up and running on your own machine. Teaser: you won't need to install Macaulay2. (Received June 20, 2017)

1131-62-131 **Gautam Raghavendra Eapi*** (gautam.eapi@uta.edu) and **Mostafa Ghandehari**. *Comparison of ground level ozone levels among five cities.* Preliminary report.

Ozone is one of the six criteria pollutants according to United States Environmental Protection Agency (EPA). Analysis of Variance (ANOVA) is used to decide if there is any statistical significance among five cities. Environmental applications are discussed. (Received July 10, 2017)

1131-62-180 **Art Duval*** (aduval@utep.edu) and **Amy Wagler** (awagler2@utep.edu). *Matroids and statistical dependency.* Preliminary report.

What does it mean for a set of more than two variables to be statistically dependent, even if no two of them are pairwise dependent? We compare different ways of determining this dependency, show they are consistent, and interpret them geometrically. We show that, if we make common statistical assumptions on data, then the resulting structure of dependencies may be described by a matroid. (Received July 14, 2017)

1131-62-286 **Jared Lee Ostmeyer*** (jared.ostmeyer@utsouthwestern.edu), 5323 Harry Hines Blvd, Dallas, TX 75390-9066, and **Scott Christley**, **William Rounds**, **Inimary Toby**, **Nancy Monson** and **Lindsay Cowell** (lindsay.cowell@utsouthwestern.edu), 5323 Harry Hines Blvd, Dallas, TX 75390-9066. *Machine Learning on sets and sequences and its applications in diagnosing disease.*

We will present our methods for performing statistical classification on labeled sets and labeled sequences. Our overall approach is to score each item in a set or each symbol in a sequence using a parameterized scoring function and to aggregate the scores into a predicted label. When the items are permutation invariant, as is the case with a set, a generalized mathematical mean is used to reduce the scores to a single value and predict a label. When dealing with symbols in a sequence, the ordering of the symbols is critical information, and so we introduce the idea of aggregating the scores from each symbol using a recurrent weighted average. In either case, once a predicted label is obtained for each data point, we can define the likelihood function and use standard optimization techniques to determine specific values for the model's parameters. As a practical application of our research, we will show how to build a simple statistical classifier that takes a set of immune receptor sequences as input and reduces the data to a predicted diagnosis of either Multiple Sclerosis or other neurological disease. On unseen test data collected separately from our training data, our model achieves ∼75% accuracy, an improvement over the current standard diagnostic approach. (Received July 17, 2017)

1131-62-346 **Emil Horobet** and **Jose Israel Rodriguez*** (joisro@uchicago.edu), University of Chicago, Department of Statistics, Chicago, IL 60637. *Subvarieties of the likelihood correspondence.* Preliminary report.

The likelihood correspondence encodes geometric properties of maximum likelihood estimation for discrete statistical models. Restricting the correspondence to a particular data point allows us to find all local maxima of the likelihood function on a statistical model. This solves the problem of maximum likelihood estimation under reasonable hypothesis. If one considers missing data, then we are studying the likelihood correspondence restricted to a linear space of data points. Alternatively, we can ask which data points yield critical points of the likelihood function with a particular property. All of these can be framed as instances of subvarieties of the likelihood correspondence. In this talk we use computational algebraic geometry to develop algorithms to determine these subvarieties. (Received July 18, 2017)

65 ► Numerical analysis

1131-65-24 **Ying Wang*** (wang@math.ou.edu). *Mathematical Analysis and Numerical Methods for an Underground Oil Recovery Model.*

In this talk, I will discuss a multi-scale underground oil recovery model which include a third-order mixed derivatives term resulting from the dynamic effects in the pressure difference between the two phases. Analytic study on the computational domain reduction will be provided. A variety of numerical examples in both one and two space dimensions will be given. They show that the solutions may have many different saturation profiles depending on the initial conditions, diffusion parameter, and the third-order mixed derivatives parameter. The results are consistent with the study of traveling wave solutions and their bifurcation diagrams. (Received May 22, 2017)

1131-65-64 **Yifei Lou*** (yifei.lou@utdallas.edu), 800 West Campbell Road, Richardson, TX 75080, and **Sung Ha Kang**, **Stefano Soatto** and **Andrea Bertozzi**. *Video Stabilization of Atmospheric Turbulence Distortion.*

We present a method to enhance the quality of a video sequence captured through a turbulent atmospheric medium, and give an estimate of the radiance of the distant scene, represented as a "latent image," which is assumed to be static throughout the video. Due to atmospheric turbulence, temporal averaging produces a blurred version of the scene's radiance. We propose a method combining Sobolev gradient and Laplacian to stabilize the video sequence, and a latent image is further found utilizing the "lucky region" method. The video sequence is stabilized while keeping sharp details, and the latent image shows more consistent straight edges. We analyze the well-posedness for the stabilizing PDE and the linear stability of the numerical scheme. (Received June 30, 2017)

1131-65-74 **Jue Yan*** (jyan@iastate.edu), Department of Math, 396 Carver Hall, Iowa State University, Ames, IA 50010. *Direct discontinuous Galerkin methods for Keller-Segel Chemotaxis equations.* Preliminary report.

We develop a new direct discontinuous Galerkin (DDG) methods to solve Keller-Segel Chemotaxis equations. Different to available DG methods or other numerical methods in literature, we introduce no extra variable to approximate the chemical density gradients but solve the system directly. With P^k polynomial approximations, we observe no order loss and optimal (k+1)th order convergence is obtained. The reason that DDG methods is convergent with optimal orders is that DDG methods have the super convergence property on its approximating to solution gradients. With Fourier (Von Neumann) analysis technique, we prove the DDG solution's spatial derivative is super convergent with at least (k+1)th order under moment norm. We show the cell density approximations are strictly positive with at least third order of accuracy. We also carry out second order finite difference schemes to simulate the liquid and semi-solid models of chemotaxis. The pattern formations observed are consistent to those in literature. (Received July 02, 2017)

1131-65-127 **Xiaofeng Cai**, **Wei Guo** and **Jingmei Qiu*** (jingqiu@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77024. *A high order conservative semi-Lagrangian discontinuous Galerkin method for two-dimensional transport simulations.*

We develop a class of high order conservative semi-Lagrangian discontinuous Galerkin methods for solving multi-dimensional linear transport equations. The methods rely on a characteristic Galerkin weak formulation, leading to L^2 stable discretizations for linear problems. One key ingredient in the scheme formulation, borrowed from CSLAM *[Lauritzen, Nair & Ullrich, 2010]*, is the use of Green's theorem which allows us to convert volume

integrals into a set of line integrals. The resulting line integrals are much easier to approximate with high order accuracy, hence facilitating the implementation. Another novel ingredient is the construction of quadratic curves in approximating sides of upstream cell, leading to quadratic-curved quadrilateral upstream cells. Formal third order accuracy is obtained by such a construction. The desired positivity-preserving property is further attained by incorporating a high order bound-preserving filter. To assess the performance of the proposed methods, we test and compare the numerical schemes with a variety of configurations for solving several benchmark transport problems with both smooth and nonsmooth solutions. The efficiency and efficacy are numerically verified. (Received July 10, 2017)

1131-65-203 **Azmy S. Ackleh***, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, Louisiana 70506, and **Baoling Ma** and **Tingting Tang**. *A High-Resolution Finite Difference Method for a Nonlinear Model of Structured Susceptible-Infected Population Coupled with the Environment.*

In this talk I will present a general model describing a structured Susceptible-Infected (SI) population coupled with the environment. This model applies to problems arising in ecology, epidemiology and cell biology. The model consists of a system of quasilinear hyperbolic partial differential equations coupled with a system of nonlinear ordinary differential equations that represents the environment. I will discuss a second order high-resolution finite difference scheme to numerically solve the model. Convergence of this scheme to a weak solution with bounded total variation is established. Numerical simulations are provided to demonstrate the high-resolution property of the scheme. Finally, an application to a multi-host wildlife disease model is explored. (Received July 14, 2017)

1131-65-208 **Pierson T Guthrey*** (piersonguthrey@gmail.com), 428 S. Shaw Lane, East Lansing, MI 48824, and **James A Rossmanith** (rossmani@iastate.edu), 411 Morrill Road, Ames, IA 50014. *Regionally Implicit Discontinuous Galerkin Schemes for the Relativistic Vlasov-Maxwell System.*

The relativistic Vlasov-Maxwell system (RVM) models the behavior of collisionless plasma. Solving these equations is important in many application problems, including in the development of laser wakefield accelerators for medical imaging applications. The goal of the current work is to develop a new class of high-order accurate numerical methods for solving kinetic Vlasov models of plasma. The main discretization in configuration space is handled via a high-order finite element method called the discontinuous Galerkin method (DG). One difficulty is that standard explicit time-stepping methods for DG suffer from time-step restrictions that are significantly worse than what a simple Courant-Friedrichs-Lewy (CFL) argument requires. In this work, we overcome this difficulty by introducing a novel time-stepping strategy: the regionally-implicit discontinuous Galerkin method. Upon the development of the general RIDG method, we apply it to the non-relativistic 1D1V Vlasov-Poisson equations and the relativistic 1D2V Vlasov-Maxwell equations. For each we validate the high-order method on several test cases. In the final test case, we demonstrate the ability of the method to simulate the acceleration of electrons to relativistic speeds in a simplified laser wakefield accelerator example. (Received July 14, 2017)

1131-65-272 **Zicong Zhou*** (zicong.zhou@uta.edu), 411 S. Nedderman Drive, 478 Pickard Hall, Arlington, TX 76019-04, and **Guojun Liao**. *A Novel Deformation Method for Higher Oder Mesh Generation.*

In [G.Liao et.al, Adaptive Grid Generation based on the Least Square Finite Element Method(LSFEM)], the prescribed positive Jacobian determinant is essential and a LSFEM had built to solve the Div-Curl system that appears in Liao's deformation method for mesh generation. In this work, similarly to [G.Liao et.al, A New Method for Triangular Mesh Generation], this method is extended to generate higher order mesh by an adaptive moving mesh technique. Numerical examples for p=3 will be shown to demonstrate the procedures and its effectiveness. The applications in image registration will also be discussed, as presented in [X.Chen et.al, New Variational Method of Grid Generation with prescribed Jacobian determinant and prescribed curl] and [X.Chen et.al, New method of averaging diffiomorphisms based on Jacobian determinant and curl vector]. (Received July 18, 2017)

1131-65-333 **Eric Chung**, **Yalchin Efendiev**, **Wing Tat Leung**, **Maria Vasilyeva** and **Yating Wang*** (wytgloria@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77840. *Multiscale model reduction for transport and flow problems in perforated domains.*

Convection-dominated transport phenomena have broadly applications. In these physical processes, the transport velocity is often a solution of a heterogeneous flow problem. In this work, we consider coupled flow (Stokes

problem) and transport (unsteady convection-diffusion problem) in perforated domains. We construct a coarse-scale solver based on Generalized Multiscale Finite Element Method (GMsFEM). The main idea of the GMsFEM is to develop a systematic approach for computing multiscale basis functions. We use a mixed formulation and appropriate multiscale basis for both flow and transport to guarantee mass conservation. Petrov-Galerkin mixed formulations are used for the transport problem, which guarantee stability. We consider two different approaches. As a first approach, we use the multiscale flow solution in constructing basis functions for the transport equation. In the second approach, the multiscale basis functions for flow and transport are constructed jointly. The novelty of this approach is to construct a coupled multiscale basis functions. An algorithm for adaptively adding online multiscale basis functions is presented to speed up convergence. In summary, our results indicate that only a few of the proposed basis functions are able to give accurate solutions. (Received July 18, 2017)

1131-65-384 **Mei Yang*** (mei.yang@mavs.uta.edu), 300 College Street. Apt.B, Arlington, TX 76010, and **Ren-Cang Li** (rcli@uta.edu), P.O. Box 19408, Department of Mathematics, University of Texas at Arlington, Arlington, TX 76019. *Heavy Ball Flexible GMRES Method for Linear System.*

GMRES method is one of Krylov subspace methods for nonsymmetric linear systems. There are many variants of GMRES method such as restarted GMRES, heavy ball GMRES (HBGMRES) and flexible GMRES (FGMRES). The heavy ball GMRES combines the restarted GMRES and the heavy ball method which is applied in optimization to accelerate the convergent speed. Inspired by HBGMRES, we present a heavy ball FGMRES method (HBFGMRES) not only to limit memory usage and control the orthogonalization cost, but also to cover up the slow convergence problem in restarted FGMRES. Numerical tests on real data are presented to demonstrate the superiority of the new methods restarted FGMRES. (Received July 18, 2017)

1131-65-394 **Gul Karaduman*** (gul.karaduman@mavs.uta.edu) and **Ren Cang Li**. *Iterative Solution of Saddle Point Problems by LSMR.* Preliminary report.

Wide variety of applications in computational science and engineering give rise to the non-symmetric saddle point problems of the form

$$\begin{bmatrix} A & B^T \\ B & 0 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} f \\ 0 \end{bmatrix}$$

where $A \in R^{n\times n}$, $B \in R^{m\times n}$ has a full column rank with $n \geq m$ and $f \in R^n$. This system can also be written as two linear systems $Ax + B^T y = f$, $Bx = 0$. In our work, we use a projection matrix Q to write the solution vector $x \in R^n$ as $x = Qz$, where $z \in R^n$, to transform the problem to a least squares problem. Least Square Minimal Residual Method(LSMR) is used to solve the least the system. Numerical experiments with matrices from various application areas show the potential of this approach. (Received July 18, 2017)

74 ► Mechanics of deformable solids

1131-74-407 **Dmitry Zenkov*** (dvzenkov@ncsu.edu). *Moving Frames in Mechanics.*

The use of moving frames and nonmaterial velocity in mechanics has a two and a half century long history. The key steps of this development were carried out by Euler, Poincaré, Hamel, and recently Marsden in relation to the dynamics and stability of rigid body, fluid, and interconnected mechanical systems. The talk will review some of these ideas and discuss recent development of this formalism for infinite-dimensional mechanical systems. (Received July 18, 2017)

76 ► Fluid mechanics

1131-76-34 **Eleftherios Gkioulekas*** (eleftherios.gkioulekas@utrgv.edu), University of Texas Rio Grande Valley, School of Mathematical and Statistical Scienc, 1201 West University Drive, Edinburg, TX 78539-2999. *Energy and potential enstrophy flux constraints in quasi-geostrophic models.*

We investigate an inequality constraining the energy and potential enstrophy flux spectra in two-layer and multi-layer quasi-geostrophic models. Its physical significance is that it can diagnose whether any given multi-layer model that allows co-existing downscale cascades of energy and potential enstrophy can allow the downscale energy flux to become large enough to yield a mixed energy spectrum where the dominant k^{-3} scaling is overtaken by a subdominant $k^{-5/3}$ contribution beyond a transition wavenumber k_t situated in the inertial range. The validity of the flux inequality implies that this scaling transition cannot occur within the inertial

range, whereas a violation of the flux inequality beyond some wavenumber k_t implies the existence of a scaling transition near that wavenumber. This flux inequality holds unconditionally in two-dimensional Navier-Stokes turbulence, however, it is far from obvious that it continues to hold in multi-layer quasi-geostrophic models, because the dissipation rate spectra for energy and potential enstrophy no longer relate in a trivial way, as in two-dimensional Navier-Stokes. (Received June 09, 2017)

1131-76-152 **Yue Liu*** (yliu@uta.edu), Department of Mathematics, University of Texas at Arlington, Arlington, TX 76019. *Asymptotic analysis on the modelling of the shallow-water waves with the Coriolis effect.* Preliminary report.

In this talk, a mathematical model of long-crested water waves propagating mainly in one direction with the effect of Earth's rotation is derived by following the formal asymptotic procedures. Such a model equation is analogous to the Camassa-Holm approximation of the two-dimensional incompressible and irrotational Euler equations and has a formal bi-Hamiltonian structure. Its solution corresponding to physically relevant initial perturbations is more accurate on a much longer time scale. It is shown that the deviation of the free surface can be determined by the horizontal velocity at a certain depth in the second-order approximation. The effects of the Coriolis force caused by the Earth rotation and nonlocal higher nonlinearities on blow-up criteria and wave-breaking phenomena are also investigated. Our refined analysis is approached by applying the method of characteristics and conserved quantities to the Riccati-type differential inequality. (Received July 12, 2017)

1131-76-292 **Nguyenho Ho*** (hono@uc.edu), **Karin Leiderman** and **Sarah Olson**. *A 3-dimensional model of flagellar swimming in a Brinkman fluid.*

We investigate 3-dimensional flagellar swimming in a fluid with a sparse network of stationary obstacles or fibers. The Brinkman equation is used to model the average fluid flow where a resistance term is inversely proportional to the permeability and represents the effect due to the presence of fibers. The flagellum is represented as a Kirchhoff rod that can exhibit propagating planar or spiral bending. To solve for the local fluid velocity and angular velocity, we use the method of regularized Brinkmanlets and extend it to the case for a Kirchhoff rod that is discretized as point forces and torques along the centerline. The new numerical method is validated by comparing to asymptotic swimming speeds derived for an infinite-length cylinder propagating lateral or spiral waves in a Brinkman fluid. Similar to the asymptotics, we observe that in the case of small amplitude, swimming speed is enhanced relative to the Stokes case as the resistance is increased. For larger amplitude bending, the simulations show a non-monotonic change in swimming speed as the resistance is varied. This is due to the emergent amplitude and wavelengths; as the resistance is increased (or as the number of stationary fibers is increased), the emergent amplitude of the swimmer has a tendency to decrease. (Received July 17, 2017)

1131-76-373 **Gautam Iyer***, Dept. of Math. Sci, WEH 6113, Carnegie Mellon University, Pittsburgh, PA 15213. *Time fractional PDE's arising in scalar transport.*

The long time behaviour of passively transported diffusive scalars is usually goverend by the heat equation. On intermediate time scales, however, the effective equation is often non-local in time. One situation where this was recently proved is in the context of cellular flows, and I will summarize this result briefly. I will also discuss other scenarios where time-nonlocal equations arise as scaling limits in the context of fluid flows, both from a deterministic and a probabilistic perspective. (Received July 18, 2017)

1131-76-377 **Vu Hoang***, duynguyenvu.hoang@utsa.edu. *Well-defined singularities for a nonlocal transport equation.* Preliminary report.

I consider a simple nonlocal transport equation in one space dimension. While it is easy to show that generic smooth solutions will blow up in finite time, constructing solutions that have a well-defined behavior at the singularity time is a hard problem. I discuss some helpful ideas and some present some preliminary results. (Received July 18, 2017)

81 ► Quantum theory

1131-81-47 **Razvan Gelca*** (rgelca@gmail.com), Department of Mathematics and Statistics, Texas Tech University, 1108 Memorial Circle Drive, Lubbock, TX 79409. *The product-to-sum formula in SU(2) Chern-Simons theory.*

Almost 20 years ago, Ch. Frohman and R. Gelca discovered a product-to-sum formula that governs the multiplication of quantized Wilson lines on the torus in SU(2) Chern-Simons theory. This formula led to many developments in the field, but also to many misunderstandings. The present talk will explain this formula, place

it in a general context, clarify the misunderstandings, and discuss possible generalizations. It is based on the work of the speaker, A. Uribe, A. Hamilton, and J. Staff. (Received June 24, 2017)

1131-81-90 **Yilong Wang*** (wang.3003@osu.edu), 412 Math Building, 231 West 18th Avenue, Columbus, OH 43202. *Integrality of $SO(p)_2$ TQFTs.*

We present recent results on the integrality of the Reshetikhkin-Turaev TQFT associated to the $SO(p)_2$ TQFTs, which leads a possible way to find new integral TQFTs. (Received July 05, 2017)

1131-81-179 **Iana I. Anguelova*** (anguelovai@cofc.edu), Charleston, SC 29424. *Character identities arising from the two bosonizations of the CKP hierarchy.*

Surprisingly, the CKP hierarchy admits two bosonizations, one in terms of a twisted Heisenberg field, and the second via an untwisted Heisenberg field. These two bosonizations are associated with three different families of Virasoro fields, and thus there are 4 different grading operators acting on the Fock space. In this talk we will discuss the graded dimension formulas and identities arising from these four grading operators. (Received July 13, 2017)

1131-81-302 **Y Berest** and **A Eshmatov*** (alimjon.eshmatov@utoledo.edu), 2801 W Bancroft St, Toledo, OH 43606, and **Wai-kit Yeung**. *Perverse sheaves and knot contact homology.*

We present a universal construction, called homotopy braid closure, that produces invariants of links in R^3 starting with a braid group action on objects of a (model) category. Applying this construction to the natural action of the braid group B_n on the category of perverse sheaves on the two-dimensional disk with singularities at n marked points, we obtain a differential graded (DG) category that gives knot contact homology in the sense of L. Ng. As an application, we show that the category of finite-dimensional modules over the 0-th homology of this DG category is equivalent to the category of perverse sheaves on R^3 with singularities at most along the link. [This is joint work with Yu. Berest and .] (Received July 17, 2017)

83 ► Relativity and gravitational theory

1131-83-28 **M. T. Mustafa*** (tahir.mustafa@qu.edu.qa), Department of Mathematics, Statistics and Phy, Qatar University, Doha, 2713, Qatar. *Exact solutions of wave equation on Minkowski spacetime.*

Wave equation on Minkowski spacetime is investigated using Lie symmetry method. Symmetry algebra of the wave equation is obtained and joint invariants of appropriate subalgebras are utilized to obtain many exact solutions of the wave equation on Minkowski spacetime. (Received May 27, 2017)

92 ► Biology and other natural sciences

1131-92-4 **Mostafa Ghandehari*** (ghandeha@uta.edu) and **Shiva Keramati**. *Discrete Two-compartmental Pharmacokinetics Model.*

A system of differential equations for two-compartmental model of pharmacokinetics is given. Discrete approximation of the system will result in a system of difference equations. Eigenvalues and eigenvectors are used to find powers of a matrix which yield approximate solution of the system. Examples of medications for two-compartmental models are discussed. (Received January 08, 2017)

1131-92-18 **Kazuo Yamazaki*** (kyamazak@ur.rochester.edu), Hylan 1017, Department of Mathematics, University of Rochester, Rochester, NY 14627, and **Xueying Wang** (xueying.wsu@gmail.com), PO Box 643113, Department of Mathematics and Statistics, Washington State University, Pullman, WA 99164. *Global stability and uniform persistence of the reaction-convection-diffusion cholera epidemic model.*

This talk concerns the speaker's work, partially in collaboration with Prof. Xueying Wang of Washington State University.

We study the global stability issue of the reaction-convection-diffusion cholera epidemic PDE model and show that the basic reproduction number serves as a threshold parameter that predicts whether cholera will persist or become globally extinct. Specifically, when the basic reproduction number is beneath one, we show that the disease-free-equilibrium is globally attractive. On the other hand, when the basic reproduction number exceeds one, if the infectious hosts or the concentration of bacteria in the contaminated water are not initially identically zero, we prove the uniform persistence result and that there exists at least one positive steady state.

We also discuss work in progress and difficult remaining problems concerning Ebola virus disease model, Zika virus model, as well as extension to the case when the diffusivity coefficients among the susceptible, infected and recovered hosts are not all equal. (Received May 10, 2017)

1131-92-31 **Ido Golding*** (golding@bcm.edu), Dept of Biochemistry and Molecular Biology, Baylor College of Medicine, Houston, TX 77005. *Deciphering the Stochastic Kinetics of Gene Regulation.*

Gene activity is the prime mover in the living cell, driving a cell's function at any given time. I will report on recent advances in our ability to describe the stochastic kinetics of gene regulation, achieved through the combination of single-molecule microscopy in individual cells, novel image analysis algorithms, and theoretical modeling. We apply our approach to explore gene regulation in a number of organisms representing a gradation of complexity: E. coli bacteria, Drosophila embryos and mouse embryonic stem cells. (Received June 05, 2017)

1131-92-62 **Luis David Garcia Puente*** (lgarcia@shsu.edu), Department of Mathematics and Statistics, Sam Houston State University, Huntsville, TX 77341-2206, and **Rebecca Garcia**, **Ryan Kruse**, **Jessica Liu**, **Dane Miyata**, **Ethan Petersen**, **Kaitlyn Phillipson** and **Anne Shiu**. *Gröbner Bases of Neural Ideals.*

The neural ideal was introduced recently as an algebraic object that can be used to better understand the combinatorial structure of neural codes. Every neural ideal has a particular generating set, called the canonical form, that directly encodes a minimal description of the receptive field structure intrinsic to the neural code. On the other hand, for a given monomial order, any polynomial ideal is also generated by its unique (reduced) Gröbner basis with respect to that monomial order. How are these two types of generating sets - canonical forms and Gröbner bases - related? In this talk, we will demonstrate that when the canonical form of the neural ideal is a Gröbner basis, it is the universal Gröbner basis. A natural question to pursue, then, is under what conditions will the canonical form be a Gröbner basis? We will give some partial answers to this question. (Received June 29, 2017)

1131-92-68 **Jonathan Bell*** (jbell@ubc.edu). *Predator-mediated coexistence with chemorepulsion.*

We discuss analysis and simulations associated with a model system consisting of two competing populations and one common predator population; all populations are mobile (random dispersal), but the predator's movement is influenced by one prey's gradient representing a chemorepulsive effect on the predator population. There is no adaptive mechanism in the present model. We examine pattern formation through bifurcations with respect to the chemotactic sensitivity parameter, and the prey diffusivity parameter. We also mention existence and convergence to steady state results. This work is in collaboration with Evan Haskell (Nova Southeastern University, Ft. Lauderdale, FL). (Received July 01, 2017)

1131-92-92 **Artem Novozhilov*** (artem.novozhilov@ndus.edu), North Dakota State University, Department of Mathematics, Minard 408, PO Box 6050, Fargo, ND 58108-6050. *Heterogeneous Mathematical Models and the Problem of System Identification.*

Abstract differential equations that arise in various biological contexts provide an example of infinite dimensional nonlinear dynamical systems, which aim to describe simultaneously ecological and evolutionary processes. In many cases the analysis of such systems is highly non-trivial. It turns out, however, that an additional assumption on the specific birth rates in the models allows to significantly reduce the dimensionality of the problem, ending up with a system of ordinary differential equations. In my talk I will introduce such heterogeneous mathematical models and present some non-obvious consequences of the key simplifying assumption. The problem of systems identification, i.e., inferring parameter values from the available data, will be discussed. (Received July 06, 2017)

1131-92-110 **Minh Van Nguyen*** (mvnguyen1@ualr.edu), Department of Mathematics and Statistics, University of Arkansas at Little Rock, 2801 S University Ave, Little Rock, AR 72113. *Monotone traveling waves in a general discrete model for populations.*

In this talk we consider the existence of monotone traveling waves for a class of general integral difference model for populations that allows the dispersal probability to have no continuous density functions but the fecundity functions to generate a monotone dynamical systems. In this setting we deal with the non-compactness of the evolution operator by using the monotone iteration method. This is a joint work with Le Manh Thuc. (Received July 07, 2017)

1131-92-123 **Jared O Barber*** (jarobarb@iupui.edu), Department of Mathematical Sciences, 402 N Blackford St, LD 270E, Indianapolis, IN 46202. *A mathematical model of breast cancer cell translocation through a microfluidic device using viscoelastic elements submersed in a surrounding Stokes flow.* Preliminary report.

Deaths associated with breast cancer are not usually caused by the primary infection but by metastases at other locations (e.g. bone). Much research has targeted understanding how to lower the metastatic potential of individual breast cancer cells with the end goal being the mitigation of the effects of breast cancer on the 3.5 million people in the US affected by the disease.

Experiments have shown that metastatic potential correlates well with the physical properties of a cell and its surrounding environment. Biology also suggests that mechanotransduction of cellular pathways (e.g. apoptosis, division) can affect metastatic potential.

Because of these insights, we are developing a mechanical model of breast cancer cell translocation in microvessels. Our first model is a two-dimensional model with interconnected viscoelastic elements submersed in a surrounding Stokes flow. This model has been used to consider breast cancer cell translocation through a microfluidic device that was designed as a diagnostic tool for assessing the metastatic potential of breast cells. We will present this current model and share results. We believe that further development of this model will allow consideration of metastatic potential in both in vitro and in vivo settings. (Received July 10, 2017)

1131-92-141 **Ying Wang*** (wang@ou.edu), 601 Elm Ave Rm 423, Norman, OK 73019. *Mean ages for a terrestrial carbon dynamics model.*

In this talk, I will introduce a nine-dimensional non-autonomous compartmental system modeling the terrestrial carbon cycle. I will define a non-autonomous version of transit time as the mean age of mass leaving the compartmental system at a particular time and show that our non-autonomous theory generalizes the autonomous case. I will apply these results to study the nine-dimensional non-autonomous carbon cycle compartmental model. I will demonstrate that the non-autonomous versions of transit time and mean age differ significantly from the autonomous quantities when calculated for that model. This is a joint work with Yiqi Luo et al. (Received July 11, 2017)

1131-92-177 **Tracy Stepien*** (stepien@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ, **Erica Rutter** (erutter@ncsu.edu), Center for Research in Scientific Computation, Department of Mathematics, North Carolina State University, Raleigh, NC , and **Yang Kuang** (kuang@asu.edu), School of Mathematical & Statistical Sciences, Arizona State University, Tempe, AZ. *Traveling Wave Solutions of a Glioma Tumor Growth Model.*

Glioblastoma multiforme is an aggressive brain tumor that is extremely fatal. Gliomas are characterized by both high amounts of cell proliferation as well as diffusivity, which make them impossible to remove with surgery alone. To gain insight on the mechanisms most responsible for tumor growth and the difficult task of forecasting future tumor behavior, we investigate a mathematical model in which tumor cell motility and cell proliferation are considered as separate processes. We explore the existence of traveling wave solutions and determine conditions for various wave front forms. We also examine the model's efficacy in fitting in vitro experimental data. (Received July 13, 2017)

1131-92-195 **Konstantin Doubrovinski*** (konstantin.doubrovinski@utsouthwestern.edu), The Green Center for Systems Biology, UT Southwestern Medical Center, ND11.300, Dallas, TX 75235. *Physical Aspects of Drosophila Gastrulation.* Preliminary report.

Gastrulation is a process whereby a layer of epithelial cells gives rise to a multilayered structure. In Drosophila, gastrulation starts with apical constriction of mesodermal cells followed by invagination of the mesoderm. Understanding the mechanism of Drosophila gastrulation requires answering two key questions. 1) Why does the mesoderm constrict along a particular axis? 2) Why does the mesoderm invaginate? To answer the first question, we measured mechanical properties of the mesoderm using an assay that involves injecting embryos with ferrouid droplets. Our measurements showed that the mesoderm is highly elastic. Based on our data, we propose a mathematical model where embryonic surface is represented by a at elastic shell with a rectangular contractile domain. Our model explains the preferred axis of constriction based entirely on our measured data. To address the question of why the mesoderm invaginates, we propose and experimentally test a mathematical model. A key feature of our model is that lateral membranes constrict actively. In our model, lateral membrane constriction is required for mesoderm invagination. In support of this, we present data where we ablate lateral membranes with micrometer precision and show that invagination stops if membranes are severed. (Received July 14, 2017)

1131-92-197 **Brian D Zoltowski*** (bzoltowski@smu.edu), Department of Chemistry, FOSC Rm 231, Dallas, TX 75275. *Mathematical modelling of circadian networks in plants.*

Organisms have developed circadian oscillators to allow adaptation to daily fluctuations in light-intensity, metabolic resources and oxidative stress. Regulatory networks governing these sensory networks are complex, adaptive and difficult to study using traditional biological techniques. Herein we employ a combination of protein engineering and biophysical techniques to develop complex mathematical models that interrogate sensory input and adaptation in circadian networks. These methods enable the identification of previously unknown chemical parameters necessary for proper regulation of circadian timing that dictate growth and development in plants. (Received July 14, 2017)

1131-92-210 **Peng Tao*** (ptao@smu.edu), 3215 Daniel Avenue, P.O. Box 750314, Dallas, TX 75275-0314. *Application of machine learning methods in computer simulations of protein dynamics.* Preliminary report.

Proteins are large biomolecules, consisting of long chains of amino acids, which fold into stable three-dimensional structures to carry out specific biological functions in living organisms. Protein dynamics at molecular level are critical for their functions, and often subjected to computer simulations. In computational biology, proteins are modeled as balls (representing atoms) connected by springs (representing chemical bonds) with specific interactions described by a set of energy functions. These energy functions for protein are referred as force field. Molecular dynamics (MD) simulation is one of the most widely applied computer simulation methods of protein based on force field. In MD simulations, atomic motions in protein are simulated by solving equations of motion based on Newton's law. The collection of atomic motion of protein during any given time period (e.g. several nanoseconds) is called MD trajectory. Analysis of protein MD trajectory is an active area of computational biology. In this study, we applied two machine learning methods, decision tree and neural network models as novel ways to analyze MD trajectories of a protein from fungi circadian clock system to explore its dynamics and the potential relationship with its function as a circadian clock protein. (Received July 14, 2017)

1131-92-305 **Andrea K. Barreiro*** (abarreiro@smu.edu), POB 750156, Dallas, TX 75275. *A geometric method for analyzing operators with low-rank perturbations.*

We consider the problem of finding the spectrum of an operator taking the form of a low-rank (rank one or two) non-normal perturbation of a self-adjoint operator. We use a simple idea of classical differential geometry (the envelope of a family of curves) to analyze the spectrum. When the rank of the perturbation is two, this allows us to view the system in a geometric way through a phase plane in the perturbation strengths. We apply this technique to two problems: a neural network model of the oculomotor integrator (Anastasio and Gad 2007), and a nonlocal model of phase separation (Rubinstein and Sternberg 1992). This is work with Tom Anastasio and Jared Bronski (UIUC). (Received July 17, 2017)

1131-92-308 **Andrea K. Barreiro*** (abarreiro@smu.edu), POB 750156, Dallas, TX 75275. *Constraining neural networks with spiking statistics.*

As experimental tools in neuroscience have advanced, measuring whole-brain dynamics with single-neuron resolution is becoming closer to reality. However, a task that remains technically elusive is to measure the interactions within and across brain regions that govern such system-wide dynamics. We propose a method to derive constraints on hard-to-measure neural network attributes — such as inter-region synaptic strengths — using easy-to-measure spiking statistics.

First, we propose a closure formula for multi-population firing rate models which allows fast evaluation of equilibrium statistics. Second, fast evaluation allows us to survey the high-dimensional parameter space of admissible networks, to find which part of parameter space is consistent with the experimental data.

As a test case, we studied interactions in the olfactory system. We used two micro-electrode arrays to simultaneously record from olfactory bulb (OB) and anterior piriform cortex (PC) of anesthetized rats who were exposed to several odors. We were able to make several predictions about the network, notably that inhibition within the afferent region (OB) has to be less than inhibition in PC. This is joint work with Cheng Ly (VCU), S.H. Gautam and Woodrow Shew (U. Arkansas). (Received July 17, 2017)

1131-92-378 **Jianzhong Su*** (su@uta.edu), Department of Mathematics, University of Texas at Arlington, Arlington, TX 76019, and **Honghui Zhang** and **Ariel Bowman**. *EEG Source Localization and Reconstruction: Methods and Applications.* Preliminary report.

EEG Source Reconstruction is an imaging modality based on multi-channel Electroencephalography (EEG) signals. It measures the brain field potential fluctuations on the skull and mathematically calculate the electric current density inside the brain by solving an inverse problem. In this talk, we introduce mathematical methods

for the EEG source reconstruction problems and discuss some of the applications. One is in finding abnormality in brain activities during seizures of an infant patient with Glucose Transporter Deficiency Syndrome, particularly to identify the brain areas that lead other areas of brain activities during peak seizure periods. Another example of EEG imaging is to find the neuronal signatures of seizure by finding its underlying network and its oscillatory dynamics that resembles seizure EEG signals. (Received July 18, 2017)

1131-92-391 **Yusuf Talha Tamer** and **Haleh Abdizadeh**, Istanbul, **Tugce Altinusak Batur**, Istanbul, **Ali Rana Atilgan**, Istanbul, **Canan Atilgan**, Istanbul, and **Erdal Toprak***, 6001 Forest Park Rd, ND11.136D, Dallas, TX 75390-8597. *Predictability in Evolution of Antibiotic Resistance.* Preliminary report.

Antibiotic resistance is a growing public health problem. One of the most prevalent resistance mechanisms is increased antibiotic tolerance as a result of spontaneous mutations on the enzymes that are the targets of antibiotic molecules. In a custom made continuous culture device that we call the Morbidostat, we evolved several wild type Escherichia coli populations against trimethoprim under nearly constant drug induced growth inhibition. In the Morbidostat, trimethoprim resistance increased in a stepwise manner as a result of accumulation of multiple point mutations on folA gene coding for dihydrofolate reductase (DHFR) enzyme, following a quasi-deterministic order. We quantified the epistatic interactions in the adaptation landscape of DHFR enzyme by synthetically constructing and phenotyping all combinatorial alleles carrying up to six trimethoprim resistance-conferring mutations. Our results suggest that evolution of resistance depends on fitness constraints imposed by protein structure as well as environmental factors. (Received July 18, 2017)

1131-92-403 **Ravi S Pandey**, **David J Burks** and **Rajeev K Azad*** (rajeev.azad@unt.edu). *Towards More Robust Metagenome Profiling.*

Current methods for whole metagenome profiling are inherently limited by their inability to exemplify the microbial dynamism that shapes the genomes, resulting in chimeras with DNAs of different ancestries or origins. To circumvent this limitation, we propose a probabilistic framework to model segments of apparently different ancestries in microbes that are thus represented as ensembles of compositional signatures. By incorporating segmental signature models, a more robust metagenome profiling could be achieved. Our proposed method, Segmental Genome Model (SGM), brings in a remarkable improvement in accuracy over composition-based methods, with its performance further augmented by integrating with the alignment-based BLAST program. (Received July 18, 2017)

1131-92-417 **Pengcheng Xiao***, 1800 Lincoln Ave, Evansville, IN 47722. *Postpartum Depression Modeling Analysis.* Preliminary report.

Postpartum depression has been extensively studied in the past decades. The question whether a theoretical framework exists for postpartum depression is still unclear. In this talk, we propose a postpartum depression model based on hypothalamus-pituitary-adrenal (HPA) axis. We will discuss the dynamics of this model, theoretical and numerical results will be presented. (Received July 18, 2017)

03 ► Mathematical logic and foundations

1132-03-37 **Hao Sun*** (haosun3@illinois.edu), 2034 S ORCHARD ST, APT A, Urbana, IL 61801.
W-Operator and the Generating Function of Hurwitz Number.

Hurwitz number is the number of ramified coverings of over $\mathbb{P}^1$. Goulden and Jackson use cut-and-join operator to calculate the simple Hurwitz number or (2-Hurwitz number). The cut-and-join operator is a special case of the W-operator. We find W-operator plays an important role in calculating the generating functions of the single d-Hurwitz number, where d is a positive integer. I will introduce the W-operator and discuss several generating functions about d-Hurwitz number, (Received July 02, 2017)

1132-03-330 **Chang-Yuan Cheng*** (cycheng@mail.nptu.edu.tw), No.4-18 Minsheng Rd., Pingtung, 90003, Taiwan, and **Yueping Dong** and **Yasuhiro Takeuchi**. *An age-structured virus model with two routs of infection in heterogeneous environments.* Preliminary report.

On the basis of the complexity of the human body, we explore viral dynamics by using a two-compartment model incorporating the age since infection of infected cells and both virus-to-cell infection and cell-to-cell transmission routes. The basic reproduction number, $\mathcal{R}_0$, of the system is formulated from two mechanisms: one is the potential trigger from a single infection route in a compartment and the other is the synergistic effect of a viral infection in two compartments. Accordingly, we prove that the infection-free equilibrium is globally asymptotically stable (GAS) if $\mathcal{R}_0 < 1$, whereas virus persists uniformly with respect to the initial infection if $\mathcal{R}_0 > 1$. From the viewpoint of a predominant infection route incorporated with another mild infection route, we demonstrate global convergence to the infected equilibrium by applying a theory of perturbation on the globally stable steady state. (Received July 25, 2017)

05 ► Combinatorics

1132-05-4 **Bruce E Sagan*** (sagan@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *The protean chromatic polynomial.*

Let t be a positive integer and let G be a combinatorial graph with vertices V and edges E. A *proper coloring of G from a set with t colors* is a function $c : V \to \{1, 2, \ldots, t\}$ such that if $uv \in E$ then $c(u) \neq c(v)$, that is, the endpoints of an edge must be colored differently. These are the colorings considered in the famous Four Color Theorem. The *chromatic polynomial* of G, $P(G; t)$, is the number of proper colorings of G from a set with t colors. It turns out that this is a polynomial in t with many amazing properties. One can characterize the degree and coefficients of $P(G; t)$. There are also connections with acyclic orientations, increasing spanning forests, hyperplane arrangements, symmetric functions, and Chern classes in algebraic geometry. This talk will survey some of these results. (Received February 22, 2017)

1132-05-5 **Alexander Diaz-Lopez** (adiazlo1@swarthmore.edu), **Pamela E. Harris** (peh2@williams.edu), **Erik Insko** (einsko@fgcu.edu) and **Mohamed Omar*** (omar@g.hmc.edu). *A Proof of the Peak Polynomial Positivity Conjecture.*

We say that a permutation $\pi = \pi_1\pi_2\cdots\pi_n \in \mathfrak{S}_n$ has a peak at index i if $\pi_{i-1} < \pi_i > \pi_{i+1}$. Let $\mathcal{P}(\pi)$ denote the set of indices where π has a peak. Given a set S of positive integers, we define $\mathcal{P}(S; n) = \{\pi \in \mathfrak{S}_n : \mathcal{P}(\pi) = S\}$. In 2013 Billey, Burdzy, and Sagan showed that for subsets of positive integers S and sufficiently large n, $|\mathcal{P}(S; n)| = p_S(n)2^{n-|S|-1}$ where $p_S(x)$ is a polynomial depending on S. They gave a recursive formula for $p_S(x)$ involving an alternating sum, and they conjectured that the coefficients of $p_S(x)$ expanded in a binomial coefficient basis centered at $\max(S)$ are all nonnegative. In this paper we introduce a new recursive formula for $|\mathcal{P}(S; n)|$ without alternating sums and we use this recursion to prove that their conjecture is true. (Received March 10, 2017)

1132-05-24 **Tair Akhmejanov***, Cornell University, Department of Mathematics, 112 Malott Hall, Ithaca, NY. *Growth Diagrams from Polygons in the Affine Grassmannian.*

We introduce a new type of growth diagram, arising from the geometry of the affine Grassmannian for GL_m. These affine growth diagrams are in bijection with the $c_{\vec{\lambda}}$ many components of the polygon space $\mathrm{Poly}(\vec{\lambda})$ for $\vec{\lambda}$

a sequence of minuscule weights and $c_{\vec{\lambda}}$ the Littlewood–Richardson coefficient. Unlike Fomin growth diagrams, they are infinite periodic on a staircase shape, and each vertex is labeled by a dominant weight of GL_m. Letting m go to infinity, a dominant weight can be viewed as a pair of partitions, and we recover the RSK correspondence and Fomin growth diagrams within affine growth diagrams. The main combinatorial tool used in the proofs is the n-hive of Knutson-Tao-Woodward. (Received June 24, 2017)

1132-05-26 **Pamela E Harris*** (peh2@williams.edu), Williamstown, MA 01267, and **Erik Insko** and **Mohamed Omar**. *The q-analog of Kostant's partition function and the highest root of the simple Lie algebras.*

Kostant's partition function counts the number of ways to represent a particular vector (weight) as a nonnegative integral sum of positive roots of a Lie algebra. For a given weight the q-analog of Kostant's partition function is a polynomial where the coefficient of q^k is the number of ways the weight can be written as a nonnegative integral sum of exactly k positive roots. In this talk, we present generating functions for the q-analog of Kostant's partition function when the weight in question is the highest root of the classical Lie algebras of types B, C, and D, and the exceptional Lie algebras of type G_2, F_4, E_6, E_7, and E_8. (Received June 25, 2017)

1132-05-29 **David Forge** and **Thomas Zaslavsky*** (zaslav@math.binghamton.edu), Dept. of Math. Sci., Binghamton University, Binghamton, NY 13902-6000. *A huge Tutte polynomial that is not transparent.* Preliminary report.

Graphs are valuable because, being fundamentally simple, they have many developable properties. For instance, deletion-contraction invariants of graphs are classified by Tutte's universal polynomial with one countable set of variables. Those with slight restrictions are classified by the well-known two-variable Tutte polynomial, which depends only on the graphic matroid.

One wants a generalization that shares much of the essential simplicity of graphs. Gain graphs, where each edge has an invertible labelling from a group G, are such a generalization. We have looked into describing a universal deletion-contraction invariant of gain graphs over G, not the 2-variable one that depends on the matroid, which is known, but a graphic one similar to Tutte's countable-variables polynomial for ordinary graphs. Such a universal for gain graphs has relations among its variables that we have only slightly deciphered. I will explain the objective and the difficulties of this project. (Received June 27, 2017)

1132-05-47 **Thao T Do*** (thaodo@mit.edu), Department of Mathematics, MIT,77 Massachusetts Ave, Cambridge, MA 02139. *Zarankiewicz's problem for semi-algebraic hypergraphs.*

Zarankiewicz's problem asks for the largest possible number of edges in a graph with n vertices that does not contain $K_{s,t}$ for some fixed integers s, t. Recently, Fox, Pach, Sheffer, Sulk and Zahl considered this problem for semi-algebraic graphs, the ones whose vertices are points in Euclidean spaces and edges are defined by some semi-algebraic relations. They found an upper bound that only depends on the dimensions of those Euclidean spaces; this result is a vast generalization of the well-known Szemerédi-Trotter theorem and has many geometric applications. In this talk, we extend their result to semi-algebraic hypergraphs. Our proof uses a packing result in VC-dimension theory and a new variant of the recently-developed polynomial partitioning method. As an application, we find an upper bound for the number of unit $d \times d$ minors in a $d \times n$ matrix. There are also applications to geometric intersection hypergraphs and to the unit volume problem. (Received July 07, 2017)

1132-05-58 **Benjamin Braun** (benjamin.braun@uky.edu) and **McCabe Olsen*** (mccabe.olsen@uky.edu), 165 Donabrook Court, B-8, Lexington, KY 40517. *Euler-Mahonian statistics and descent bases for semigroup algebras.*

We consider quotients of the unit cube semigroup algebra by particular $\mathbb{Z}_r \wr S_n$-invariant ideals. Using Gröbner basis methods, we show that the resulting graded quotient algebra has a basis where each element is indexed by colored permutations $(\pi, \epsilon) \in \mathbb{Z}_r \wr S_n$ and each element encodes the negative descent and negative major index statistics on (π, ϵ). This gives an algebraic interpretation of these statistics which was previously unknown. This basis of the $\mathbb{Z}_r \wr S_n$-quotients allows us to recover certain combinatorial identities involving Euler-Mahonian distributions of statistics. (Received July 10, 2017)

1132-05-59 **Neranga Fernando*** (w.fernando@northeastern.edu), Department of Mathematics, 567 Lake Hall, Northeastern University, Boston, MA 02115. *Self-reciprocal polynomials arising from reversed Dickson polynomials.*

The reciprocal $f^*(x)$ of a polynomial $f(x)$ of degree n is defined by $f^*(x) = x^n f(\frac{1}{x})$. A polynomial $f(x)$ is called *self-reciprocal* if $f^*(x) = f(x)$. Self-reciprocal polynomials have important applications in coding theory.

Let p be an odd prime and $q = p^e$, where e is a positive integer. Let $\mathbb{F}_q$ be the finite field with q elements. For $a \in \mathbb{F}_q$, the n-th reversed Dickson polynomial of the $(k+1)$-th kind $D_{n,k}(a,x)$ is defined by

$$D_{n,k}(a,x) = \sum_{i=0}^{\lfloor \frac{n}{2} \rfloor} \frac{n-ki}{n-i} \binom{n-i}{i} (-x)^i a^{n-2i},$$

and $D_{0,k}(a,x) = 2-k$. When p is odd, $D_{n,k}(1,x)$ can be written as

$$D_{n,k}(1,x) = \left(\frac{1}{2}\right)^n f_{n,k}(1-4x),$$

where

$$f_{n,k}(x) = k \sum_{j \geq 0} \binom{n-1}{2j+1} (x^j - x^{j+1}) + 2 \sum_{j \geq 0} \binom{n}{2j} x^j \ \in \mathbb{Z}[x]$$

for $n \geq 1$ and

$$f_{0,k}(x) = 2-k.$$

I am primarily interested in the question: When is $f_{n,k}(x)$ a self-reciprocal polynomial? In this talk, I will explain a complete answer to this question. As a consequence, I will explain how to obtain coterm polynomials arising from reversed Dickson polynomials. (Received July 10, 2017)

1132-05-64 **Michael Kopreski**, Williamsburg, VA 23188, and **Gexin Yu*** (gyu@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23188. *Maximum average degree and relaxed coloring.*

We say a graph is $(d,d,\ldots,d,0,\ldots,0)$-colorable with a of d's and b of 0's if $V(G)$ may be partitioned into b independent sets $O_1, O_2, \ldots, O_b$ and a sets $D_1, D_2, \ldots, D_a$ whose induced graphs have maximum degree at most d. The maximum average degree, $mad(G)$, of a graph G is the maximum average degree over all subgraphs of G. In this note, for nonnegative integers a, b, we show that if $mad(G) < \frac{4}{3}a + b$, then G is $(1_1, 1_2, \ldots, 1_a, 0_1, \ldots, 0_b)$-colorable. (Received July 11, 2017)

1132-05-65 **Xueliang Li*** (lxl@nankai.edu.cn), Center for Combinatorics, Nankai University, Tianjin, Peoples Rep of China. *Conflict-free connections of graphs.*

An edge-colored graph G is *conflict-free connected* if, between each pair of distinct vertices of G, there exists a path in G containing a color used on exactly one of its edges. The *conflict-free connection number* of a connected graph G, denoted by $cfc(G)$, is defined as the smallest number of colors that are needed in order to make G conflict-free connected. These concepts are comparatively new and have some potential use in connection with frequency assignment problems for cellular networks. This talk aims to give a survey of the known results in this subject. (Received July 11, 2017)

1132-05-70 **Arthur L.B. Yang*** (yang@nankai.edu.cn), Center for Combinatorics, Nankai University, Tianjin, 300071, Peoples Rep of China. *The Kazhdan-Lusztig polynomial of a fan matroid.* Preliminary report.

Elias, Proudfoot and Wakefield associated to every matroid a polynomial with integer coefficients, in analogy with the classical Kazhdan-Lusztig polynomials in representation theory. They conjectured that the Kazhdan-Lusztig polynomial of a matroid has only non-negative coefficients, and its coefficients form a log-concave sequence with no internal zeros. Gedeon, Proudfoot and Young further conjectured that the Kazhdan-Lusztig polynomial of a matroid has only non-positive real zeros. For some specific families of matroids, the Kazhdan-Lusztig polynomials have been determined recently. We explicitly computed the Kazhdan-Lusztig polynomial of a fan matroid, as well as that of a wheel matroid, giving two examples to support their conjectures. This is a joint work with Linyuan Lu and Matthew Xie. (Received July 11, 2017)

1132-05-84 **John Goldwasser*** (jgoldwas@math.wvu.edu), **Ryan Hansen**, **Maria Axenovich**, **Bernard Lidicky**, **Ryan Martin**, **David Offner**, **John Talbot** and **Michael Young**. *Polychromatic colorings of complete graphs with respect to 1-regular and 2-regular subgraphs.*

If G is a graph and H is a set of subgraphs of G, then an edge coloring of G is called H-polychromatic if every graph from H gets all colors present in G. The H-polychromatic number of G is the largest number of colors such that G has an H-polychromatic coloring. We determine precisely the H-polychromatic number of G when G is a complete graph on n vertices and H is the family of all matchings spanning n-p vertices of G (p fixed), when H is the family of all (n-p)-cycles, and when H is the family of all 2-regular subgraphs of G spanning at least n-p vertices. (Received July 13, 2017)

1132-05-92 **Miaomiao Han** and **Jiaao Li*** (joli@mix.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506, and **Yezhou Wu** and **Cun-Quan Zhang**. *Jaeger's circular flow conjecture: counterexamples and new problems.*

In 1981, Jaeger conjectured that every $4p$-edge-connected graph admits a modulo $(2p+1)$-orientation, known as the circular flow conjecture. The cases of $p = 1, 2$ implies Tutte's 3-flow conjecture and 5-flow conjecture, respectively. On the positive side, this conjecture is verified for $6p$-edge-connected graphs by Lovasz et al.(JCTB 2013). However, we disprove this conjecture for every $p \geq 3$. Some new open problems are also proposed. This is a joint work with Han, Wu and Zhang. (Received July 15, 2017)

1132-05-100 **Yongxin Lan**, **Suil O**, **Yongtang Shi** and **Zi-Xia Song*** (zixia.song@ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Extremal C_6-free or P_k-free Planar Graphs for Small k.* Preliminary report.

Given a planar graph F, we define $ex_{\mathcal{P}}(n, F)$ to be the maximum number of edges possible in a planar graph on n vertices which does not contain F as a subgraph. Dowden initiated the study of "extremal" planar graphs in his recent paper [Extremal C_4-free/C_5-free planar graphs, **J. Graph Theory** 83 (2016) 213–230]. He obtained that $ex_{\mathcal{P}}(n, C_4) \leq \frac{15}{7}(n-2)$ for all $n \geq 4$, $ex_{\mathcal{P}}(n, C_5) \leq \frac{12n-33}{5}$ for all $n \geq 11$, and both bounds are tight. We studied the cases when F is a C_6 or a path on at most 10 vertices. We prove that $ex_{\mathcal{P}}(n, C_6) \leq \frac{18}{7}(n-2)$ for all $n \geq 6$, and the bound is sharp. We also determine the values of $ex_{\mathcal{P}}(n, P_k)$ for $k \leq 10$ and characterize all the extremal planar graphs.

This is joint work with Yongxin Lan, Suil O, and Yongtang Shi. (Received July 16, 2017)

1132-05-105 **Jiaao Li** (joli@mix.wvu.edu), Dept. Mathematics, West Virginia University, Morgantown, WV 26506, **Carsten Thomassen** (ctho@dtu.dk), Department of Applied Mathematics and Compute, Technical University of Denmark, DK-2800 Lyngby, Denmark, **Yezhou Wu** (yezhouwu@zju.edu.cn), Ocean College, Zhejiang University, Hangzhou, 310027, Peoples Rep of China, and **Cun-Quan Zhang*** (cqzhang@mail.wvu.edu), Dept. Mathematics, West Virginia University, Morgantown, WV 26506. *The flow index and strongly connected orientation.*

We prove that, for any natural number p, the flow index $\phi(G) < 2 + \frac{1}{p}$ if and only if G has a strongly connected modulo $(2p+1)$-orientation. For the case $p = 1$ we prove that the flow index of every 8-edge-connected graph is strictly less than 3. (Received July 17, 2017)

1132-05-112 **Karola Meszaros*** (karola@math.cornell.edu) and **Avery St. Dizier**. *From generalized permutahedra to Grothendieck polynomials via flow polytopes.*

We prove that for permutations $1\pi'$ where π' is dominant, the Grothendieck polynomial $\mathfrak{G}_{1\pi'}(\mathbf{x})$ is a weighted integer-point transform of its Newton polytope with all weights nonzero. We also show that the Newton polytopes of the homogeneous components of $\mathfrak{G}_{1\pi'}(\mathbf{x})$ are generalized permutahedra. Moreover, the Schubert polynomial $\mathfrak{S}_{1\pi'}(\mathbf{x})$ for dominant π' equals the integer-point transform of a generalized permutahedron. These results imply recent conjectures of Monical, Tokcan and Yong regarding the supports of Schubert and Grothendieck polynomials for the special case of permutations $1\pi'$, where π' is dominant. We connect Grothendieck polynomials and generalized permutahedra via a family of dissections of flow polytopes obtained from the subdivision algebra. (Received July 17, 2017)

1132-05-128 **Mingfang Huang**, **Gexin Yu** and **Xiangqian Joe Zhou***, Xiangqian.Zhou@wright.edu. *Strong Edge-coloring for Bipartite Graphs.*

A proper edge-coloring of a simple graph G is an assignment of colors to every edge of G such that adjacent edges receive different colors. A strong edge-coloring of G is a proper edge-coloring such that every two edges that are connected by another edge receive different colors. So in a proper edge-coloring, every color class is a matching, while in a strong edge-coloring, every color class is an induced matching. In this talk, I will give a short survey on open problems in this area and also present some recent progress on strong edge-coloring for bipartite graphs. (Received July 18, 2017)

1132-05-130 **Axel Brandt*** (axbrandt@davidson.edu). *Additive Coloring of Some Planar Graphs.*

The *additive coloring number* of G, denoted $\chi_\Sigma(G)$, is the least integer k for which G has a labeling of its vertices from $\{1, 2, ..., k\}$ such that two adjacent vertices have distinct sums of labels on their neighbors. In 2009, Czerwiński, Grytczuk, and Żelazny conjectured that $\chi_\Sigma(G) \leq \chi(G)$, where $\chi(G)$ is the chromatic number of G. In this talk, we discuss how the Combinatorial Nullstellensatz and the discharging method can be used to improve the bounds for particular classes of graphs through a list version of additive coloring. (Received July 18, 2017)

1132-05-134 **Steve Butler*** (butler@iastate.edu). *Ordered multiplicity inverse eigenvalue problem for graphs on six vertices.*

The ordered multiplicity inverse eigenvalue problem asks for a given graph G on n vertices and an ordered partition of n if there is a real symmetric matrix A so that the nonzero off-diagonal entries exactly agree with the edges of G and the ordered multiplicities of the eigenvalues agree with the ordered partition.

This problem is solved for graphs on six vertices and we give an overview of the various techniques to include or rule out possible ordered multiplicities for graphs.

This is joint work with John Ahn, Christine Alar, Beth Bjorkman, Joshua Carlson, Audrey Goodnight, Haley Knox, Casandra Monroe, and Michael Wigal; the research was conducted at the REU held at Iowa State University in summer of 2017. (Received July 18, 2017)

1132-05-135 **Jason I. Brown*** (jason.brown@dal.ca), Department of Mathematics and Statistics, Dalhousie University, 6316 Coburg Rd., PO BOX 15000, Halifax, NS B3H 4R2. *On Graph Polynomials Related to Vertex Colorings.*

There are a number of graph polynomials that can be defined related to vertex colorings. The well known *chromatic polynomial* $\pi(G,x)$ counts the number of proper vertex colorings of the graph G with x colors (when x is a nonnegative integer). The closely related *σ-polynomial* of G is $\sigma(G,x) = \sum a_i x^i$, where a_i is the number of partitions of the vertex set of G into i nonempty color classes. Thirdly, given any fixed sets r_v of *forbidden* colors at each vertex v, the *restrained chromatic polynomial* $\pi_r(G,x)$ denotes the number of x-colorings of G permitted by the *restraint* r. In this talk I will present recent work on new bounds for chromatic polynomials, discuss the nature and location of roots of both chromatic and σ-polynomials, and determine restraints that permit the most or least number of x-colorings, asymptotically. (Joint work with Aysel Erey, Jian Li and David Wagner.) (Received July 18, 2017)

1132-05-139 **Axel Brandt**, **Michael Ferrara**, **Nathan Graber**, **Stephen Hartke** and **Sarah Loeb*** (sjloeb@wm.edu). *Entire Colorability for a Class of Plane Graphs.*

Let G be a plane graph with maximum degree $\Delta(G)$. If every element in the sets of vertices, edges, and faces of G can be colored with k colors so that any two adjacent or incident elements have distinct colors, then G is said to be entirely k-colorable. In 2011, Wang and Zhu asked if every simple, plane graph $G \neq K_4$ is entirely $(\Delta(G)+3)$-colorable. In 2012 Wang, Mao, and Miao answered in the affirmative for simple, plane graph G with $\Delta(G) \geq 8$. We show that every plane multigraph with $\Delta(G) = 7$, no loops, no 2-faces, and no 3-faces sharing an edge is entirely $(\Delta(G)+3)$-colorable. (Received July 19, 2017)

1132-05-145 **Jennifer Vandenbussche*** (jvandenb@kennesaw.edu), **Gexin Yu** and **Heather Hoskins**. *Planar graphs without 4-cycles and close triangles are $(2,0,0)$-colorable.* Preliminary report.

The search for conditions under which planar graphs are 3-colorable, or "nearly" 3-colorable, has a long history. In this talk, we present one such result. A graph is $(2,0,0)$-colorable if it can be colored with three colors so that one color class induces a subgraph with maximum degree 2, and each of the other two color classes form independent sets. We show that all planar graphs without 4-cycles and no less than two edges between triangles are $(2,0,0)$-colorable. This is joint work with Gexin Yu and Heather Hoskins. (Received July 19, 2017)

1132-05-148 **Radmila Sazdanovic*** (rsazdanovic@math.ncsu.edu), Department of Mathematics, NC State, SAS Hall PO Box 8205, Raleigh, NC 27606, and **Martha Yip**. *A categorification of the chromatic symmetric function.*

The Stanley chromatic symmetric polynomial X_G of a graph G is a symmetric function generalization of the chromatic polynomial, and has interesting combinatorial properties. We apply the techniques of Khovanov homology to construct a homology of bigraded S_n-modules, whose bigraded Frobenius series reduces to the chromatic symmetric polynomial at q=t=1. We also obtain analogues of several familiar properties of the chromatic symmetric polynomial in terms of homology, including the decomposition formula for X_G discovered recently by Orellana and Scott, and Guay-Paquet. (Received July 19, 2017)

1132-05-171 **Mark Ellingham*** (mark.ellingham@vanderbilt.edu), **Wenzhong Liu**, **Dong Ye** and **Xiaoya Zha**. *Orientable cycle double covers of toroidal graphs.* Preliminary report.

An *orientable cycle double cover* of a graph is a collection of cycles that may be oriented to cover each edge exactly once in each direction. The Orientable Cycle Double Cover Conjecture says that every 2-edge-connected graph has an orientable cycle double cover. We verify this conjecture for graphs embeddable in the torus. The proof uses embeddings of cubic graphs: we show that every 2-connected toroidal cubic graph has a closed 2-cell

embedding (in which each face is homeomorphic to an open disk and is bounded by a cycle in the graph) in some orientable surface.

This last result would also follow from Tutte's conjecture that every 2-connected cubic graph not containing a subdivision of the Petersen graph is 3-edge-colorable. A proof of Tutte's conjecture has been announced by Robertson, Seymour and Thomas, but it uses machinery similar to the proof of the Four Color Theorem. Our proof is much simpler and uses ideas that may extend to other surfaces besides the torus. (Received July 20, 2017)

1132-05-175 **Josh Hallam*** (hallamjw@wfu.edu) and **Rafael S. González D'León**. *Whitney Duals of Partially Ordered Sets.*

Let P and Q be graded posets of rank n. We say P and Q are *Whitney duals* if (up to a sign) the Whitney numbers of the first kind of P are the Whitney numbers of the second kind of Q and vice-versa. For many posets, the Whitney number of the first kind alternates in sign. In this case, we can recast the definition of Whitney duals in terms of polynomials. Let $\chi(P,t)$ and $F(P,t)$ be the characteristic polynomial and rank-generating function of P. Then P and Q are Whitney duals exactly when

$$(-1)^n\chi(P,-t) = t^nF(Q,1/t)$$

and

$$(-1)^n\chi(Q,-t) = t^nF(P,1/t).$$

In this talk we will discuss how edge labelings and quotient posets can be used to construct Whitney duals. In particular we will show that every geometric lattice has a Whitney dual. (Received July 21, 2017)

1132-05-177 **Michael Young*** (myoung@iastate.edu). *Polychromatic colorings on the integers.*

Given $S \subseteq \mathbb{Z}$, an r-coloring of $\mathbb{Z}$ is *polychromatic* if every translate of S contains all r colors. The *polychromatic number* of S is the largest r such that there exists a polychromatic r-coloring of $\mathbb{Z}$ with respect to S. In this talk, we prove that the polychromatic number of a set of size 4 is at least 3, which implies that S has a codensity of at most $1/3$, proving a conjecture of Newman. (Received July 21, 2017)

1132-05-189 **Xiaofeng Gu***, Department of Mathematics, University of West Georgia, Carrollton, GA 30118. *Spanning rigid subgraph packing and sparse subgraph covering.*

A graph G is sparse if $|E(H)| \leq 2|V(H)| - 3$ for every subgraph H of G with $|V(H)| \geq 2$; If in addition $|E(G)| = 2|V(G)| - 3$, then G is minimally rigid. A graph is rigid if it contains a spanning minimally rigid subgraph. By definition, every rigid graph with at least 3 vertices is 2-connected.

We discover a sufficient partition condition of packing spanning rigid subgraphs and spanning trees. As a corollary, we show that a simple graph G contains a packing of k spanning rigid subgraphs and l spanning trees if G is $(4k+2l)$-edge-connected, and $G-Z$ is essentially $(6k+2l-2k|Z|)$-edge-connected for every $Z \subset V(G)$. Thus every $(4k+2l)$-connected and essentially $(6k+2l)$-connected graph G contains a packing of k spanning rigid subgraphs and l spanning trees. Utilizing it, we show that every 6-connected and essentially 8-connected graph G contains a spanning tree T such that $G-E(T)$ is 2-connected. These improve some previous results. Sparse subgraph covering problems are also studied. (Received July 21, 2017)

1132-05-190 **Jim Haglund*** (jhaglund@math.upenn.edu) and **Emily Sergel** (esergel@math.upenn.edu). *Inversion and Major Index Statistics on Standard Young Tableaux.* Preliminary report.

There is a natural extension of MacMahon's major index statistic maj to SYT which has many applications. Several years ago Stevens and the speaker introduced an inversion statistic inv on SYT, somewhat complicated to describe, which is equidistributed with maj on SYT. In this talk we introduce a common generalization of inv and maj we call majk, which is equidistributed with maj on SYT for all k, answering a question of S. Assaf.

This is joint work with Emily Sergel. (Received July 21, 2017)

1132-05-191 **Joanna Ellis-Monaghan*** (jellis-monaghan@smcvt.edu), Saint Michael's College, One Winooski Park, Colchester, VT 05439. *An Introduction to the Quantum Ising Model.* Preliminary report.

The connection between the Tutte polynomial in combinatorics and the Potts model of physics is well-known, as is the connection with its specialization, the Ising model, which corresponds to the Tutte polynomial along the hyperbola (x-1)(y-1)=2.

There is now a quantum version of the Ising model that captures quantum tunneling effects. However, very little is known about its mathematical properties, or even how to compute it for graphs with more than a couple

edges. We introduce this model from a graph theoretical perspective, together with far more questions than answers. (Received July 21, 2017)

1132-05-197 **Linyuan Lu*** (lu@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208, and **Zhiyu Wang** (zhiyuw@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC. *A note on 1-guardable graphs in the cops and robber game.*

Consider the cops and robber game on graphs. We say one cop can guard an induced subgraph H if the robber cannot enter H after finite steps. We extend Aigner and Fromme's lemma that an isometric path is 1-guardable to a larger family of graphs and give metric characterizations of these graphs. In particular, we show that a generalization of block graphs, namely vertebrate graphs, are 1-guardable. We use this result to determine the cop number of some special class of multi-layer generalized Peterson graphs. (Received July 21, 2017)

1132-05-198 **Jobby Jacob*** (jxjsma@rit.edu). *Rank numbers of some Cartesian products involving complete graphs.*

A k-ranking of a graph G is a function $f : V(G) \to \{1, 2, ..., k\}$ such that if $f(u) = f(v)$ then every $u - v$ path contains a vertex w such that $f(w) > f(u)$. The rank number of G is the minimum k such that a k-ranking exists for G. Given a graph G and a positive integer t, deciding if its rank number is less than or equal to t is shown to be NP-Complete. We will discuss properties of rankings of some Cartesian products involving complete graphs, along with their rank numbers. (Received July 21, 2017)

1132-05-201 **Jianbing Liu*** (jl0068@mix.wvu.edu), 1101 University Commons drive, Morgantown, WV 26505. *Enumerating regular graph coverings whose covering transformation groups are $\mathbb{Z}_2$-extensions of a cyclic group.*

Several types of the isomorphism classes of graph coverings have been enumerated by many authors. In 1988, Hofmeister enumerated the double covers of a graph, and this work was extended to n-fold coverings of a graph by the second and third authors. For *regular* coverings of a graph, their isomorphism classes were enumerated when the covering transformation group is a finite abelian or dihedral group in SIAM J. Discrete Math., 11 (1998), 273–285. In this paper, we enumerate the isomorphism classes of graph coverings when the covering transformation group is a $\mathbb{Z}_2$-extension of a cyclic group, including generalized quaternion and semi-dihedral groups. (Received July 21, 2017)

1132-05-204 **Dong Ye*** (dong.ye@mtsu.edu), Department of Mathematical Sciences, Middle Tennessee State University, Murfreesboro, TN 37132, and **Yezhou Wu**, Zhejiang University, Hangzhou, Zhejiang , Peoples Rep of China. *Circuit Covers of Signed Graphs.* Preliminary report.

A signed graph, denoted by (G, σ), is a graph G associated with a mapping $\sigma : E(G) \to \{-1, +1\}$. A cycle of (G, σ) is a connected 2-regular subgraph. A cycle C is positive if it has an even number of negative edges, and negative otherwise. A circuit of a signed graph (G, σ) is a positive cycle or a barbell consisting of two edge-disjoint negative cycles joined by a path. A circuit cover of (G, σ) is a family of circuits covering all edges of (G, σ). A circuit cover with the smallest total length is called a shortest circuit cover of (G, σ) and its length is denoted by $\mathrm{scc}(G, \sigma)$. Bouchet proved that a signed graph with a circuit cover if and only if it is ow-admissible (i.e., has a nowhere-zero integer flow). In this talk, we discuss the recent developments of circuit covers of signed graphs (G, σ) such as shortest circuit cover and circuit k-cover. This is joint work with Yezhou Wu. (Received July 21, 2017)

1132-05-214 **Guiying Yan*** (yangy@amss.ac.cn), Zhongguancun East road, No.55, Haidian District.Beijing, Beijing, 100190, Peoples Rep of China. *An approximate Ore-type result for tight Hamilton cycles in uniform hypergraphs.* Preliminary report.

A Hamilton l-cycle in a k-uniform hypergraph of n-vertex is an ordering of all vertices, combined with an ordered subset C of edges, such that any two consecutive edges share exactly l vertices and each edge in C contains k consecutive vertices. A classic result of O. Ore in 1960 is that if the degree sum of any two independent vertices in an n-vertex graph is at least n, then the graph contains a Hamiltonian cycle. Naturally, we consider to generalize it to hypergraphs situation. In this paper, we prove the following theorems. (i) for any n $\geq$ 4k2, there is an n-vertex k-uniform hypergraph, with degree sum of any two strongly independent sets of k1 vertices bigger than 2n4(k1), contains no Hamilton l-cycle, $1 \leq l \leq$ k1. (ii) if the degree sum of two weakly independent sets of k1 vertices in an n-vertex k-uniform hypergraph is $(1 + o(1))n$, then the hypergraph contains a Hamilton (k1)-cycle, where two distinct sets of k1 vertices are weakly (strongly) independent if there exist no edge containing the union of them (intersecting both of them). (Received July 22, 2017)

1132-05-222 **Joel Brewster Lewis** and **Alejandro H. Morales*** (ahmorales.math@gmail.com). *Rook theory of the finite general linear group.*

Matrices over a finite field having fixed rank and restricted support are a natural q-analogue of rook placements on a board. We develop this q-rook theory by defining a corresponding analogue of the hit numbers of a board. Using tools from coding theory, we show that these q-hit and q-rook numbers obey a variety of identities analogous to the classical case. We also explore connections to earlier q-analogues of rook theory, find a q-analogue of the classical menage problem, as well as settling a polynomiality conjecture and finding a counterexample of a positivity conjecture of the authors and Klein. (Received July 23, 2017)

1132-05-228 **Richard Ehrenborg***, University of Kentucky, Lexington, KY 40506, **Alex Happ**, University of Kentucky, Lexington, KY 40506, **Dustin Hedmark**, Montgomery Bell Academy, Nashville, TN 37205, and **Cyrus Hettle**, Georgia Institute of Technology, Atlanta, GA 30332. *Box polynomials.*

We consider properties of the box polynomials, a one variable polynomial defined over all integer partitions λ whose Young diagrams fit in an m by n box. We show that these polynomials can be expressed by the finite difference operator Δ applied to the power x^{m+n}. Using the chromatic polynomial and restricted growth words we obtain connections between set partition enumeration and the box polynomials. We also discuss the location of the roots of the box polynomial. (Received July 23, 2017)

1132-05-241 **Vesna Andova** and **Bernard Lidický*** (lidicky@iastate.edu), Department of Mathematics, Iowa State University, 396 Carver Hall, Ames, IA 50011, and **Borut Lužar** and **Riste Škrekovski**. *On facial unique-maximum (edge-)coloring.*

A *facial unique-maximum coloring* of a plane graph is a vertex coloring where on each face α the maximal color appears exactly once on the vertices of α. If the coloring is required to be proper, then the upper bound for the minimal number of colors required for such a coloring is set to 5. Fabrici and Göring even conjectured that 4 colors always suffice. Confirming the conjecture would hence give a considerable strengthening of the Four Color Theorem. In this paper, we prove that the conjecture holds for subcubic plane graphs, outerplane graphs and plane quadrangulations. Additionally, we consider the facial edge-coloring analogue of the aforementioned coloring and prove that every 2-connected plane graph admits such a coloring with at most 4 colors. (Received July 23, 2017)

1132-05-242 **Charles Camacho**, **Silvia Fernandez-Merchant**, **Marija Jelic**, **Rachel Kirsch**, **Linda Kleist**, **Elizabeth Bailey Matson** and **Jennifer White*** (jennifer.diemunsch@stvincent.edu). *Bounding the tripartite-circle crossing number of complete tripartite graphs.* Preliminary report.

A tripartite-circle drawing of the complete tripartite graph $K_{m,n,p}$ is a drawing in the plane where the vertices of each partite set are placed on one of three disjoint circles, and the edges do not cross the circles. The tripartite-circle crossing number of a graph is the minimum number of crossings among all tripartite-circle drawings. These are a natural extension of cylindrical drawings of bipartite graphs, which are particularly interesting in light of the Harary-Hill and Zarankiewicz Conjectures. In this talk we give lower bounds for the tripartite-circle crossing number of $K_{m,n,p}$, as well as upper bounds for the balanced case, $K_{n,n,n}$, and small complete tripartite graphs, such as $K_{2,2,n}$. (Received July 23, 2017)

1132-05-245 **Tao Jiang*** (jiangt@miamioh.edu), 301 Patterson Ave, Department of Mathematics, Oxford, OH 45056, and **Liana Yepremyan**. *Supersaturation of even linear cycles in linear hypergraphs.*

A classic result of Erdős and, independently, of Bondy and Simonovits says that the maximum number of edges in an n-vertex graph not containing C_{2k}, the cycle of length $2k$, is $O(n^{1+1/k})$. Simonovits established a corresponding supersaturation result for C_{2k}'s, showing that there exist positive constants C, c depending only on k such that every n-vertex graph G with $e(G) \geq Cn^{1+1/k}$ contains at least $c\left(\frac{e(G)}{v(G)}\right)^{2k}$ many copies of C_{2k}, this number of copies tightly achieved by the random graph (up to multiplicative constant).

In this talk, we extend Simonovits' result to supersaturation of r-uniform linear cycles of even length in r-uniform linear hypergraphs. Our proof is self-contained and includes the $r = 2$ case. As an auxiliary tool, we develop a reduction lemma from general host graphs to almost-regular host graphs that can be used for other supersaturation problems, and may therefore be of independent interest. This is joint work with Liana Yepremyan. (Received July 23, 2017)

1132-05-247 **Federico Castillo***, One Shields Ave., Davis, CA 95616. *Positivity of Ehrhart polynomials' coefficients.*

Given any lattice polytope P, the Ehrhart polynomial is a function that counts the number of points in dilations of P. There is an interpretation for some of the coefficients, for instance the leading term correspond to the volume of the polytope, in particular, it is always positive. However the rest of the coefficients are not always positive. I will survey known results and techniques to be applied to a particular class of polytopes: smooth polytopes. This is joint work with Fu Liu, Benjamin Nill, and Andreas Paffenholz. (Received July 24, 2017)

1132-05-248 **Mikhail Mazin***, mmazin@math.ksu.edu, and **Eugene Gorsky** and **Monica Vazirani**. *Rational Dyck Paths in the Non-Relatively Prime Case.*

In the relatively prime case, the rational (n, m)-Dyck paths are in bijection with the (n, m)-invariant subsets of integers, considered up to shifts. This bijection provides a connection between rational Catalan combinatorics and the geometry of certain algebraic varieties. In particular, it allows one to reinterpret the *dinv* statistic as the dimension of the corresponding complex affine cell in an affine Springer fiber. The non-relatively prime case is more complicated. Although on the combinatorial side many things can be generalized, including the *dinv* statistic and even Shuffle conjecture (theorem), there is no known generalization of the geometric interpretation of the *dinv* statistic.

In this talk, I will explain how one can extend the bijection between rational Dyck paths and the invariant subsets in $\mathbb{Z}$ to the non-relatively prime case. The natural obstacle is that the set of invariant subsets is not finite in the non-relatively prime case. One has to consider certain equivalence relation on the invariant subsets to make the bijection work. The hope is that this construction will lead to a geometric or representation theoretic interpretation of the *dinv* statistic in the non-relatively prime case. (Received July 24, 2017)

1132-05-250 **Jie Ma*** (jiema@ustc.edu.cn), No. 96 Jinzhai Road, Hefei, Anhui 230026, Peoples Rep of China. *Some stability results on the circumference of a graph.*

In this talk we will discuss some stability results on the circumference of graphs. This includes a stability result of a classic theorem of Bondy. (Received July 24, 2017)

1132-05-255 **Florian Pfender*** (florian.pfender@ucdenver.edu) and **Bernard Lidický**. *On 5-cycles in Graphs.*

Maximizing the number of induced 5-cycles was a long standing open problem, both for triangle-free and general graphs. Recently, both of these problems were solved for large graphs with the help of the flag algebra method.

In this talk, we show how we can modify the method to resolve both questions for all graph sizes. (Received July 24, 2017)

1132-05-257 **Yan Cao** and **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, and **Suyun Jiang**, **Huiqing Liu** and **Fuliang Lu**. *Average degrees in edge-chromatic critical graphs.*

Denote by Δ, $\overline{d}$ and χ' the maximum degree, the average degree and chromatic index of a simple graph G, respectively. A simple graph G *edge-Δ-critical* if $\chi'(G) = \Delta + 1$ and $\chi'(H) \leq \Delta$ for every proper subgraph H of G. Vizing in 1968 conjectured that if G is edge-Δ-critical, then $\overline{d} \geq \Delta - 1 + \frac{3}{n}$. We show that

$$\overline{d} \geq \begin{cases} 0.69241\Delta - 0.15658 & \text{if } \Delta \geq 66, \\ 0.69392\Delta - 0.20642 & \text{if } \Delta = 65, \text{ and} \\ 0.68706\Delta + 0.19815 & \text{if } 56 \leq \Delta \leq 64. \end{cases}$$

This result improves the best known bound $\frac{2}{3}(\Delta + 2)$ obtained by Woodall in 2007 for $\Delta \geq 56$. Woodall constructed an infinite family of graphs showing his result cannot be improved by well-known Vizing's Adjacency Lemma and other known edge-coloring techniques. To over come the barrier, we follow the recently developed recoloring technique of Tashkinov trees to expand Vizing fans technique to a larger class of trees. (Received July 24, 2017)

1132-05-260 **Michael Tait*** (mtait@cmu.edu). *Degree Ramsey numbers for even cycles.*

Let $H \xrightarrow{s} G$ denote that any s-coloring of $E(H)$ contains a monochromatic G. The degree Ramsey number of a graph G, denoted by $R_\Delta(G, s)$, is $\min\{\Delta(H) : H \xrightarrow{s} G\}$. We consider degree Ramsey numbers where G is a fixed even cycle. Kinnersley, Milans, and West showed that $R_\Delta(C_{2k}, s) \geq 2s$, and Kang and Perarnau showed that $R_\Delta(C_4, s) = \Theta(s^2)$. Our main result is that $R_\Delta(C_6, s) = \Theta(s^{3/2})$ and $R_\Delta(C_{10}, s) = \Theta(s^{5/4})$. Additionally, we substantially improve the lower bound for $R_\Delta(C_{2k}, s)$ for general k. (Received July 24, 2017)

1132-05-265 **Louis DeBiasio*** (debiasld@miamioh.edu), **Bob Krueger**, **Dan Pritikin** and **Eli Thompson**. *Robust Expansion and Hamiltonian Cycles in k-partite Graphs.*

It was shown by Kühn, Osthus, and Treglown that graphs with linear minimum degree having a certain robust expansion property must contain a Hamiltonian cycle. This concept of robust expansion has since been used to prove a number of even stronger results for graphs and digraphs.

We will discuss a recent result regarding a minimum degree condition for Hamiltonian cycles in not-necessarily-balanced k-partite graphs, which generalizes known results for balanced k-partite graphs. Along the way, we will present a simplified method for showing that a graph is either a robust expander or it is close to an extremal example. (Received July 24, 2017)

1132-05-272 **Robert Guralnick**, **John Shareshian*** (shareshi@math.wustl.edu) and **Russ Woodroofe**. *Coset posets and invariant generation of simple groups.*

I will discuss joint work of Shareshian-Woodroofe and Guralnick-Shareshian-Woodroofe relating the topology of coset posets and generation of simple groups by various classes of p-subgroups and p-elements. (Received July 24, 2017)

1132-05-273 **Deepak Bal*** (bald@montclair.edu), Montclair State University, Department of Mathematical Sciences, 1 Normal Ave., Montclair, NJ 07043, and **Michael Anastos**. *Monochromatic Components in Random Graphs.* Preliminary report.

We are concerned with the following Ramsey-type question: if the edges of a graph are r-colored (not necessarily properly), what is the largest monochromatic component (or path, or cycle) which must appear? We address this question for random regular and random k-out graphs. This is joint work with Michael Anastos. (Received July 24, 2017)

1132-05-275 **Ruth Luo***, 273 Altgeld Hall, 1409 W Green St, Urbana, IL 61801, and **Zoltan Furedi**, **Alexandr Kostochka** and **Jacques Verstraete**. *Some results for graphs without long cycles.*

The Erdös–Gallai states that every n-vertex graph with more than $\frac{1}{2}(k-1)(n-1)$ edges has a cycle of length k or longer. Kopylov proved a refinement of the theorem: if G is a 2-connected graph with more than $\max\{\binom{k-2}{2}+2(n-k+2), \binom{k-\lfloor(k-1)/2\rfloor}{2}+\lfloor(k-1)/2\rfloor(n-k+\lfloor(k-1)/2\rfloor)\}$ edges, then G contains a cycle of length k or longer. Two sharpness examples $H_{n,k,2}$ and $H_{n,k,\lfloor(k-1)/2\rfloor}$ are provided. In this talk, we present a stability version of Kopylov's theorem for dense 2-connected graphs with circumference less than k. We also present a generalization of the theorem, that is, we show a sharp upper bound for the number of cliques in such graphs. (Received July 24, 2017)

1132-05-278 **Laura Escobar*** (lescobar@illinois.edu), Urbana, IL 61801, and **Alexander Yong**. *Newton polytopes and symmetric Grothendieck polynomials.*

Symmetric Grothendieck polynomials are inhomogeneous versions of Schur polynomials that arise in combinatorial K-theory. A polynomial has saturated Newton polytope (SNP) if every lattice point in the polytope is an exponent vector of a term of the polynomial. We show Newton polytopes of these Grothendieck polynomials and their homogeneous components have SNP. Moreover, the Newton polytope of each homogeneous component is a permutahedron. This addresses recent conjectures of C. Monical-N. Tokcan-A. Yong and of A. Fink- K. Mészáros-A. St. Dizier in this special case. (Received July 24, 2017)

1132-05-279 **Edward Allen**, **Joshua Hallam** and **Sarah Mason*** (masonsk@wfu.edu). *Dual immaculate quasisymmetric functions expand positively into quasisymmetric Schur functions.*

We discuss the connection between two recently introduced bases for quasisymmetric functions, both of which are natural quasisymmetric analogs of Schur functions due to the combinatorial properties they exhibit. The quasisymmetric Schur functions are obtained through specializations of Macdonald polynomials. The dual immaculate basis is dual to a basis for non-commutative symmetric functions constructed through non-commutative Berenstein creation operators. Both bases can be defined using tableaux-like objects. We describe a Remmel-Whitney-style algorithm for writing a dual immaculate quasisymmetric function as a positive sum of quasisymmetric Schur functions. We also explore properties of the insertion algorithm used to prove this decomposition. (Received July 24, 2017)

1132-05-280 **Michael Ferrara*** (michael.ferrara@ucdenver.edu). *Saturation Problems in Edge-colored Graphs.*

Let $\mathcal{C}$ denote a family of edge colored graphs. A t-edge-colored graph G is $(\mathcal{C}, t)$-*saturated* if G does not contain any element of $\mathcal{C}$ but for any edge $e \notin G$ and any color $i \in [t]$, the addition of e to G in color i creates some element of $\mathcal{C}$ in G. Let $sat_t(n, \mathcal{C})$ denote the minimum number of edges in an $(\mathcal{C}, t)$-saturated graph of order n. In this talk, we discuss both specific and rather general results on $sat_t(n, \mathcal{C})$ for a number of families of graphs. In particular, we highlight some interesting contrasts between the cases where $\mathcal{C}$ consists of copies of a fixed graph F colored with either "many" or "few" colors. This is joint work with a number of coauthors over several papers. (Received July 24, 2017)

1132-05-281 **James McKeown*** (mckeown@math.miami.edu). *Deformations of Stiefel Diagrams.* Preliminary report.

In 2005 J.L. Waldspurger proved a remarkable theorem: given a finite real reflection group W, the closed positive root cone is tiled by the images of the open weight cone under the action of the linear transformations $id - w$ for $w \in W$. Shortly thereafter E. Meinrenken extended the result to affine Weyl groups. P.V. Bibikov and V.S. Zhgoon then gave a uniform proof for a discrete reflection group acting on a simply-connected space of constant curvature. Along with Drew Armstrong, this presenter recently show that, in the type A finite and affine cases, these tilings are extremely combinatorial and give a new geometric description of certain permutation statistics.

Meinrenken paper has another intriguing theorem: For W^a an affine Weyl group, given $S \in \mathrm{End}(V)$, with determinant sufficiently small, and $V_w^{(S)} := (S - w)A$ where A is the fundamental alcove, the $V_w^{(S)}$ are all disjoint and their closures cover the entire vector space V.

When $S = 0$ the resulting decomposition of V is the Stiefel diagram, and when $S = k\mathrm{id}$, where $k \to 1$, one recovers the affine extension of Waldspurger's original result.

We will investigate the set of such S, and look at some interesting limiting cases in type A. (Received July 24, 2017)

1132-05-282 **Erik Insko*** (einsko@fgcu.edu), **Alexander Diaz-Lopez**, **Pamela E. Harris**, **Mohamed Omar** and **Bruce Sagan**. *Bounding the roots of peak and descent polynomials.* Preliminary report.

In 2012, Billey, Burdzy, and Sagan showed that given a positive integer n and a subset $S \subset \{1, 2, \ldots, n\}$ the number of permutations of length n with peak set S is $2^{n-|S|-1} p_S(n)$, where p_S is a polynomial called the peak polynomial corresponding to S. In 2014, Billey, Fahrbach, and Talmage conjectured that the complex roots of peak polynomials of degree $m - 1$ all lie within a circle of radius m, and they have real parts that are bounded below by -3. In this talk we will define descent polynomials, share a conjecture that states the roots of descent polynomials of degree $m - 1$ satisfy the same bounds as those identified by Billey, Fahrbach, and Talmage, and discuss a number of partial results in support of these two conjectures. (Received July 25, 2017)

1132-05-284 **Michael Ferrara**, **Bill Kay**, **Lucas Kramer**, **Ryan C. Martin**, **Benjamin Reiniger**, **Heather C. Smith** and **Eric Sullivan*** (eric.2.sullivan@ucdenver.edu). *The Saturation Number of Induced Subposets of the Boolean Lattice.*

Given a poset $\mathcal{P}$, a family $\mathcal{F}$ of points in the Boolean lattice is said to be $\mathcal{P}$-saturated if (1) $\mathcal{F}$ contains no copy of $\mathcal{P}$ as a subposet and (2) every strict superset of $\mathcal{F}$ contains a copy of $\mathcal{P}$ as a subposet. The maximum size of a $\mathcal{P}$-saturated subposet is denoted by $\mathrm{La}(n, \mathcal{P})$, which has been studied for a number of choices of $\mathcal{P}$.

Here, we are interested in $\mathrm{sat}(n, \mathcal{P})$, the size of the smallest family in $\mathcal{B}_n$ which is $\mathcal{P}$-saturated. This notion was introduced by Gerbner et al. (2013), and parallels the deep literature on the saturation function for graphs.

In particular, we introduce and study the concept of saturation for induced subposets. As opposed to induced saturation in graphs, the above definition of saturation for posets extends naturally to the induced setting. We give several exact results and a number of bounds on the induced saturation number for several small posets. We also use a transformation to the biclique cover problem to prove a logarithmic lower bound for a rich infinite family of target posets. (Received July 24, 2017)

1132-05-291 **Sean English**, **Jessica Fuller**, **Nathan Graber*** (nathan.graber@ucdenver.edu), **Pamela Kirkpatrick**, **Abhishek Methuku** and **Eric Sullivan**. *Berge-Saturation of Paths and K_3 in k-uniform hypergraphs.*

Let H be a hypergraph, and G be a simple graph on the same vertex set. We say H is *Berge-G* if there exists a bijection $f : E(G) \to E(H)$ such that for each $e \in E(G)$, we have $e \subset f(e)$. If there exists a subhypergraph

of H that is Berge-G we say that H contains G, otherwise H is said to be *G-free*. A hypergraph, H is *Berge-G-saturated* if H does not contain G but $H + e$ contains G for every $e \notin E(H)$. The *Berge-saturation number*, denoted B-sat(H, G), is the minimum number of edges in a hypergraph H such that H is G-saturated.

In this talk we will discuss the Berge-saturation number for several classes of graphs and draw comparisons between Berge-saturation and saturation in the traditional graph sense. (Received July 24, 2017)

1132-05-293 **Guangqi Cui*** (bestwillcui@gmail.com), **Sung Hyun Yoo*** (sunnyyoo812@gmail.com) and **Kaan Dokmeci** (kdokmeci@gmail.com). *Monochromatic Rectangles in Grid Colorings.*

Ramsey Theory is a branch of combinatorics in which structures like graphs, grids, and integers are colored, and interesting properties are proven to arise. We focus on colorings of 2-dimensional grids and prove certain properties regarding shapes such as monochromatic rectangles. For example, every coloring of the vertices of a 5 by 5 grid using 2 colors must contain a monochromatic rectangle with sides parallel to the x and y axes (a previously known result). We find better upper bounds on the size of grids that must contain monochromatic rectangles and L shapes (3 specific points of a rectangle) with specified dimensions, culminating with a generalization of the Square Theorem. We address lower bounds on grids containing rectangles with specific dimensions, which has never before been addressed, and provide a state of the art proof technique. Finally, we analyze grids that avoid all monochromatic rectangles, including non axis-parallel rectangles, and find new and strict bounds.

Keywords: Ramsey theory, grid, monochromatic, coloring, rectangle (Received July 24, 2017)

1132-05-294 **Brittney Ellzey*** (b.ellzey@math.miami.edu) and **Michelle L. Wachs** (wachs@math.miami.edu). *On restricted Smirnov words enumerated by descent number.* Preliminary report.

A Smirnov word is a word over the positive integers in which consecutive letters must be different. The descent enumerator of all Smirnov words of fixed length is the same as the chromatic quasisymmetric function of the naturally labeled path graph. It follows from results of Shareshian and the second author that the descent enumerator is a polynomial whose coefficients are symmetric functions. They gave a formula for the generating function of the descent enumerator in terms of the elementary symmetric functions, which establishes e-positivity of its coefficients. Here we consider the descent enumerator of Smirnov words with restrictions on the relationship between the first and last letter of each word. Our main result is a formula for the generating function, which establishes e-positivity of the descent enumerator of restricted Smirnov words. This formula yields two additional e-positivity formulas for chromatic quasisymmetric functions, one for the naturally labeled cycle graph and another for the directed cycle. The formula for the directed cycle was proved earlier by the first author and is used in the proof of our main result. (Received July 24, 2017)

1132-05-301 **Danny Rorabaugh*** (dr76@queensu.ca). *Combinatorial Nullstellensatz in Graph Theory.*

Combinatorial Nullstellensatz is an algebraic technique developed by Alon and Tarsi in 1992. Alon named this method in 2001 when he demonstrated its applicability to a wide range of problems in additive number theory and graph theory. This is an early instance of what is now called the Polynomial Method, a general approach for applying algebraic geometry to solve problems in discrete mathematics. Roughly speaking, by strategically associating a discrete structure or configuration with a polynomial, one can utilize algebraic properties of the Nullstellen (zero locus). This talk will focus on graph theoretic applications of Combinatorial Nullstellensatz, especially to guarantee the existence of particular subgraphs or labelings. (Received July 24, 2017)

1132-05-308 **Jordan Almeter**, **Samet Demircan**, **Andrew Kallmeyer**, **Kevin G Milans*** (milans@math.wvu.edu) and **Robert Winslow**. *Ordered Star-colorings.* Preliminary report.

Ordered Star-colorings

An *ordered star-coloring* of a graph G is a partition of $V(G)$ into independent sets $S_1, \ldots, S_k$ such that for $i < j$, the set $S_i \cup S_j$ induces a star forest in which vertices in S_j have degree at most 1. The *ordered star chromatic number*, denoted $\chi_{\text{os}}(G)$, is the minimum number of colors needed for an ordered star-coloring.

Let $\chi'_{\text{os}}(G) = \chi_{\text{os}}(L(G))$, where $L(G)$ is the line graph of G; it is also the least integer k such that $E(G)$ can be partitioned into matchings $M_1, \ldots, M_k$ such that M_j is an induced subgraph of the subgraph with edge set $\bigcup_{i<j} M_i$. We obtain $\chi'_{\text{os}}(K_{m,n})$ asymptotically when m is fixed and $n \to \infty$. In the diagonal case, we know only that $\Omega(n \log n) \leq \chi'_{\text{os}}(K_{n,n}) \leq O(n^{\log_2 3})$. We also discuss an interesting connection to a variant of the Van der Waerden numbers. (Received July 25, 2017)

1132-05-319 **Ron Gould**, **Victor Larsen*** (vlarsen@kennesaw.edu) and **Luke Postle**. *Using discharging to understand structure in k-critical graphs.*

Ore conjectured in 1967 that $f_k(n)$, the minimum number of edges in a k-critical graph on n vertices, followed the formula $f_k(n+k-1) = f_k(n) + (k-1)\left(\frac{k}{2} - \frac{1}{k-1}\right)$. This formula mimics the growth of a k-critical graph using the Hajós construction, which modifies a k-critical graph to obtain a k-critical graph with $k-1$ extra vertices and $\binom{k}{2} - 1$ extra edges.

Recently, this conjecture has been shown to be asymptotically true. The proof method used a type of discharging argument to exhibit a lower bound on $f_k(n)$. We further examine this bound and show that a modification of the discharging method used gives extra information about the structure of k-critical graphs near the lower bound. (Received July 25, 2017)

1132-05-322 **Alexander Diaz-Lopez*** (alexander.diaz-lopez@villanova.edu), 800 Lancaster Ave, SAC 305, Villanova, PA 19085, and **Pamela Harris**, **Erik Insko**, **Mohamed Omar** and **Bruce Sagan**. *Positivity Property of Descent Polynomials.* Preliminary report.

We say that a permutation $\pi = \pi_1\pi_2\cdots\pi_n \in S_n$ has a descent at index i if $\pi_i > \pi_{i+1}$. Let $Des(\pi)$ denote the set of indices where π has a descent. Given a set I of positive integers, we define $D(I;n) = \{\pi \in S_n \,|\, Des(\pi) = I\}$ and $d(I;n) := |D(I;n)|$. We say $d(I;n)$ is the descent polynomial of I. In this talk we will show that descent polynomials, like peak polynomials, can be written in a binomial basis with (strictly) positive coefficients. We will then describe the coefficients combinatorially, and explore some of their properties. (Received July 25, 2017)

1132-05-331 **Arthur L Gershon*** (arthur.gershon@case.edu). *Reaching for the StArs: An Asymptotic Estimate for the Number of Strip Arrangements on Chessboards of Fixed Width.* Preliminary report.

We attempt to find a formula for the number $T(m,n)$ of strip arrangements on an $m \times n$ chessboard with at most one horizontal strip in each row and at most one vertical strip in each column; the author has previously called such objects *(1, 1)-restricted StArrs*. Previous work has used the transfer matrix method for fixed values of m, which shows that the corresponding generating functions must be rational and therefore the formula for $T(m,n)$ must be of the form $\sum \lambda(m)^n P_{\lambda(m)}(n)$, where the $\lambda(m)$ are complex numbers depending on m, and the associated factor $P_{\lambda(m)}$ is a *polynomial* in n. Determining a general exact formula, however, has proven elusive, as the transfer matrices grow exponentially with m, so we have resolved to a general asymptotic formula for $T(m,n)$ for fixed m as $n \to \infty$. In particular, we will give an expression for the dominant term in the sum, and therefore deduce that, as $n \to \infty$,

$$T(m,n) \sim \frac{1}{(m!)^2} \prod_{j=1}^{m} \left[1 + \binom{j}{2} + \binom{m+1-j}{2}\right] n^m \left(1 + \binom{m+1}{2}\right)^n$$

(Received July 25, 2017)

1132-05-340 **Stephen G. Hartke** and **Luke L. Nelsen*** (luke.nelsen@ucdenver.edu). *Computing f-Choosability of Small Graphs.* Preliminary report.

When employing the discharging method to obtain graph coloring results, one typically balances the task of determining a set of discharging rules against the task of determining a set of useful reducible configurations. In all known proofs of the Four Color Theorem, the latter task requires computational assistance. A more recent example which demonstrates the usefulness of computational assistance for checking reducible configurations is the proof of the cubic case of Wegner's Conjecture (if G is planar with maximum degree 3, then $\chi(G^2) \leq 7$) by Hartke, Jahanbekam, and Thomas. Toward the end of checking reducible configurations for coloring problems, we discuss an approach for computing whether a graph is f-choosable for a given f, and what directions we may go with such a program. Joint work with Stephen Hartke. (Received July 25, 2017)

11 ► Number theory

1132-11-15 **Daniel J Garbin*** (dgarbin@qcc.cuny.edu), Dept. of Math and Comp. Sci., Queensborough Community College, 222-05 56th Avenue, Bayside, NY 11364. *Spectral asymptotics on sequences of elliptically degenerating Riemann surfaces.* Preliminary report.

This is the second in a series of two articles where we study various aspects of the spectral theory associated to families of hyperbolic Riemann surfaces obtained through elliptic degeneration. In the first article, we investigate the asymptotics of the trace of the heat kernel both near zero and infinity and we show the convergence of small eigenvalues and corresponding eigenfunctions. Having obtained necessary bounds for the trace, this second article

presents the behavior of several spectral invariants. Some of these invariants, such as the Selberg zeta function and the spectral counting functions associated to small eigenvalues below 1/4, converge to their respective counterparts on the limiting surface. Other spectral invariants, such as the spectral zeta function and the logarithm of the determinant of the Laplacian diverge. In these latter cases, we identify diverging terms and remove their contributions, thus regularizing convergence of these spectral invariants. Our study is motivated by a result which D. Hejhal attributes to A. Selberg, proving spectral accumulation for the family of Hecke triangle groups. In this article, we obtain a quantitative result to Selberg's remark. (Received May 10, 2017)

1132-11-16 **Rufei Ren*** (rufeir@uci.edu), 28 lilac dr Apt.2, Rochester, NY 14620. *Generic Newton polygon for exponential sums in two variables with triangular base.* Preliminary report.

Let p be a prime number. Every n-variable polynomial $f(\underline{x})$ over a finite field of characteristic p defines an Artin–Schreier–Witt tower of varieties whose Galois group is isomorphic to $\mathbb{Z}_p$. Our goal of this paper is to study the Newton polygon of the L-functions associated to a finite character of $\mathbb{Z}_p$ and a generic polynomial whose convex hull is an n-paralleltope Δ. We denote this polygon by $\mathrm{GNP}(\Delta)$. We prove a lower bound of $\mathrm{GNP}(\Delta)$, which is stronger than the usual Hodge polygon and is called the improved Hodge polygon $\mathrm{IHP}(\Delta)$. We conjecture that $\mathrm{GNP}(\Delta)$ and $\mathrm{IHP}(\Delta)$ are the same. Indeed, when p is larger than a fixed number determined by Δ, we prove that $\mathrm{GNP}(\Delta)$ and $\mathrm{IHP}(\Delta)$ coincide at infinitely many points. As a corollary, we deduce that the slopes of $\mathrm{GNP}(\Delta)$ roughly form an arithmetic progression with increasing multiplicities. (Received July 25, 2017)

1132-11-33 **Abhishek Parab*** (aparab@purdue.edu). *Continuity of the Twisted Arthur-Selberg Trace Formula.*

We show that the distributions occurring in the geometric and spectral side of the twisted Arthur-Selberg trace formula extend to non-compactly supported test functions. The geometric assertion is modulo a hypothesis on root systems proven in many useful cases. This result is a small technical step towards Langlands' Beyond Endoscopy. It extends the work of Finis-Lapid (and Mueller, spectral side) in the non-twisted setting. We will also give an application towards residues of Rankin-Selberg L-functions. (Received June 30, 2017)

1132-11-36 **Cesar Valverde*** (cvalverde@mec.cuny.edu), 1638 Bedford Avenue, Brooklyn, NY 11225. *Distinguished representations.*

Distinguished representations are expected to characterize functorial liftings and to have L-functions with central values related to central periods. In this talk, we will present an overview of a global result via Relative Trace Formula, as well as an example from the local theory of distinction by orthogonal subgroups of the general linear group. (Received July 01, 2017)

1132-11-52 **Wen-Ching Winnie Li*** (wli@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Langlands L-functions and counting geodesic cycles in complexes.*

A traditional zeta function in number theory counts either integral ideals of a number field or rational points on a variety over a finite field. Selberg introduced the zeta function which counts geodesic cycles on a compact Riemann surface and related its zeros to the spectrum of the Laplacian on the Riemann surface. Its p-adic analogue studied by Ihara led to the zeta function of a finite graph which counts geodesic cycles in the graph, following the observation by Serre. The zeta functions for graphs share interesting properties with the Selberg zeta functions and the zeta functions of curves over finite fields.

Graphs are 1-dimensional simplicial complexes. In this talk we shall introduce the zeta functions attached to 2-dimensional simplicial complexes arising as finite quotients of the buildings of PGL(3) and SL(4) over a p-adic field. They are rational functions with explicit closed form expressions reminiscent of the zeta function of a surface over a finite field. Further, the Langlands L-function appears as a factor of the zeta function. We shall explain how this happens.

This is a survey talk based on several joint works with Yang Fang, Ming-Hsuan Kang, and Chian-Jen Wang. (Received July 08, 2017)

1132-11-73 **John Bergdall*** (bergdall.jf@gmail.com), Department of Mathematics, Michigan State University, 619 Red Cedar Road, East Lansing, MI, MI 48824. *Upper bounds for constant slope p-adic families of modular forms.*

If f is a classical Hecke eigenform of level p and weight k, then there exists a p-adic family $F(\kappa) = a_0(\kappa) + a_1(\kappa)q + a_2(\kappa)q^2 + \cdots$ whose evaluation at $\kappa = k$ is the q-expansion of f. Here, the $a_n(\kappa)$ are rigid analytic functions of κ (a p-adic integer, say). The existence of such families was proven by Hida, Coleman and Mazur, and Buzzard.

It remains an interesting problem to study the radius of convergence of the family. Previous results of Wan suggest in spirit that a family exists on a disc of κ whose radius is roughly p^{-h^2} where h is the p-adic valuation of the U_p-eigenvalue of f. Computer evidence compiled since the 1990's and since, however, points to much larger families.

In this talk we will present two bounds for the *maximal* radius of families on which the p-th coefficient has constant absolute value ("constant slope families"). One bound is roughly $p^{-\log h}$ and the other depends not just on h, but on f itself. We will then describe numerical evidence that our bounds are near to tight. (Received July 12, 2017)

1132-11-79 **Chris D Birkbeck*** (cd.birkbeck@gmail.com). *Slopes of Hilbert modular forms.*

Computations done by Buzzard and Kilford (among others) of slopes of overconvergent modular forms gave us great insights into the geometry of the associated eigenvarieties and are the basis of many conjectures. This is an active area of research and in many cases these conjectures are now proven, yet not much is known in the case of Hilbert modular forms. In my talk I will discuss some recent computations of slopes of overconvergent Hilbert modular forms and what they suggest about the geometry of the associated eigenvarieties. (Received July 13, 2017)

1132-11-85 **Joe Kramer-Miller*** (j.kramer-miller@ucl.ac.uk), 25 Gordon St, Department of Mathematics, Room 610c, London, WC1H 0AY, United Kingdom. *F-isocrystals with infinite monodromy and applications.*

We will explain a precise monodromy theorem for rank one F-isocrystals with infinite monodromy. Then we will explain how the Newton polygon of an overconvergent F-isocrystal with a rank one etale subcrystal relates to the monodromy of this subcrystal. As an application we give a new proof of a recent theorem of Drinfeld and Kedlaya on slopes of indecomposable F-isocrystals. We also apply these results to conjectures by Daqing Wan on the p-adic behavior of zeta functions in geometric towers of curves. (Received July 14, 2017)

1132-11-88 **Michiel Kosters*** (kosters@gmail.com), kosters@gmail.com, and **Hui June Zhu**, hjzhu@math.buffalo.edu. *On slopes of L-functions of $\mathbb{Z}_p$-covers over the projective line.*

Let $P : ... \to C_2 \to C_1 \to \mathbb{P}^1$ be a $\mathbb{Z}_p$-cover of the projective line over a finite field of cardinality q and characteristic p which ramifies at exactly one rational point, and is unramified at other points. In this talk, we study the q-adic valuations of the reciprocal roots in $\mathbb{C}_p$ of L-functions associated to characters of the Galois group of P. We show that for all covers P such that the genus of C_n is a quadratic polynomial in p^n for n large, the valuations of these reciprocal roots are uniformly distributed in the interval $[0, 1]$. Furthermore, we show that for a large class of such covers P, the valuations of the reciprocal roots in fact form a finite union of arithmetic progressions. (Received July 14, 2017)

1132-11-89 **Daniel R. Gulotta*** (dgulotta@math.columbia.edu). *Adic eigenvarieties and locally analytic distributions.*

An eigenvariety is a space that parameterizes systems of Hecke eigenvalues arising from overconvergent p-adic automorphic forms. In order to explain some results of Buzzard and Kilford on the slopes of modular forms, Coleman predicted that eigenvarieties can have "spectral halos" consisting of characteristic p points.

One way of defining p-adic automorphic forms is by interpolating the cohomology of locally symmetric spaces. When using this approach, the main challenge in constructing the spectral halo is to devise a notion of "local analyticity" for functions that take values in rings where p is not invertible. I will define what it means for a function from a locally $\mathbb{Q}_p$-analytic manifold to a complete Tate $\mathbb{Z}_p$-algebra to be "locally analytic". This definition makes it possible to construct the spectral halos of Urban's equidimensional eigenvarieties for groups with discrete series. (Received July 17, 2017)

1132-11-94 **Matthew Schmidt*** (mwschmid@buffalo.edu), Buffalo, NY 14223. *Higher Local fields and the Schmid-Witt symbol.*

For a local field of characteristic $p > 0$, K, the combination of local class field theory and Artin-Schreier-Witt theory yield what is known as the Schmid-Witt symbol. The symbol encodes interesting data about the ramification theory of p-extensions of K and we can, for example, use it to compute the higher ramification groups of such extensions. In 1936, Schmid discovered an explicit formula for the Schmid-Witt symbol of Artin-Schreier extensions of local fields. Later, his formula was generalized to Artin-Schreier-Witt extensions, but still over a local field. In this talk we work to generalize Schmid's formula to compute the Artin-Schreier-Witt-Parshin symbol for Artin-Schreier-Witt extensions of two-dimensional local fields. (Received July 15, 2017)

1132-11-97 **Cormac O'Sullivan*** (cosullivan@gc.cuny.edu). *Hyperbolic Fourier coefficients of modular forms and associated Dirichlet type series.*

The usual Fourier expansion of a modular form is about the parabolic cusp at infinity. Petersson realized in 1941 that it is also possible to give a Fourier expansion associated to any hyperbolic fixed point pair. We show how to numerically compute these hyperbolic Fourier coefficients and bound their growth. We find there is a natural hyperbolic analog of the usual Dirichlet series construction and these new series are shown to have meromorphic continuations to the entire complex plane. This is joint work in different projects with Ozlem Imamoglu, Yves Martin and Karen Taylor. (Received July 16, 2017)

1132-11-102 **Jack Buttcane*** (buttcane@buffalo.edu). *Kuznetsov, Petersson and Weyl on $GL(3)$.*

It is known that representations of $GL(3,\mathbb{R})$ are either full principal series representations or subrepresentations of the same. Both types of representations can be regarded as generalized principal series representations, which are induced from Levy subgroups. In the space of cusp forms on $SL(3,\mathbb{Z})\backslash PSL(3,\mathbb{R})$, these decompose over the representations of $SO(3,\mathbb{R})$, of which there is one (up to isomorphism) of every odd dimension $2d+1$, $d \geq 0$. We categorize cusp forms by their minimal-weight ancestor: At $d = 0$ are spherical principal series forms, at $d = 1$ are non-spherical principal series forms, and at $d \geq 2$ are (non-principal) generalized principal series forms.

I will describe a (relatively) simple method for developing Kuznetsov-type formulas, and give an arithmetically-weighted Weyl law for each type of minimal-weight cusp form. (In particular, this confirms that such forms exist.) I will discuss some early applications to L-functions and exponential sums. (Received July 16, 2017)

1132-11-127 **Ruochuan Liu** (liuruochuan@math.pku.edu.cn), Peking University, 5 Yi He Yuan Road, Beijing, 100871, Peoples Rep of China, **Liang Xiao** (liang.xiao@uconn.edu), University of Connecticut, 341 Mansfield Road, Unit 1009, Storrs, CT 06269, and **Bin Zhao*** (bin.2.zhao@uconn.edu), University of Connecticut, 341 Mansfield Road, Unit 1009, Storrs, CT 06269. *Slopes of modular forms and the Ghost conjecture.*

In this talk, I will report on an on-going joint work with Ruochuan Liu and Liang Xiao, on the study of the p-adic slopes of modular forms. Bergdall and Pollack constructed an explicit power series, called the ghost series, and they conjectured that under certain regularity condition, the Newton polygon of the ghost series coincides with the Newton polygon of the characteristic power series of the U_p operator on the p-adic overconvergent modular forms. In this talk, I will give another formulation of this conjecture by complete homology and give some estimation results on the Newton polygons. If time allows, I will talk about some consequences of this conjecture. (Received July 18, 2017)

1132-11-133 **Freydoon Shahidi*** (shahidi@math.purdue.edu), Purdue University, Department of Mathematics, 150 N. University Street, West Lafayette, IN 47907. *On Generalized Fourier Transforms for Standard L-functions.*

In this talk we will discuss a generalization of Fourier transforms of Godement-Jacquet to the setting suggested by Braverman and Kazhdan and connect them to the work of Piatetski-Shapiro and Rallis for standard L-functions of classical groups. This requires the introduction of reductive monoids per Braverman-Kazhdan/Ngo and Vinberg, and suitably normalized intertwining operators which will play the role of Fourier transforms, when projected from the Braverman-Kazhdan setting onto doubling method of Piatetski-Shapiro and Rallis. In particular, we will show that the Fourier transforms in both settings, fix the corresponding basic function. (Received July 18, 2017)

1132-11-150 **Daqing Wan*** (dwan@math.uci.edu). *Greenberg's conjecture for Z_p^d towers of global fields.* Preliminary report.

For a Z_p^d tower of a global field K, Greenberg conjectured that the p-adic valuation of the class number of the n-th extension in the tower is given by a polynomial in n and p^n of total degree at most d for all large n. This conjecture is well known to be true for $d = 1$ (Iwasawa theory) but remains open in general. In this talk, we show that the conjecture is true when K is a global function field. (Received July 19, 2017)

1132-11-195 **Wladimir de Azevedo Pribitkin*** (wladimir.pribitkin@csi.cuny.edu). *On the Signs of Coefficients of General Dirichlet Series.* Preliminary report.

We simplify (and extend) a result pertaining to the oscillatory behavior of coefficient sequences of certain ordinary Dirichlet series. If time permits, we present applications to arithmetic functions associated with automorphic forms and L-functions. (Received July 21, 2017)

1132-11-235 **Amy T. DeCelles*** (adecelles@stthomas.edu), Department of Mathematics, 201 O'Shaunessy Science Hall, 2115 Summit Avenue, St. Paul, MN 55105. *Global Automorphic Sobolev Theory and Automorphic Heat Kernels.*

Automorphic heat kernels are important in number theory: applications include a version of Weyl's law (Müller 2007), periods of wave functions (Tsuzuki 2009), integral representations for Selberg zeta functions (Jorgenson and Lang 2009), and sup norm bounds for Bergman kernels (e.g. Bouche 1996, Berman 2004, Jorgenson and Kramer 2004, Aryasomayajula 2016), to name a few. Typically, an automorphic heat kernel is constructed by winding up a heat kernel on a free space. In this paper, we present an alternate method, using global automorphic Sobolev theory, which definitively rigorizes the analysis and makes the automorphic eigenfunction expansion clear. (Received July 24, 2017)

1132-11-238 **Herve Jacquet** and **Baiying Liu*** (liu2053@purdue.edu), Department of Mathematics, Purdue University, 150 N. University St, West Lafayette, IN 47907. *A remark on a converse theorem of Cogdell and Piatetski-Shapiro.*

Cogdell and Piatetski-Shapiro proved a (n,n-2) converse theorem, using both local and global methods. In particular, they used a local trick. In this talk, I will show a global argument which is a replacement of this local trick. This work is joint with Herve Jacquet. (Received July 23, 2017)

1132-11-289 **Xiaoqing Li***, XL29@buffalo.edu. *Nonvanishing of Rankin-Selberg L-functions.* Preliminary report.

In this talk, we will prove there are infinitely many L-functions of GL(4)xGL(2) which don't vanish at the central point, here the GL(4) form is fixed and the GL(2) form is varying. (Received July 24, 2017)

1132-11-290 **Alia Hamieh** (alia.hamieh@uleth.ca), University of Lethbridge, Department of Mathematics & Computer Science, Lethbridge, Alberta , Canada, and **Naomi Tanabe*** (ntanabe@bowdoin.edu), Bowdoin College, Department of Mathematics, Brunswick, ME 04011. *Nonvanishing of central values for Rankin-Selberg L-functions.*

Our aim is to study some nonvanishing results for Rankin-Selberg central L-values associated with two Hilbert modular forms. A classical approach is to establish some bounds for the first and second moments. However, estimating the second moment using a typical method is very complicated in our setting. We employ the unfolding method used by Blomer in order to overcome such difficulty. (Received July 24, 2017)

1132-11-307 **C. Douglas Haessig*** (chaessig@math.rochester.edu), Department of Mathematics, University of Rochester, 915 Hylan Building, Rochester, NY 14620. *Dwork cohomology and Hecke polynomials.* Preliminary report.

In this talk, we revisit papers of Dwork and Adolphson from the 1970s whose aim was to give a p-adic cohomological description of Hecke polynomials. In particular, we will describe how to interpret their work in terms of weakly holomorphic modular forms, and the role played by the Tate-Deligne mapping. (Received July 25, 2017)

1132-11-317 **Brandon F Bate*** (brandonbate@gmail.com), 1 Willard Ave, Houghton, NY 14744. *Automorphic distributions and the functional equation for metaplectic Eisenstein distributions.*

Traditionally, analytic properties of automorphic L-functions are obtained by using either the Rankin-Selberg method or the Langlands-Shahidi method. About a decade ago, Miller and Schmid expanded the applicability of the Rankin-Selberg method by working with automorphic distributions rather than automorphic representations. Using this method, analytic properties of L-functions follow from those of Eisenstein distributions. In this talk, I'll give an introduction to Eisenstein distributions, and in particular, share recent results on the metaplectic Eisenstein distribution on $\widetilde{\mathrm{SL}}_2(\mathbb{R})$. (Received July 25, 2017)

1132-11-338 **Karen Taylor*** (karen.taylor@bcc.cuny.edu). *A Preliminary Report on Extending Cohen's Construction of a Maass Form.* Preliminary report.

In 1988, Anderson, Dyson and Hickerson analyzed the fourier coefficients of

$$\sigma(q) = 1 + \sum_{n\geq 0} (-1)^n q^{n+1} (q)_n \text{ and } \sigma^*(q) = -\sum_{n\geq 0} q^{n+1} (q^2;q^2)_n,$$

by exploiting their relation to the arithmetic of $\mathbb{Q}(\sqrt{6})$. Cohen, later, gave an expanded analysis of this connec-

tion with the arithmetic of $\mathbb{Q}(\sqrt{6})$. He further showed that the fourier coefficients of $q^{\frac{1}{24}}\sigma(q) + q^{-\frac{1}{24}}\sigma^*(q)$ are the fourier coefficients of a Maass form.

In this preliminary report, I will review parts of the above work, with the goal of determining other quadratic fields that connect pairs of $q-series$ and Maass forms. (Received July 25, 2017)

13 ► Commutative rings and algebras

1132-13-17 **Jacob Laubacher***, jlaub18@gmail.com. *Simplicial Structures for Higher Order Homology over the 2-Sphere.*

Constructing a chain complex by way of simplicial structures accommodates a bar-like resolution whose module structure changes in every dimension. The higher order Hochschild Homology over the 2-sphere has such a resolution. Here we present the construction for such a chain complex. (Received May 30, 2017)

1132-13-32 **Jesus A. De Loera**, **Sonja Petrovic**, **Lily Silverstein**, **Despina Stasi** and **Dane Wilburne*** (dwilburn@hawk.iit.edu), Chicago, IL 60608. *Random monomial ideals.*

Monomial ideals play a key role in computational commutative algebra and give a strong link to algebraic combinatorics e.g., through Stanley-Reisner ideals of simplicial complexes. At the same time, randomness and stochasticity have played a a key role in algebra. We were inspired by the study of random graphs (Erdos Renyi) and simplicial complexes (Linial-Meshulam, Kahle, etc) to develop a theory of random monomial ideals. We proved several theorems about the probability distributions, expectations and thresholds for events of monomial ideals with given Hilbert function, Krull dimension, first graded Betti numbers, and present experimentally-backed conjectures about the regularity, depth, Cohen-Macaulayness, and the probability of some well-known invariants. (Received June 30, 2017)

1132-13-304 **Nida Kazi Obatake** (nida@math.tamu.edu) and **Elizabeth Gross*** (elizabeth.gross@sjsu.edu), San Jose, CA , and **Nora Youngs** (neyoungs@colby.edu). *Toric ideals of neural codes.*

A neural code is a collection of codewords (0-1 vectors) of a given length n; it captures the co-firing patterns of a set of neurons. A neural code is convexly realizable if there exist n convex sets in some $\mathbb{R}^d$ so that each codeword in the code corresponds to a unique intersection carved out by the convex sets. There are some methods to determine whether a neural code is convexly realizable, however, these methods do not describe how to draw a realization. In this work, we construct toric ideals from neural codes, connect these ideals to toric ideals of hypergraphs, and show how these ideals are related to the theory of piercings in the field of information visualization. (Received July 25, 2017)

14 ► Algebraic geometry

1132-14-121 **Blake Karl Winter*** (bkwinter@oakdland.edu), 46227 Jonathan Circle, Apt 111, Shelby TWP, MI 48317. *Welded n-links and cobordisms.*

Rourke has given a geometric definition of welded knots in terms of bundle morphisms and isotopies through such morphisms. This may be generalized to arbitrary dimensions. It also allows for a definition of welded cobordisms. For 1-links, a virtual cobordism gives rise to a welded cobordism, which gives rise to a classical cobordism. This allows for a straightforward proof that virtually/welded cobordant classical knots are classically cobordant, as well as showing that the classical slice genus is equal to the virtual/welded slice genus for classical knots. It also gives rise to a relationship between the classical slice/ribbon conjecture and slice/ribbon conditions on virtual and welded knots. (Received July 18, 2017)

1132-14-205 **Vinoth Nandakumar**, **Daniele Rosso*** (rosso@math.ucr.edu) and **Neil Saunders**. *Irreducible components of exotic Springer fibres and Robinson-Schensted correspondence.*

We explicitly describe the irreducible components of the exotic Springer fibres defined by Kato, and prove that they are naturally in bijection with standard bitableaux. As a consequence, we also deduce the existence of a geometrically defined exotic Robinson-Schensted bijection between the Weyl group of type C and pairs of standard bitableaux of the same shape. (Received July 22, 2017)

15 ► Linear and multilinear algebra; matrix theory

1132-15-160 **Sk. Safique Ahmad*** (safique@iiti.ac.in), Indian Institute of Technology Indore, Simrol, Khandwa Road, Indore, 453552, India. *Perturbation analysis for palindromic and anti palindromic nonlinear eigenvalue problems.* Preliminary report.

Structured backward error analysis of an approximate eigenpair of structured nonlinear matrix equations are derived with structures T-palindromic, H-palindromic, T-antipalindromic, H-antipalindromic. We construct a minimal structured perturbation such that an approximate eigenpair becomes an exact eigenpair of an appropriately perturbed nonlinear matrix equation. Moreover, we show that our general framework generalizes the existing results in the literature on perturbation theory of a matrix polynomial. (Received July 20, 2017)

16 ► Associative rings and algebras

1132-16-22 **Leonid Krop*** (leonard.krop@gmail.com), Department of Mathematical Sciences, Chicago, IL 60614. *The number of non-isomorphic Hopf algebras in some classes of Hopf algebras.*

Let p be a prime number and G a finite abelian p-group. A class in the title consists of semisimple Hopf algebras H over an algebraically closed field of characteristic 0 of dimension $p|G|$ with the group of grouplikes equals to G. We denote by $\mathcal{C}(G)$ a class of this kind.

We let $N_G(p)$ stand for the number of isomorphism classes of nontrivial, i.e. neither commutative, nor cocommutative, Hopf algebras in $\mathcal{C}(G)$. The goal of this presentation is to compute $N_G(p)$ for all 2-generator, non-cyclic abelian p-groups, i.e. groups $G = \mathbb{Z}_{p^e} \oplus \mathbb{Z}_{p^f}$. Let us write $N_G(p) = N_{e,f}(p)$ if G is as above. Some particular values of $N_{e,f}(p)$ are known. First, A. Masuoka has shown that $N_{1,1}(p) = p + 1$ for $p > 2$ and the author computed $N_{e,1}(p) = 2p + 8$ if either $e \geq 3$ or $p > 3$ and $N_{2,1}(3) = 16$. Y. Kashina proved recently that $N_{2,2}(2) = 16$.

The main result of the talk consists of the formulas for the functions $N_{e,f}(p)$ for all e, f and $p > 3$, namely

$$N_{e,e}(p) = p + 4 \text{ for } e \geq 2, p > 3$$
$$N_{e,f}(p) = 3p + 9 \text{ for } e > f \geq 2, p > 3$$

(Received June 25, 2017)

1132-16-67 **Ben Webster*** (ben.webster@uwaterloo.ca), Pure Mathematics, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *Representation theory and the Coulomb branch.*

For many years, my collaborators and I tried to understand the Coulomb branches of certain field theories from physics and failed miserably. Luckily, recent work of Braverman-Finkelberg-Nakajima gives a mathematical construction of these spaces, and algebras quantizing them. I'll discuss an approach to the representation theory of these algebras (building on joint work with Braden-Licata-Proudfoot and many other authors). Applications include a version of theKoszul duality between the Higgs and Coulomb branches of such a theory, a new perspective on category O for Cherednik algebras, and a new understanding of coherent sheaves on Coulomb branches. (Received July 11, 2017)

1132-16-68 **Lauren Grimley***, Department of Mathematics, Spring Hill College, 4000 Dauphin St, Mobile, AL 36608. *Deformations of quantum exterior algebras extended by groups.*

The Hochschild cohomology of an associative algebra and the graded Lie (or Gerstenhaber) bracket on cohomology controls the deformations of the algebra. In this talk, we use Hochschild cohomology to determine the deformations of group extensions of quantum exterior algebras. We will focus our attention on one such class of deformations which arise as a factor algebra of quantum Drinfeld Hecke algebras. (Received July 11, 2017)

1132-16-83 **Huanchen Bao*** (huanchen@math.umd.edu) and **Weiqiang Wang**. *Canonical bases arising from quantum symmetric pairs.*

A quantum symmetric pair consists of a quantum group and its coideal subalgebra. The coideal subalgebra is a quantum analog of the fixed point subalgebra of the enveloping algebra with respect to certain involution. In this talk, we shall describe the construction of (i-)canonical bases on the modified coideal subalgebras and their modules for all quantum symmetric pairs of finite type. This is joint work with Weiqiang Wang. (Received July 13, 2017)

1132-16-142 **Mitja Mastnak*** (mmastnak@cs.smu.ca). *Deformations and cohomology of graded bialgebras.*

I will present some aspect of deformation theory for graded bialgebras and how it relates to the lifting method of Andruskiewitsch and Schneider. I will focus on some tools based on joint works with F.Fantino, G. Garcia, and S. Witherspoon for explicitly computing the relevant cohomology group.

I will also briefly discuss a braided version of this theory and how it might be used to define a concept of a quantum Lie algebra. This part is based on joint work with I. Angiono and M. Kochetov. (Received July 19, 2017)

1132-16-154 **Zhaobing Fan*** (fanz@math.ksu.edu), Nantong St 145, Harbin Engineering Univ., School of Science, Harbin, 150001, Peoples Rep of China, and **Yiqiang Li** and **Zongzhu Lin**. *Equivalence of Representation Categories of Various Quantum and Super Quantum Groups.*

We establish equivalences of several representation theories of quantum groups. Corresponding to a Cartan datum, which defines a Kac-Moody Lie algebra $\mathfrak{g}$, there are several versions of quantum enveloping algebras, including original quantum in the form of Lustig, and quantum groups with many parameters, as well as supervision. The main results of the papers that in the generic cases, the category $\mathcal{O}$'s for all these algebras including super-algebras have exactly the same decomposition matrixes and character formulas, Similarly for modular representations, including the cases of at roots of unit cases, also the same decomposition matrixes and character formulas. Using the known results (Kazhdan-Lusztig theory) in the one parameters. These decomposition numbers are determined by Kazhdan Lusztig polynomials. This is a joint work with Yiqiang Li and Zongzhu Lin. (Received July 20, 2017)

1132-16-156 **Anthony Giaquinto*** (agiaqui@luc.edu), **Alexander Gilman** (gilma080@umn.edu) and **Peter Tingley**. *Peter-Weyl Bases, Preferred Presentations, and Quantum Groups.*

We discuss the deformed function bialgebra $\mathcal{O}_\hbar(G)$ of a simply connected reductive Lie group G over $\mathbb{C}$ using a basis consisting of matrix elements of finite dimensional representations. This leads to a preferred presentation of the deformation in that basis, meaning one where the structure constants of comultiplication are unchanged on all elements. The structure constants of multiplication are controlled by quantum 3j-Symbols. Connections will be made to earlier work of Giaquinto, Gerstenhaber and Schack on preferred presentations that involved Schur-Weyl duality. (Received July 20, 2017)

1132-16-211 **Alexander H Sistko*** (alexander-sistko@uiowa.edu), 14 MacLean Hall, Iowa City, IA 52246, and **Miodrag C Iovanov** (miodrag-iovanov@uiowa.edu), 14 MacLean Hall, Iowa City, IA 52246. *Maximal Subalgebras of Finite-Dimensional Algebras.*

We present a classification for maximal subalgebras of finite-dimensional algebras over a field $\mathbb{K}$. This is done by first classifying maximal subalgebras of semisimple algebras, and then lifting to the general case. When $\mathbb{K}$ is nice (ex. algebraically closed), the classification can be understood in terms of the ideal structure of the Jacobson radical. For bound quiver algebras, this gives us nice presentations for subalgebras. Trivial/separable extensions feature prominently in the classification, and allow us to relate representation-theoretic properties of an algebra to those of its subalgebras via induction and restriction. If time permits, we discuss potential applications of our classification theorem, ex. to determining isomorphism classes of subalgebras, or minimal generating sets of algebras. (Received July 22, 2017)

1132-16-251 **Yevgenia Kashina***, Department of Mathematical Sciences, DePaul University, Chicago, IL. *Abelian extensions of semisimple Hopf algebras of dimension* 2^m.

In this talk we will discuss the cohomological description of abelian extensions which arise in the process of classifying semisimple Hopf algebras of dimension 2^m with large abelian group of grouplike elements. Our ability to describe all such extensions heavily depends on the structure of this group, in particular, on the number of its order 2 automorphisms and on the structure of its Schur multiplier. (Received July 24, 2017)

1132-16-252 **X Chen** and **A Eshmatov*** (alimjon.eshmatov@utoledo.edu), Department of Mathematics and Statistics, University of Toledo, Toledo, OH 43606, and **F Eshmatov** and **V Futorny**. *Noncommutative deformations of Kleinian singularities.*

Associated to a finite cyclic subgroup G of $SL_2(\mathbb{C})$, there is a family of noncommutative algebras $O^\tau = O^\tau(\mathbb{C}^2//G)$ representing a universal deformation of the coordinate ring of the classical Kleinian singularity $\mathbb{C}^2//G$.

Earlier, in his thesis, F. Eshmatov constructed an isomorphism between the moduli space of rank one projective modules (noncommutative line bundles) over O^τ and a certain class of Nakajima quiver varieties M^τ

associated to G via the McKay correspondence. He showed that the varieties M^τ carry a natural action of the automorphism group $Aut[O^\tau]$ of the algebra O^τ, and the above isomorphism is equivariant under this action. In this talk, we will prove that the action of $Aut[O^\tau]$ on M^τ is actually transitive, and will use this result to give a geometric classification of algebras Morita equivalent to O^τ. We will also compute the Picard group of auto-equivalences of the abelian category of O^τ-modules. (This is joint work with X. Chen, F. Eshmatov and V. Futorny) (Received July 24, 2017)

1132-16-254 **Liqian Bai** and **Xueqing Chen*** (chenx@uww.edu), 800 West Main Street, Department of Mathematics, University of Wisconsin-Whitewater, Whitewater, WI 53190, and **Ming Ding** and **Fan Xu**. *A quantum analogue of generalized cluster algebras.*

We define a quantum analogue of a class of generalized cluster algebras, which can be viewed as a generalization of quantum cluster algebras defined by Berenstein and Zelevinsky. In the case of rank two, we extend some structural results from the classical theory of generalized cluster algebras obtained to the quantum case. This talk is based on joint works with L. Bai, M. Ding and F. Xu. (Received July 24, 2017)

1132-16-261 **Shijie Zhu*** (zhu.shi@husky.neu.edu), Mathematics Department, 567 Lake Hall, 360 Huntington Ave, Boston, MA 02115. *Preprojective algebras of tree type quivers.*

We show the equivalence of several descriptions of preprojective algebras for any tree-type quiver Q. In particular, we construct irreducible morphisms, in the Auslander-Reiten quiver of the transjective component of the bounded derived category of its path algebra kQ, that satisfy what we call the λ-relations, where λ a nonzero element in the field k. When $\lambda = 1$, the relations are known as mesh relations. When $\lambda = -1$, they are known as commutativity relations. Using this technique together with the results given by Baer-Geigle-Lenzing, Crawley-Boevey, Ringel, and others, we show that for any tree-type quiver, several descriptions of its preprojective algebra are equivalent. (Received July 24, 2017)

1132-16-270 **Andrei H Caldararu***, 480 Lincoln Dr, Madison, WI 53705. *Problems surrounding the PBW and HKR isomorphisms in positive characteristic.* Preliminary report.

I will discuss some problems surrounding failures of the Poincare-Birkhoff-Witt isomorphism (and, similarly, of the Hochschild-Kostant-Rosenberg isomorphism for schemes) in positive characteristic. I will review known results, and discuss what is known for spaces of invariants. In closing I will present ideas from homotopy theory that may suggest a general solution to these problems. (Received July 24, 2017)

1132-16-297 **vincent e coll*** (vec208@lehigh.edu). *Seaweed algebras and their associated meanders.*

Meanders were introduced by Dergachev and A. Kirillov as planar representations of biparabolic (seaweed) subalgebras of sl(n) - the Type-A case. In their natural matrix representation, seaweed algebras have a distinctive block decomposition defined by two partitions of n. The index of such "seaweeds" can be computed by counting the connected components of their associated meander. In this talk, we extend the Type-A results to the other classical cases (Types-B, C, and D) and provide, in particular, all possible closed form linear greatest common divisor formulas for the seaweed's index in terms of its defining partitions. (Received July 24, 2017)

1132-16-311 **Jie Xiao*** (jxiao@math.tsinghua.edu.cn), Department of Mathematics, Tsinghua University, Beijing, 100084, Peoples Rep of China, and **Fan Xu** and **Minghui Zhao**. *Ringel-Hall algebras beyond their quantum groups.*

This talk is my recent joint work with Fan Xu and Minghui Zhao. We generalize the categorical constructions of a quantum group and its canonical basis introduced by Lusztig to the generic form of the whole Ringel-Hall algebra. We clarify the explicit relation between the Green formula and the restriction functor. By a geometric way to prove the Green formula, we show that the Hopf structure of a Ringel-Hall algebra can be categorified under Lusztig's framework. (Received July 25, 2017)

17 ► Nonassociative rings and algebras

1132-17-9 **Chad R Mangum*** (cmangum@niagara.edu), **Kailash C Misra** and **Naihuan Jing**. *Fermionic Representations of Twisted Toroidal Lie Algebras.* Preliminary report.

Lie algebra representation theory has been significant in various areas of mathematics and physics for several decades. In this talk, we will discuss one instance of this theory, namely certain representations of twisted (2-)toroidal (Lie) algebras, which we view as universal central extensions of twisted multi-loop algebras. The usual loop algebra realization generalizes the familiar realization of affine Kac-Moody algebras. To facilitate our study of the representation theory, however, we will discuss a new realization given by generators and relations; this

is similar to a realization by Moody, Rao, and Yokonuma in the untwisted case. Subsequently, we will discuss an application, namely fermionic free field representations, which are similar to those of Feingold and Frenkel in the case of affine algebras. This is joint work with Kailash Misra and Naihuan Jing. (Received April 11, 2017)

1132-17-66 **Chun-Ju Lai*** (cjlai@uga.edu), Department of Mathematics, Boyd Graduate Studies Research Center, University of Georgia, Athens, GA 30602, and **Li Luo** (lluo@math.ecnu.edu.cn), Department of mathematics, East China Normal University, Shanghai, 200241, Peoples Rep of China. *Schur algebras with unequal parameters.*

We study the (quantum) Schur algebras of type B/C as the endomorphism algebras of the Hecke algebras with unequal parameters, from which one can obtain the one-parameter Schur algebras of type B/C/D by specialization. We establish, in the sense of Beilinson-Lusztig-MacPherson, the stabilization property of the family of these Schur algebras. It hence leads to the construction of a two-parameter upgrade of the coideal subalgebras in the quantum symmetric pairs of type A III/IV. We obtain, at the specialization associated to a weight function, the (stably) canonical basis of the Schur algebras and the coideal subalgebras. These bases are analogues of Lusztig's bar-invariant basis for Hecke algebras with unequal parameters, and they are used to establish a Kazhdan-Lusztig theory for the Lie superalgebras of type D. (Received July 11, 2017)

1132-17-276 **Sachin Gautam*** (gautam.42@osu.edu) and **Andrea Appel**. *Isomorphisms between $U_\hbar(\mathfrak{sl}_n)$ and $U(\mathfrak{sl}_n)$.* Preliminary report.

It has been known for almost fifty years that the enveloping algebra of a simple Lie algebra $\mathfrak{g}$ cannot be deformed. Thus the Drinfeld–Jimbo quantum group associated to $\mathfrak{g}$ must be isomorphic to the enveloping algebra of $\mathfrak{g}$. However the proof of the last assertion uses Hochschild cohomology and no such isomorphism is known explicitly, except for $\mathfrak{g} = \mathfrak{sl}_2$. In this talk I will present an explicit isomorphism between $U_\hbar(\mathfrak{sl}_n)$ and $U(\mathfrak{sl}_n)[[\hbar]]$. I will also discuss its semiclassical limit which is related to the Gelfand–Zetlin integrable system. This talk is based on a joint work with Andrea Appel. (Received July 24, 2017)

1132-17-298 **Denis Bashkirov*** (bashk003@umn.edu), 206 Church St. SE, Minneapolis, MN 55455, and **Alexander A. Voronov**. *On homotopy Lie bialgebroids.*

The concept of a Lie bialgebroid, naturally arising in Poisson geometry, unifies the notions of Lie bialgebras and Lie algebroids. We give an interpretation of Lie bialgebroids and their morphisms in terms of odd symplectic differential graded manifolds using the Hamiltonian framework D.Roytenberg. We extend this further to the homotopy Lie case and discuss the notions of homotopy Lie bialgebroids and morphisms between them. (Received July 24, 2017)

18 ► Category theory; homological algebra

1132-18-53 **Alexandru Chirvasitu*** (chirvasitua@gmail.com), Department of Mathematics, University at Buffalo, Buffalo, NY , and **S. Paul Smith**. *Cocycle deformations of projective spaces and their quantum symmetries.*

Non-commutative (or quantum) projective spaces are connected graded algebras analogous to polynomial rings in the sense of having the expected Hilbert series and a host of convenient homological properties. As the terminology suggests, they are in many ways analogous to projective spaces; many concepts applicable to the latter, such as points, lines and Grassmannian varieties parametrizing these, transport over to the non-commutative setting.

The talk describes a family of non-commutative projective three-dimensional spaces obtained by mixed deformation process involving both integrating a Poisson structure and performing a cocycle deformation.

One interesting feature will be the fact that the quantum symmetries of these non-commutative projective spaces (i.e. their structures as comodule algebras over certain non-commutative finite-dimensional Hopf algebras) are crucial to the description of their Grassmannians of lines.

(joint w/ S. Paul Smith) (Received July 09, 2017)

1132-18-95 **Alexandru Chirvasitu*** (chirvasitua@gmail.com), University at Buffalo, Buffalo, NY , and **Ivan Penkov**. *Universal representation categories.*

The talk describes certain symmetric monoidal categories of modules over Lie algebras of infinite matrices attached canonically to non-degenerate pairings $W \otimes V \to \mathbb{C}$ of infinite-dimensional vector spaces: the associated Lie algebra is then defined as the subalgebra of $\mathrm{End}(V)$ preserving the pairing.

The resulting representation theory admits parallels to familiar phenomena such as Schur-Weyl duality, but the differences to the finite-dimensional setting are as striking as the similarities: the categories in question fail

to be semisimple, but do so in a particularly interesting fashion (they turn out to be categories of comodules over Koszul coalgebras).

Furthermore, they satisfy universality properties that allow us to describe them as "categorified commutative algebras" by a handful of generators and relations.

(joint w/ Ivan Penkov) (Received July 16, 2017)

1132-18-143 **Alexander A Voronov*** (voronov@umn.edu), School of Mathematics, 206 Church St SE, Minneapolis, MN 55455. *Quantum master equation and deformation theory.* Preliminary report.

Classical deformation theory is based on the Classical Master Equation (CME), a.k.a. the Maurer-Cartan Equation: $dS + 1/2[S, S] = 0$. Physicists have been using a quantized CME, called the Quantum Master Equation (QME), a.k.a. the Batalin-Vilkovisky (BV) Master Equation: $dS + \hbar\Delta S + 1/2\{S, S\} = 0$. The CME is defined in a differential graded (dg) Lie algebra, whereas the QME is defined in a space $V[[\hbar]]$ of formal power series with values in a dg BV algebra V. One can anticipate a generalization of classical deformation theory arising from the QME, quantum deformation theory. This theory has been emerging with people like K. Costello, Jae-Suk Park, J. Terilla, and T. Tradler making first steps in abstract quantum deformation theory. Main ideas of quantum deformation theory and further steps will be discussed in the talk. (Received July 19, 2017)

1132-18-216 **Christopher L Rogers*** (chrisrogers@unr.edu), Department of Mathematics and Statistics, University of Nevada, Reno, 1664 N. Virginia Street, Reno, NV 89557. *The unicity of homotopy transfer: A deformation theoretic proof.*

Suppose we are given a cochain complex A, a homotopy algebra B of some particular type (e.g., a homotopy associative, homotopy Lie, or homotopy Gerstenhaber algebra) and a quasi–isomorphism of complexes $\phi\colon A \to B$. Then a solution to the "homotopy transfer problem" is a pair consisting of a homotopy algebra structure on A, and a lift of ϕ to an equivalence of homotopy algebras $A \simeq B$.

Using techniques from algebraic deformation theory, I will give an explicit construction of the space of solutions to the homotopy transfer problem. I will show that when we are working over a field of characteristic 0 that: (1) the space of solutions is non-empty, and (2) it is contractible. The first statement implies that a homotopy equivalent transferred structure always exists, and the second implies that this structure is unique, up to homotopy, in the strongest possible sense. (Received July 22, 2017)

1132-18-300 **Emre Sen*** (sen.e@husky.neu.edu), Boston, MA. *φ dimension of cyclic Nakayama algebras.*

Igusa and Todorov introduced φ function which generalizes the notion of projective dimension. We study the behavior of the φ functions for cyclic Nakayama algebras of infinite global dimension. We prove that it is always an even number. In particular we show that φ dimension is 2 if and only if algebra satisfies certain symmetry conditions. (Received July 24, 2017)

1132-18-327 **Rina Anno*** (ranno@ksu.edu) and **Timothy Logvinenko**. *Bar categories of modules and categorical actions of algebras.*

Given a DG-category A we introduce the bar category of modules over A. It is a DG-enhancement of the derived category $D(Mod-A)$ which is isomorphic to the category of DG A-modules with A_∞-morphisms between them. However, it is defined intrinsically in the language of DG-categories and requires no complex machinery or sign conventions of A_∞-categories.

The intended application is working with DG-bimodules as enhancements of exact functors between triangulated categories. In particular, using bar categories allows us to construct explicitly homotopy adjunctions lifting pairs of adjoint exact functors and prove the existence of natural Postnikov towers for certain differential complexes of exact functors. Such techniques can be instrumental in constructing categorical representations of algebras since they allow us to categorify a relation in an algebra to a twisted complex and not necessarily to a direct sum. (joint work with T. Logvinenko) (Received July 25, 2017)

19 ► K-theory

1132-19-253 **Wolfgang Lück**, **Holger Reich**, **John Rognes** and **Marco Varisco*** (mvarisco@albany.edu). *Assembly maps for topological cyclic homology.*

I will present the results of [http://dx.doi.org/10.1515/crelle-2017-0023], in which we use assembly maps to study the topological cyclic homology of group algebras. Topological cyclic homology (TC) is a far-reaching generalization of Hochschild homology and a powerful tool in algebraic K-theory. We prove that, for any

finite group G, any connective ring spectrum $\mathbb{A}$, and any prime p, the spectrum $TC(\mathbb{A}[G];p)$ is determined by $TC(\mathbb{A}[C];p)$ as C ranges over the cyclic subgroups of G. More precisely, we prove that for any finite group the assembly map with respect to the family of cyclic subgroups induces isomorphisms on all homotopy groups. For infinite groups we establish pro-isomorphism, (split) injectivity, and rational injectivity results, as well as counterexamples to injectivity and surjectivity. In particular, for hyperbolic groups and for virtually finitely generated abelian groups, we show that the assembly map with respect to the family of virtually cyclic subgroups is injective but in general not surjective, in contrast to what happens in algebraic K-theory. (Received July 24, 2017)

20 ► Group theory and generalizations

1132-20-28 **Lvzhou Chen*** (lzchen@math.uchicago.edu). *Spectral gap of stable commutator length.* Stable commutator length (scl) is a function on each group G, which from a topological view measures the least complexity of surfaces in $K(G,1)$ with prescribed boundary. The set of values that scl takes is called the spectrum. We will discuss, in the free groups case, a few interesting phenomena of the spectrum, especially a gap between 0 and 1/2 first proved by Duncan and Howie. If time permits, I will explain a new short proof of this fact via examples. (Received June 27, 2017)

1132-20-56 **Martin Kassabov**, **Vivian Kuperberg** and **Timothy Riley*** (tim.riley@math.cornell.edu). *Soficity and variations on Higman's group.* Preliminary report.

A group is sofic when every finite subset can be well approximated in a finite symmetric group. The outstanding question (due to Gromov) is whether every group is sofic. Helfgott and Juschenko recently argued that a celebrated group constructed by Higman is unlikely to be sofic because its soficity would imply the existence of some seemingly pathological functions. We construct variations on Higman's group which have large sofic quotients (in an appropriate sense). Then, by applying Helfgott and Juschenko's arguments, we deduce the existence of similarly pathological functions. This casts doubt on whether Helfgott and Juschenko's heuristics represent evidence for the non-soficity of Higman's group. (Received July 10, 2017)

1132-20-74 **You Qi***, Department of Mathematics, California Institute of Technology, Pasadena, CA 91125. *On the center of small quantum groups.*

We report some recent progress on the problem of determining the center of small quantum groups. This is joint work with A. Lachowska. (Received July 12, 2017)

1132-20-75 **Brian D. Boe**, **Jonathan R. Kujawa** and **Daniel K. Nakano*** (nakano@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Tensor Triangular Geometry for Quantum Groups.*

Let $\mathfrak{g}$ be a complex simple Lie algebra and let $U_\zeta(\mathfrak{g})$ be the corresponding Lusztig $\mathbb{Z}[q,q^{-1}]$-form of the quantized enveloping algebra specialized to an ℓth root of unity. Moreover, let $\mathrm{mod}(U_\zeta(\mathfrak{g}))$ be the braided monoidal category of finite-dimensional modules for $U_\zeta(\mathfrak{g})$. In this paper we classify the thick tensor ideals of $\mathrm{mod}(U_\zeta(\mathfrak{g}))$ and compute the prime spectrum of the stable module category associated to $\mathrm{mod}(U_\zeta(\mathfrak{g}))$ as defined by Balmer. (Received July 12, 2017)

1132-20-87 **Tyrone Ghaswala*** (ty.ghaswala@gmail.com) and **Alan McLeay** (a.mcleay.1@research.gla.ac.uk). *Mapping class groups, coverings, braids and groupoids.*

Given a finite-sheeted, possibly branched covering space between surfaces, it's natural to ask how the mapping class group of the covering surface relates to the mapping class group of the base surface.

In this talk, we will take a journey through this question for surfaces with boundary. It will feature appearances from the fundamental groupoid, the Birman-Hilden theorem, and new embeddings of the braid group in mapping class groups.

This is joint work with Alan McLeay (Received July 14, 2017)

1132-20-104 **Genevieve S Walsh***, genevieve.walsh@tufts.edu. *Relatively hyperbolic groups vs 3-manifold groups.*

Bowditch described the boundary of a relatively hyperbolic group pair (G,P) as the boundary of any hyperbolic space that G acts geometrically finitely upon, where the maximal parabolic subgroups are conjugates of the subgroups in P. For example, the fundamental group of a hyperbolic knot complement acts geometrically finitely on $\mathbb{H}^3$, where the maximal parabolic subgroups are the conjugates of $\mathbb{Z}\oplus\mathbb{Z}$. Here the Bowditch boundary

is S^2. We show that torsion-free relatively hyperbolic groups whose Bowditch boundaries are S^2 are relative $PD(3)$ groups. This is joint work with Bena Tshishiku. (Received July 16, 2017)

1132-20-109 **Adam Piggott*** (adam.piggott@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837. *Rewriting and unique geodesics.* Preliminary report.

We discuss a collection of problems concerning rewriting systems in groups and geodetic Cayley graphs. (Received July 17, 2017)

1132-20-110 **Pallavi Dani*** (pdani@lsu.edu) and **Timothy Riley**. *Subgroup distortion in hyperbolic groups.*

The distortion function of a subgroup measures the extent to which the intrinsic word metric of the subgroup differs from the metric induced by the ambient group. Olshanskii showed that there are almost no restrictions on which functions arise as distortion functions of subgroups of finitely presented groups. This prompts one to ask what happens if one forces the ambient group to be particularly nice, say, for example, to be hyperbolic. I will survey which functions are known to be distortion functions of subgroups of hyperbolic groups. I will then describe joint work with Tim Riley which adds to this list: we construct free subgroups of hyperbolic groups with distortion functions $2^{n^{p/q}}$, for all integers $p > q > 0$. (Received July 17, 2017)

1132-20-111 **Patrick M Gilmer*** (gilmer@math.lsu.edu) and **Gregor Masbaum**. *An application of TQFT to modular representation theory.*

For $p \geq 5$ a prime, and $g \geq 3$ an integer, we use a Topological Quantum Field Theory (TQFT) defined over $\mathbb{Z}[\zeta_p]$ to study a family of $p-1$ highest weight modules $L_p(\lambda)$ for the symplectic group $Sp(2g, K)$ where K is an algebraically closed field of characteristic p. This permits explicit formulae for the dimension and the formal character of $L_p(\lambda)$ for these highest weights. (Received July 17, 2017)

1132-20-113 **Victoria S Akin*** (victoria.akin@duke.edu). *Automorphisms of the Punctured Mapping Class Group.*

Using group theoretic tools and a classic theorem of Burnside, we can recover a result of Ivanov-McCarthy establishing the triviality of $\mathrm{Out}(\mathrm{Mod}^{\pm})$. To this end, we'll demonstrate that the point-pushing subgroup is "unique" in the mapping class group. (Received July 17, 2017)

1132-20-126 **Matthew Gentry Durham**, **Federica Fanoni** and **Nicholas G Vlamis*** (vlamis@umich.edu), 530 Church St, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Left-invariant pseudo-metrics on big mapping class groups.*

A surface is of infinite type if its fundamental group is infinitely generated. The mapping class group of an infinite-type surface is uncountable and therefore does not have a natural notion of a word metric. Does such a group have any infinite-diameter left-invariant (pseudo-)metrics? For a large class of surfaces we construct such a pseudo-metric by studying an infinite-diameter subgraph of the curve graph on which the mapping class group acts. (Received July 18, 2017)

1132-20-129 **Matt Zaremsky*** (zaremskym@gmail.com). *Virtual splittings of RAAGs over abelian subgroups, and abstract commensurability.*

A result of Groves and Hull says that a right-angled Artin group (RAAG) splits non-trivially as an amalgamated product over an abelian subgroup if and only if it does so in an "obvious" way, namely if and only if its defining graph has a separating clique. Using techniques involving the Bieri-Neumann-Strebel invariant, we show that an analogous statement is even true for arbitrary finite index subgroups of RAAGs. This has consequences for the problem of classifying RAAGs up to abstract commensurability and up to quasi-isometry. (Received July 18, 2017)

1132-20-151 **Catherine E Pfaff*** (cpfaff@math.ucsb.edu), UCSB Math Department, South Hall, Room 6607, Santa Barbara, CA 93106, and **Yael Algom-Kfir** and **Ilya Kapovich**. *Geodesics in Outer Space.*

Outer automorphisms of free groups are often studied via their action on Culler-Vogtmann Outer Space. One of the more interesting aspects of the interplay between these outer automorphisms and Outer Space is the relationship between automorphisms and geodesics in Outer Space. In fact, unlike hyperbolic spaces and Teichmueller spaces, a given automorphisms can have many geodesics canonically associated to it. The properties of outer automorphisms with only a single associated geodesic are only now being understood. Specifically, we show that having certain invariant values is an "almost open" condition. Since the fact that it is not exactly an open condition differs from the Teichmueller space setting, we give examples contradicting openness and prove

results further elucidating this situation. Our hope is that better understanding such behavior of geodesics will lead to new dynamical and genericity results emulating those in the hyperbolic and Teichmuller space settings. This is joint work with Yael Algom-Kfir and Ilya Kapovich. (Received July 20, 2017)

1132-20-153 **Khalid Bou-Rabee*** (khalid.math@gmail.com), 55 E 87TH ST APT 8m, New York, NY 10128. *The Primitive Torsion Problem.*

Let $P(a,k)$ be the subgroup of the rank a free group generated by kth powers of primitive elements. We show that $P(2,k)$ is finite index if and only if $k = 1$ or 2 or 3. We frame this as a solution to the Primitive Torsion Problem and discuss applications to the Bounded Burnside Problem. This covers joint work with Patrick W. Hooper. (Received July 20, 2017)

1132-20-155 **Daniel Groves** and **Jason Fox Manning*** (jfmanning@math.cornell.edu), 310 Malott Hall, 301 Tower Road, Ithaca, NY 14853. *Quasiconvexity and Dehn filling.*

We extend the techniques of quasiconvex Dehn filling to relatively quasiconvex subgroups which are not necessarily full. Combined with the ubiquitous surfaces constructed by Cooper and Futer, these techniques give an alternative approach to Wise's theorem on virtual fibering of cusped hyperbolic 3-manifolds. This is joint work with Daniel Groves. (Received July 20, 2017)

1132-20-164 **Kasia Jankiewicz*** (kasia.jankiewicz@mcgill.ca), Montreal, Canada. *C(6) groups that do not act on n-dimensional CAT(0) cube complexes.*

I will discuss a construction of groups with finite presentations satisfying the C(6) small cancellation condition that do not admit a proper action on an n-dimensional CAT(0) cube complex. (Received July 20, 2017)

1132-20-172 **Giulio Tiozzo***, 40 St George St, Toronto, ON , Canada. *Counting loxodromics for actions of relatively hyperbolic groups.*

For actions of (certain) relatively hyperbolic groups on delta-hyperbolic spaces, we prove that loxodromic elements are generic with respect to counting in balls.

Joint with I. Gekhtman and S. Taylor. (Received July 20, 2017)

1132-20-186 **Rachel Skipper*** (skipper@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University, PO Box 6000, Binghamton, NY 13902-6000, and **Matthew C.B. Zaremsky**, Department of Mathematics and Statistics, Earth Science 110, University at Albany, Albany, NY 12222. *Finiteness Properties of Nekrashevych groups.*

Given a self-similar group G acting on a regular rooted d-ary tree, we consider the subgroup $V_d(G)$ of almost automorphisms of the tree that "locally look like" G. This forms a Nekrashevich group and provides a natural way of joining the Higman-Thompson group V_d with the self-similar group G.

In this talk, we discuss finiteness properties of certain Nekrashevich groups. This work follows and expands on work of Belk and Matucci who considered the Röver group, $V_2(G)$ where G is the Grigorchuk Group. (Received July 21, 2017)

1132-20-193 **Matt Clay**, **Johanna Mangahas*** (mangahas@buffalo.edu) and **Dan Margalit**. *Normal right-angled Artin group subgroups of mapping class groups.*

Free normal subgroups of mapping class groups abound, by the result of Dahmani, Guirardel, and Osin that the normal closure of high powers of pseudo-Anosovs is free. At the other extreme, if a normal subgroup contains a mapping class supported on too small a subsurface, it can never be isomorphic to a right-angled Artin group, by work of Brendle and Margalit. I will talk about a case right in between: a family of normal subgroups isomorphic to non-free right-angled Artin groups. We also recover, expand, and make constructive the result of Dahmani, Guirardel, and Osin about free normal subgroups. We do this by creating a version of their "windmill" construction tailor-made for the projection complexes introduced by Bestvina, Bromberg, and Fujiwara. This is joint work with Matt Clay and Dan Margalit. (Received July 24, 2017)

1132-20-209 **Elisabeth Fink*** (efink@uottawa.ca) and **Kirill Zainoulline**. *Labelled geodesics in Coxeter groups.* Preliminary report.

Studying geodesics in Cayley graphs of groups has been a very active area of research over the last decades. We introduce the notion of a uniquely labelled geodesic, a u.l.g. These will be studied first in finite Coxeter groups of type An. Here we introduce a generating function, and hence are able to precisely describe how many u.l.g.'s we have of a certain length and with which label combination. In the second part, we expand our investigation to infinite Coxeter groups described by simply laced trees. We use the example of a group to show the existence of infinite u.l.g.'s in groups which do not have any infinite unique geodesics. We conclude by exhibiting a detailed

description of the geometry of such u.l.g.'s and their relation to each other in the Cayley graph of the group. (Received July 22, 2017)

1132-20-218 **Matt Clay**, **Max Forester** and **Joel Louwsma*** (jlouwsma@niagara.edu), Department of Mathematics, Niagara University, PO Box 2044, Niagara University, NY 14109.
Quasimorphisms on groups that act on trees.

We construct efficient quasimorphisms on groups that act on trees and show that their defect is at most 6. Calculations in the Baumslag–Solitar group $BS(2,3)$ show that this is the smallest possible defect that can be achieved in this generality. A consequence of our result is that every suitable element of a group that acts on a tree must have stable commutator length at least 1/12. In Baumslag–Solitar groups, we show that no element can have stable commutator length between 0 and 1/12. (Received July 22, 2017)

1132-20-224 **Christopher Hruska** (chruska@uwm.edu), Department of Mathematical Sciences, University of Wisconsin- MIlwaukee, P.O. Box 413', Milwaukee, WI 53201-0413, and **Kim E Ruane*** (kim.ruane@tufts.edu), Tufts University, Department of Mathematics, Bromfield-Pearson Building, 503 Boston Avenue, Medford, MA 02155. *Convex Splittings of CAT(0) Groups.*

We will discuss recent joint work with C. Hruska on CAT(0) groups with the Isolated Flats Property. One of the main theorems in this work is to prove that for one-ended groups in this class, then the boundary of the group (which is connected) is not *locally connected* exactly when there exists a certain type of group-theoretic splitting over subgroups of the flat stabilizers. One important tool in this paper is the following result which I will discuss in this talk:

Suppose G is a group acting geometrically on a CAT(0) space X and G splits as a the fundamental group of a graph of groups in which all of the edge groups are convex in X. Then all of the vertex groups are also convex in X.

A subgroup H of a CAT(0) group G is *convex* if there is a convex subset C of X such that H acts geometrically on C.

We will briefly outline the proof of this result and give useful applications of it in our joint work. (Received July 23, 2017)

1132-20-286 **Pramod N. Achar***, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918, and **William Hardesty** and **Simon Riche**. *On the Humphreys conjecture on support varieties of tilting modules.*

Let G be a simply-connected semisimple algebraic group over an algebraically closed field of characteristic p, assumed to be larger than the Coxeter number. The "support variety" of a G-module M is a certain closed subvariety of the nilpotent cone of G, defined in terms of cohomology for the first Frobenius kernel G_1. In the 1990s, Humphreys proposed a conjectural description of the support varieties of tilting modules; this conjecture has been proved for $G = \mathrm{SL}_n$ in earlier work of Hardesty.

In this talk, I will discuss the following new results, valid for any G: the support variety of a tilting module always contains the variety predicted by Humphreys, and they coincide (i.e., the Humphreys conjecture is true) when p is sufficiently large. If time permits, I will also discuss variants of these statements involving "relative support varieties." (Received July 24, 2017)

1132-20-299 **Pramod N. Achar** and **Daniel S. Sage*** (sage@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *A tensor category structure on the equivariant perverse sheaves over matrices of bounded degree of nilpotency.* Preliminary report.

Let $\mathcal{N}_n^m$ be the variety of nilpotent matrices in $\mathfrak{gl}_n(\mathbb{C})$ satisfying $x^m = 0$, and let $\mathrm{Perv}_{\mathrm{GL}_n(\mathbb{C})}(\mathcal{N}_n^m)$ be the category of equivariant perverse sheaves on this variety. For fixed m, we define a binary operation

$$\mathrm{Perv}_{\mathrm{GL}_n(\mathbb{C})}(\mathcal{N}_n^m) \times \mathrm{Perv}_{\mathrm{GL}_{n'}(\mathbb{C})}(\mathcal{N}_{n'}^m) \to \mathrm{Perv}_{\mathrm{GL}_{n+n'}(\mathbb{C})}(\mathcal{N}_{n+n'}^m),$$

which makes $\mathcal{P}^m = \bigoplus_{n\geq 0} \mathrm{Perv}_{\mathrm{GL}_n(\mathbb{C})}(\mathcal{N}_n^m)$ into a graded symmetric monoidal category. At the level of Grothedieck groups, this can be viewed as a product on Young diagrams with at most m columns. We explain how this construction leads to a geometric explanation of a particular case of Howe duality. Time permitting, we further show how similar techniques can be used to construct analogous module categories over $\mathcal{P}^m$ for each classical type. (Received July 24, 2017)

1132-20-342 **Shotaro Makisumi*** (smakisumi@gmail.com). *Mixed perverse sheaves on moment graphs.*

Moment graphs are labeled graphs associated to varieties with a nice torus action and were used by Braden and MacPherson to give a combinatorial algorithm to compute torus-equivariant intersection cohomology. I will

explain an analogue of the "mixed derived category" formalism of Achar and Riche in this setting, which leads to a notion of "mixed perverse sheaves" on moment graphs, even those that do not arise from torus-equivariant geometry. I will discuss applications of this construction to the study of the Hecke category. (Received July 25, 2017)

22 ► Topological groups, Lie groups

1132-22-44 **Monica Nevins*** (mnevins@uottawa.ca) and **Peter Latham** (peter.latham@kcl.ac.uk). *Towards unicity of types for some positive depth supercuspidal representations.* Preliminary report.

The conjecture of unicity of types asserts that each irreducible supercuspidal representation should admit at most one type in its restriction to any given maximal compact open subgroup. This was established by Henniart for $\mathrm{GL}_2(k)$ in 2002 and Paskunas for $\mathrm{GL}_n(k)$ in 2005. Recently, Latham proved unicity of types for $\mathrm{SL}_n(k)$, and for tame depth zero supercuspidal representations of arbitrary p-adic groups. We present recent progress on this problem for (positive depth) toral supercuspidal representations in the tame case. (Received July 06, 2017)

1132-22-45 **Kwangho Choiy*** (kchoiy@siu.edu), 1245 Lincoln Dr., (Dept. of Mathematics, SIUC), Carbondale, IL 62901-4408, and **David Goldberg**. *R-groups for p-adic inner forms of $SU(n)$.*

The reducibility of parabolically induced representations of p-adic groups is one of studies in the local Langlands correspondence. Among several approaches to such reducibility, it is of interest to be involved with finite groups, which are called R-groups. These groups play roles in construction of tempered L-packets from discrete ones, comparison of trace formulas, and the endoscopic classification of automorphic representations. In this talk, we shall discuss various properties of R-groups for p-adic inner forms of the quasi-split $SU(n)$, and see how to transfer known results for the quasi-split to their non-quasi-split inner forms. This is joint work with D. Goldberg. (Received July 06, 2017)

30 ► Functions of a complex variable

1132-30-258 **Loredana Lanzani*** (llanzani@syr.edu), Syracuse University, Mathematics Department, 215 Carnegie Building, Syracuse, NY 13244. *On the symmetrization of Cauchy-like kernels.* Preliminary report.

In this talk I will present new symmetrization identities for a family of Cauchy-like kernels in complex dimension one.

Symmetrization identities were first employed in geometric measure theory by P. Mattila, M. Melnikov, X. Tolsa, J. Verdera et al., to obtain a new proof of $L^2(\mu)$ regularity of the Cauchy transform (with μ a positive Radon measure in $\mathbb{C}$), which ultimately led to the a partial resolution of a long-standing open problem known as the Vitushkin's conjecture.

Here we extend this analysis to a family of kernels which are more closely related to the classical kernels in complex function theory.

This is joint work with Malabika Pramanik (U. British Columbia). (Received July 24, 2017)

32 ► Several complex variables and analytic spaces

1132-32-23 **Phillip Harrington*** (psharrin@uark.edu), SCEN 336, 1 University of Arkansas, Fayetteville, AR 72701. *Sufficient Conditions for Global Regularity of the Bergman Projection.*

We say that the Bergman Projection is globally regular if it preserves the space of functions that are smooth up to the boundary (sometimes this is known as Condition R). One of the most fundamental sufficient conditions for global regularity is the existence of a defining function that is plurisubharmonic on the boundary. In this talk we will look at two generalizations of this condition: the good vector field method of Boas and Straube and the Diederich-Fornaess Index equal to one as studied by Kohn. Our goal is to show that on a large class of examples the existence of a family of good vector fields implies that the Diederich-Fornaess Index is equal to one. (Received June 22, 2017)

1132-32-60 **Debraj Chakrabarti*** (chakr2d@cmich.edu), **Luke Edholm** and **Jeff McNeal**.
Bergman spaces on Reinhadt domains. Preliminary report.

Let Ω be a possibly non-smooth Reinhardt domain in $\mathbb{C}^n$, and let $A^p(\Omega)$ be the Banach space of holomorphic functions on Ω whose p-th powers are integrable, $p \geq 1$. We study properties of $A^p(\Omega)$ as a linear space, for example, the question of convergence of Laurent series of functions in $A^p(\Omega)$ in the norm of $A^p(\Omega)$, and that of determining the dual of $A^p(\Omega)$. These questions have unsurprising answers when Ω is the unit disc in the plane. We show there are new phenomena in the general situation, some only partially understood. In particular we look at the special case of the Hartog's triangle, where some of the computations can be performed explicitly. This is joint work with Luke Edholm and Jeff McNeal. (Received July 10, 2017)

1132-32-61 **Philip S Harrington**, Fayetville, AR 72701, and **Yunus E Zeytuncu*** (zeytuncu@umich.edu), Dearborn, MI 48128. *L^p mapping properties for the Cauchy-Riemann equations on Lipschitz domains admitting subelliptic estimates.*

In this talk we look at the L^p mapping properties of some canonical operators on general pseudoconvex domains. In particular, we show that on bounded Lipschitz pseudoconvex domains that admit good weight functions the $\overline{\partial}$-Neumann operators N_q, $\overline{\partial}^* N_q$, and $\overline{\partial} N_q$ are bounded on L^p spaces for some values of p greater than 2. (Received July 10, 2017)

1132-32-63 **Hanlong Fang*** (hf115@math.rutgers.edu) and **Xiaojun Huang** (huangx@math.rutgers.edu). *Flattening a non-degenerate CR singular point of real codimension two.*

We continue the previous studies in two papers of Huang-Yin on the flattening problem of a CR singular point of real codimension two sitting in a submanifold in $\mathbb{C}^{n+1}$ with $n+1 \geq 3$, whose CR points are non-minimal. Partially based on the geometric approach and a formal theory approach used in Huang-Yin, we are able to provide a very general flattening theorem for a non-degenerate CR singular point. This is joint work with Xiaojun Huang. (Received July 10, 2017)

1132-32-86 **Andrew S Raich*** (araich@uark.edu). *The Bergman kernel on forms: General theory.*

The goal of this talk is to explore the Bergman projection on forms. In particular, we show that some of most basic facts used to construct the Bergman kernel on functions, such as the boundedness of pointwise evaluation, fail for forms. We can, however, construct the Bergman kernel and explicitly compute the Bergman kernel on $(0, n-1)$-forms. For the ball in $\mathbb{C}^2$, we also show that the size of the Bergman kernel on $(0,1)$-forms is not governed by the control metric, in stark contrast to Bergman kernel on functions. (Received July 14, 2017)

1132-32-202 **James J Heffers*** (jjheffer@syr.edu). *Geometric properties of upper level Sets of Lelong numbers of currents on $\mathbb{P}^n$.*

Let T be a positive closed current of bidimension (p,p) with unit mass on the complex projective space $\mathbb{P}^n$. For certain values of α and $\beta = \beta(p,\alpha)$, it has been shown that if T has Lelong number at least α and enough points, then the upper level set $E^+_\beta(T)$ of points where T has Lelong number strictly larger than β possesses certain geometric properties. We will look specifically at the case where $\alpha > p/(p+1)$ and T has at least two points q_1, q_2 such that $\nu(T, q_i) \geq \alpha$, and show that for certain values of $\beta < p/(p+1)$, $E^+_\beta(T)$ is either contained in a p-dimensional linear subspace of $\mathbb{P}^n$, or there is a complex line L such that$|E^+_\beta(T) \backslash L| = p$. (Received July 21, 2017)

1132-32-221 **Bingyuan Liu*** (bingyuan@ucr.edu), 900 University Ave., Riverside, CA 92521. *Geometric Analysis on the Diederich-Fornæss index.*

Geometric analysis in differential geometry is a powerful tool in Riemannian geometry. It has been used to solve many problems in Riemannian geometry. In this talk, we consider problems in the Diederich—Fornæss index with a viewpoint of geometric analysis and see what we obtain. (Received July 23, 2017)

1132-32-223 **Purvi Gupta*** (prvgupta@umich.edu). *Rational and Polynomial Density on Compact Real Manifolds.*

Starting with the elementary fact that every continuous complex-valued function on the unit circle can be approximated by rational combinations of one fixed function and polynomial combinations of two fixed functions, we will discuss analogous approximation results for compact manifolds of higher dimensions. In particular, we will emphasize the symplectic and CR-methods involved in this problem. This is joint work with R. Shafikov. (Received July 23, 2017)

1132-32-264 **Shan Tai Chan*** (schan08@syr.edu), 215 Carnegie Building, Syracuse, NY 13244-1150, and **Yuan Yuan** (yyuan05@syr.edu), 215 Carnegie Building, Syracuse, NY 13244-1150. *Holomorphic isometries from the Poincaré disk into bounded symmetric domains.*

In general, it is difficult to classify all holomorphic isometries from the unit disk into bounded symmetric domains of rank at least two with respect to their Bergman metrics up to normalizing constants. In this talk, we will first consider holomorphic isometries from the Poincaré disk into the product of the unit disk and the complex unit n-ball for n at least two with respect to certain canonical Kähler metrics and obtain the classification of all such holomorphic isometries. On the other hand, I will also discuss how our study would provide new examples of holomorphic isometries from the Poincaé disk into irreducible bounded symmetric domains of rank at least two. This is a joint work with Yuan Yuan. (Received July 24, 2017)

1132-32-266 **Zhenghui Huo*** (huo@wustl.edu), 1 Brookings Dr., Department of Mathematics, St. Louis, MO 63130. *L^p estimates for the Bergman projection on some Reinhardt domains.*

We obtain L^p regularity for the Bergman projection on some Reinhardt domains. We start with a bounded smooth complete Reinhardt domain Ω and generate successor domains in higher dimensional spaces. We prove: If the Bergman kernel on Ω satisfies appropriate estimates, then the Bergman projection on the successor is L^p bounded. For example, the Bergman projection on successors of strictly pseudoconvex initial domains is bounded on L^p for $1 < p < \infty$. (Received July 24, 2017)

1132-32-274 **Xiaojun Huang*** (xhuangj@yahoo.com), Department of Mathematics, Rutgers University, New Brunswick, NJ 08903. *A compact algebraic strongly pseudoconvex hypersurface not embeddable into a Heisenberg hypersurface of any dimension.*

The materials of this talk are based on three joint papers, one with D. Zaitsev (Math . Z.), and one with X.. Li and Ming Xiao (IMRN) and one with Ming Xiao. I will describe the construction of a family of compact strongly pseudoconvex algebraic hypersurfaces which can not be holomorphically embeded into any sphere. This answers negatively a long standing falklore conjecture in CR geometry. (Received July 24, 2017)

1132-32-312 **Muhammed A Alan*** (malan@syr.edu), Syracuse University, Mathematics Department, 215 Carnegie Building, Syracuse, NY 13244. *Weighted Pluriregularity.* Preliminary report.

In this talk, we will discuss Weighted local and global Pluriregularity, and supports of weighted equilibrium measures. We will present positive and negative answers to few open problems in this area. (Received July 25, 2017)

1132-32-318 **Song-Ying Li*** (sli@math.uci.edu), 340 Rowland Hall, Department of Mathematics, UCI, Irvine, CA 92697-3875. *Rigidity problem and theorem for the solutions of the degenerate elliptic partial differential equations.*

In this talk, I will present a short survey on the rigidity type theorem for the solutions of the degenerate PDEs. It includes some joint work with R. Chen, and a joint work with Duong N. Son, etc. As well as some earlier works. (Received July 25, 2017)

33 ► Special functions

1132-33-7 **Vladimir V. Vinogradov*** (vinograd@ohio.edu), Department of Mathematics, Morton Hall 321, Ohio University, Athens, OH 45701. *On Bell and related polynomials and their connections with the Wright function.* Preliminary report.

We establish a new representation for the complete Bell polynomials of particular values of the arguments in terms of a special case of the Wright function. In addition, we introduce a new class of related polynomials (which we term V.M. Zolotarev polynomials) and derive their numerous properties. Their applications in various branches of mathematics are discussed. Based on joint works with Richard B. Paris (Abertay University) and Olga L. Yanushkevichiene (Vilnius University). (Received April 09, 2017)

34 ► Ordinary differential equations

1132-34-54 **Mihaela Cristina Drignei*** (mdrignei@pitt.edu), University of Pittsburgh at Bradford, 400 Campus Drive, Bradford, PA 16701. *Sequence-based reconstruction in inverse Sturm-Liouville three-spectra problems on a finite interval: theoretical aspects.*

Sequences of inverse Sturm-Liouville three-spectra problems on a finite interval are considered. Dirichlet-type boundary conditions are assumed to hold at the end-points of the interval, and a Dirichlet-type (or Robin-type, by case) interior-point condition is imposed at an interior node a_n of the interval, for a sequence $(a_n)_{n\geq 1}$ converging to an a-priory specified interior point a_0 of the interval. The two sequences of the numerical solutions to these two kinds (Dirichlet interior point condition and Robin interior point condition) of inverse Sturm-Liouville three-spectra problems are shown to converge respectively to the numerical solution of the same kind inverse Sturm-Liouville three-spectra problem corresponding to the interior point a_0. Theoretical arguments are presented in support of this convergence. These research results are practically useful: When constraints prevent obtaining the input data for a particular interior point a_0, the convergence statement assures that a good approximate numerical solution can be provided to the original inverse Sturm-Liouville problem if we slightly depart from a_0. The mechanical interpretation of this scenario is also discussed. (Received July 09, 2017)

1132-34-232 **Martin Klaus*** (klaus@math.vt.edu), Department of Mathematics, McBryde 472, Blacksburg, VA 24061. *On the number and moments of eigenvalues for Zakharov-Shabat systems with long-range potentials.*

We consider Zakharov-Shabat systems of the form

$$v_1' = -i\xi v_1 + q(t)v_2, \quad v_2' = -q(t)v_1 + i\xi v_2$$

where ξ is a complex spectral parameter and $q(t)$ is a real potential satisfying certain assumptions. In particular, $q(t)$ will be slowly decaying of the form $\sim |t|^{-\gamma}$, with $0 < \gamma \leq 1$. For such potentials, there may exist infinitely many purely imaginary eigenvalues $\xi_k = is_k$ $(k = 1, 2, \dots)$ with $s_1 > s_2 > \cdots > 0$. For a given $s > 0$, let $N(s) = \#\{j : s_j > s\}$. The main part of this talk will be devoted to the problem of finding the leading asymptotics of $N(s)$ as $s \to 0$. As a consequence, we will be able to obtain estimates for moments of eigenvalues, that is, for sums of the form $\sum_j s_j^\alpha$ (for suitable $\alpha > 0$) in terms of integrals of powers of $q(t)$. These results are analogous to the Lieb-Thirring inequalities for the eigenvalues of Schrödinger operators.

An important technical issue concerns the multiplicity of eigenvalues. We will present a new result guaranteeing that eigenvalues with sufficiently small imaginary part are algebraically simple. (Received July 23, 2017)

35 ► Partial differential equations

1132-35-11 **Jerome Goddard II**, **Quinn A. Morris*** (quinnamorris@gmail.com), **Catherine Payne** and **R. shivaji**. *Steady states for classes of reaction-diffusion equations with U-shaped density dependent dispersal on the boundary.*

We consider positive solutions to nonlinear elliptic partial differential equations with nonlinear boundary conditions which model the population dynamics in a habitat when the population exhibits U-shaped density dependent dispersal on the boundary. We analyze the persistence of the population (existence, non-existence, uniqueness and multiplicity of positive solutions) as the patch size and the hostility of the outside matrix vary. We obtain results in one spatial dimension via a quadrature method, and in higher spatial dimensions by the method of sub-super solutions. (Received May 01, 2017)

1132-35-21 **Kazuo Yamazaki*** (kyamazak@ur.rochester.edu), 1017 Hylan Hall, Department of Mathematics, University of Rochester, Rochester, NY 14627. *Recent developments on the global regularity issue of the magnetohydrodynamics system.*

In this talk, I will discuss recent developments on two directions of research: global regularity of the two-dimensional magnetohydrodynamics (MHD) system with zero dissipation and full diffusion, global regularity of logarithmically supercritical MHD system with certain logarithmic powers that have seen improvements very recently. In particular, I will present a second proof of the global regularity of the two-dimensional MHD system with full diffusion and arbitrary weak dissipation using Besov space techniques. (Received June 19, 2017)

1132-35-30 **Maya Chhetri*** (maya@uncg.edu), Department of Mathematics and Statistics, 125 Petty Building, Greensboro, NC 27402. *On a class of asymptotically linear systems.*

We will consider a class of asymptotically linear elliptic system with zero Dirichlet boundary condition. We will discuss the existence of unbounded connected components of the solution set and investigate the nodal properties of solutions on these components. As a consequence, we infer the existence and multiplicity of solutions in a neighborhood of the bifurcation parameter containing the simple eigenvalue of the associated eigenvalue problem. (Received June 29, 2017)

1132-35-31 **Maya Chhetri**, **Lakshmi Sankar**, **Ratnasingham Shivaji** and **Byungjae Son*** (b_son@uncg.edu), 830 W Market Street, Apt 623, Greensboro, NC 27401. *An existence result for superlinear semipositone p-Laplacian systems on the exterior of a ball.*

We study the existence of positive radial solutions to the problem

$$\begin{cases} -\Delta_p u = \lambda K_1(|x|) f(v) & \text{in } \Omega_e, \\ -\Delta_p v = \lambda K_2(|x|) g(u) & \text{in } \Omega_e, \\ u = v = 0 & \text{if } |x| = r_0, \\ u(x) \to 0, v(x) \to 0 & \text{as } |x| \to \infty, \end{cases}$$

where $\Delta_p w := \operatorname{div}(|\nabla w|^{p-2}\nabla w)$, $1 < p < n$, λ is a positive parameter, $r_0 > 0$ and $\Omega_e := \{x \in \mathbb{R}^n | \ |x| > r_0\}$. Here $K_i : [r_0, \infty) \to (0, \infty)$, $i = 1, 2$ are continuous functions such that $\lim_{r\to\infty} K_i(r) = 0$, and $f, g : [0, \infty) \to \mathbb{R}$ are continuous functions which are negative at the origin and have a superlinear growth at infinity. We establish the existence of a positive radial solution for small values of λ via degree theory and rescaling arguments. (Received June 30, 2017)

1132-35-38 **Panayotis Kevrekidis*** (kevrekid5@gmail.com), 710 N. Pleasant Street, Amherst, MA 01003. *Multi-component nonlinear waves in optics and atomic condensates: Theory, computations and experiments.*

Motivated by work in nonlinear optics, as well as more recently in Bose-Einstein condensate mixtures, we will explore a series of nonlinear states that arise in such systems. We will start from a single structure, the so-called dark-bright solitary wave, and then expand our considerations to multiple such waves, their spectral properties, nonlinear interactions and experimental observations. A twist will be to consider the dark solitons of the one component as effective potentials that will trap the bright waves of the second component, an approach that will also prove useful in characterizing the bifurcations and instabilities of the system. Beating so-called dark-dark soliton variants of such states will also be touched upon. Generalizations of all these notions in higher dimensions and, so-called, vortex-bright solitons will also be offered and challenges for future work will be discussed. (Received July 03, 2017)

1132-35-39 **Pierre Germain*** (pgermain@cims.nyu.edu), **Fabio Pusateri** (pusaterifabio@gmail.com) and **Frederic Rousset** (frederic.rousset@u-psud.fr). *Asymptotic behaviour for NLS in dimension 1 with a potential.*

I will present new results giving the asymptotic behavior of the nonlinear Schrodinger equation, in dimension 1, when a decaying external potential is added. The proof uses the distorted Fourier transform to allow for a treatment through the space-time resonance report. This is joint work with F. Pusateri and F. Rousset. (Received July 03, 2017)

1132-35-40 **Robert Jenkins**, University of Arizona, **Jiaqi Liu***, University of Toronto, **Peter Perry**, University of Kentucky, and **Catherine Sulem**, University of Toronto. *Global Wellposedness and Soliton Resolution for the Derivative Nonlinear Schrödinger Equation.*

We study the derivative nonlinear Schröinger equation for generic initial conditions in some weighted Sobolev space that can support finitely many bright solitons (but excluding spectral singularities). We prove global well-posedness and give a full description of the long-time behavior of the solutions in space-time cones in the form of a finite sum of localized solitons and a dispersive component. The leading order term has the form of a multi-soliton whose parameters are slightly modified from their initial values by solitons-solitons and solitons-radiation interactions. Our analysis also provides an explicit expression for the correction dispersive term. We use the nonlinear steepest descent method of Deift and Zhou and complemented by the recent work of Borghese-Jenkins-McLaughlin on soliton resolution for the focusing nonlinear Schrödinger equation. (Received July 04, 2017)

1132-35-43 **XUWEN CHEN***, Department of Mathematics, University of Rochester, Rochester, NY 14627, and **Yan Guo**, Division of Applied Mathematics, Brown University, Providence, RI 02912. *On the Weak Coupling Limit of Quantum Many-body Dynamics and the Quantum Boltzmann Equation.*

The rigorous derivation of the Uehling-Uhlenbeck equation from more fundamental quantum many-particle systems is a challenging open problem in mathematics. In this paper, we exam the weak coupling limit of quantum N-particle dynamics. We assume the integral of the microscopic interaction is zero and we assume $W^{4,1}$ per-particle regularity on the coressponding BBGKY sequence so that we can rigorously commute limits and integrals. We prove that, if the BBGKY sequence does converge in some weak sense, then this weak-coupling limit must satisfy the infinite quantum Maxwell-Boltzmann hierarchy instead of the expected infinite Uehling-Uhlenbeck hierarchy, regardless of the statistics the particles obey. Our result indicates that, in order to derive the Uehling-Uhlenbeck equation, one must work with per-particle regularity bound below $W^{4,1}$. (Received July 05, 2017)

1132-35-55 **Dmitry Pelinovsky*** (dmpeli@math.mcmaster.ca), 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada. *Rogue periodic waves for the focusing mKdV and NLS equations.*

Traveling periodic waves of the modified Korteweg-de Vries (mKdV) equation are considered in the focusing case. By using one-fold and two-fold Darboux transformations, we construct explicitly the rogue periodic waves of the mKdV equation expressed by the Jacobian elliptic functions. The rogue periodic waves represent the outcome of the modulation instability of the periodic wave with respect to long-wave perturbations and serves for the same purpose as the rogue wave of the nonlinear Schrodinger equation (NLS), where it is expressed by the rational function. We compute the magnification factor and show that it remains the same as in the small-amplitude NLS limit for all amplitudes. We also present similar results for the periodic waves of the NLS equation. This is a joint work with Jinbing Chen (Southeast University, China). (Received July 10, 2017)

1132-35-69 **Jared Speck*** (jspeck@math.mit.edu), Massachusetts Institute of Technology, Department of Mathematics, 77 Massachusetts Ave, Bldg. 2 Rm. 265, Cambridge, MA 02139-4307. *Breakdown Results for Solutions to Hyperbolic PDEs.*

In the last decade, there has been a flurry of research activity that, for solutions to various nonlinear hyperbolic PDEs with ties to geometry and physics, has yielded i) proofs of stable breakdown, ii) sharp information about the nature of the breakdown, and iii) a detailed description of the mechanisms driving it. One type of breakdown is the formation of a singularity, but other types of breakdown are also possible. The most significant advancements have occurred in the setting of more than one spatial dimension, where new ideas are needed to complete the proofs compared to the case of one spatial dimension. In this talk, I will survey some of these results and, in the relevant cases, highlight the role that geometry plays in the proofs. Some of the works that I will describe are joint with G. Holzegel, S. Klainerman, J. Luk, and W. Wong. (Received July 11, 2017)

1132-35-76 **Jonathan Bell*** (jbell@umbc.edu). *Inverse Problems for Neuronal Cable Models on Graphs.*

For a parabolic equation defined on a tree graph domain, a dynamic Neumann-to-Dirichlet map associated with the boundary vertices can be used to recover the topology of the graph, length of the edges, and unknown coefficients and source terms in the equation. The motivation for this investigation is that the parabolic equation comes from a (linear) neuronal cable equation defined on the dendritic tree of a neuron, and the inverse problem concerns parameter identification of k unknown distributed conductance parameters. The talk is based on joint work with Sergei Avdonin (University of Alaska, Fairbanks, AK) (Received July 12, 2017)

1132-35-80 **Jingwei Hu*** (jingweihu@purdue.edu) and **Xiangxiong Zhang** (zhan1966@purdue.edu). *On a class of implicit-explicit Runge-Kutta schemes for stiff kinetic equations preserving the Navier-Stokes limit.*

Implicit-explicit (IMEX) Runge-Kutta (RK) schemes are popular high order time discretization methods for solving stiff kinetic equations. As opposed to the compressible Euler limit (leading order asymptotics of the Boltzmann equation as the Knudsen number ε goes to zero), their asymptotic behavior at the Navier-Stokes (NS) level (next order asymptotics) was rarely studied. In this paper, we analyze a class of existing IMEX RK schemes and show that, under suitable initial conditions, they can capture the NS limit without resolving the small parameter ε, i.e., $\varepsilon = o(\Delta t)$, $\Delta t^m = o(\varepsilon)$, where m is the order of the explicit RK part in the IMEX scheme. Extensive numerical tests for BGK and ES-BGK models are performed to verify our theoretical results. (Received July 13, 2017)

1132-35-81 **Otis C Wright*** (wrighto@cedarville.edu). *Two-phase solutions of the cubic nonlinear Schrödinger equation.*

Elementary techniques are used to find simple formulas for both the maximum and the minimum of bounded two-phase solutions of the cubic nonlinear Schrödinger equation. (Received July 13, 2017)

1132-35-91 **Xudan Luo*** (xudanluo@buffalo.edu), 318 Mathematics Building, State University of, New York at Buffalo, 1 Putnam Way, North Campus, Buffalo, NY 14260, and **Mark J. Ablowitz**, **Ziad H. Musslimani** and **Baofeng Feng**. *Inverse scattering transform for some integrable nonlocal nonlinear equations.*

Recently, some new integrable nonlocal nonlinear equations are found. I this talk, the inverse scattering transform (IST) and pure soliton solutions will be discussed. (Received July 15, 2017)

1132-35-96 **Xiulan Lai*** (xiulanlai@ruc.edu.cn), 3027 Stadium Dr Apt 4, Columbus, OH 43202, and **Avner Friedman** (afriedman@math.osu.edu), 231 W 18th Ave, MW 532, Columbus, OH 43210. *Combination therapy of cancer with cancer vaccine and immune checkpoint inhibitors: A mathematical model.* Preliminary report.

We consider a combination therapy of cancer. One drug is a vaccine which activates dendritic cells so that they induce more T cells to infiltrate the tumor. The other drug is a checkpoint inhibitor, which enables the T cells to remain active against the cancer cells. To address the question of synergy between the two drugs, we develop a mathematical model using a system of partial differential equations. The variables include dendritic and cancer cells, CD4+ and CD8+T cells, IL-12 and IL-2, GM-CSF produced by the vaccine, and a T cell checkpoint inhibitor associated with PD-1. We use the model to explore the efficacy of the two drugs, separately and in combination, and compare the simulations with data from mouse experiments. We next introduce the concept of synergy between the drugs and develop a synergy map which suggests the proportion in which to administer the drugs in order to achieve the maximum efficacy. This is a joint work with Professor Avner Friedman. (Received July 16, 2017)

1132-35-99 **Xiaoying Wang*** (xwang4@uottawa.ca), Ottawa, Ontario K1N 6N5, Canada. *Pattern formation of a predator-prey model with the cost of anti-predator behaviors.*

We propose and analyse a reaction-diffusion-advection predator-prey model in which we assume that predators move randomly but prey avoid predation by perceiving a repulsion along predator density gradient. Based on recent experimental evidence that anti-predator behaviors alone lead to a 40% reduction on prey reproduction rate, we also incorporate the cost of anti-predator responses into the local reaction terms in the model. Sufficient and necessary conditions of spatial pattern formation are obtained for various functional responses between prey and predators. By mathematical and numerical analyses, we find that small prey sensitivity to predation risk may lead to pattern formation if the Holling type II functional response or the Beddington-DeAngelis functional response is adopted while large cost of anti-predator behaviors homogenises the system by excluding pattern formation. However, the ratio-dependent functional response gives an opposite result where large predator-taxis may lead to pattern formation but small cost of anti-predator behaviors inhibits the emergence of spatial heterogeneous solutions. (Received July 16, 2017)

1132-35-117 **Alex Himonas*** (himonas.1@nd.edu), Notre Dame, IN 46556. *Norm inflation and non-uniqueness for the Novikov equation.*

Novikov's equation is an integrable equation that can be thought of as a cubic analogue to the well-known Camassa-Holm equation. Using appropriate 2-peakon solutions, we prove that when one takes initial data in Sobolev spaces with exponents less than 3/2 the data-to-solution map becomes discontinuous in the sense of norm-inflation. Additionally, if the Sobolev exponent is less than 5/4, it is possible to construct non-unique solutions. This is a joint work with Curtis Holliman and Carlos Kenig. (Received July 17, 2017)

1132-35-120 **Kunquan Lan*** (klan@ryerson.ca), 350 Victoria Street, Toronto, Ontario M5B 2K3, Canada. *Population models governed by parabolic boundary value problems.* Preliminary report.

This presentation is based on recent work on population models governed by parabolic boundary value problems with nonlinearity changing signs. New results on existence of nonzero nonnegative or positive steady-state solutions of such boundary value problems are obtained by using a nonzero fixed point theorem for r-nowhere normal-outward compact maps obtained by Yang and Lan in 2016. The existence result is essential for studying long term Convergence of positive solutions of such parabolic boundary value problems in the Banach space C^1 as time goes to ∞ is obtained. Previous results considered weak convergence or uniform convergence. (Received July 17, 2017)

1132-35-122 **Estapraq Kahlil*** (estapraq.k@gmail.com). *On the well-posedness of the Cauchy problem for some nonlocal nonlinear Schrödinger equations*

This talk addresses the global and local well-posedness of the initial-value problem for the dispersion-managed nonlinear Schrödinger equation

$$iu_t + \alpha u_{xx} + \int_0^1 g(s)T^{-1}(s)\left[|T(s)u|^2 T(s)u\right]\, ds = 0,$$

which has applications in nonlinear fiber optics. The operator $T(s)$ is a nonlocal operator defined by $T(s) = \exp\left[-iD(s)\partial_x^2\right]$, where $D(s)$ models the dispersive properties of the fiber. We establish sufficient conditions on $D(s)$ to prove well-posedness (in the sense of Hadamard) in L^2, and to prove the existence and stability of solitary-wave solutions, which model localized light pulses within the fiber. (Received July 18, 2017)

1132-35-132 **Santosh Bhattarai*** (bhattarais@trocaire.edu), Trocaire College, 360 Choate Ave, Buffalo, NY 14220. *Standing waves for pseudo-relativistic nonlinear Schrodinger equations.* Preliminary report.

We study standing waves for pseudo-relativistic Schrödinger equations involving the operator of the form

$$\sqrt{-c^2\Delta + m^2c^4} - mc^2.$$

Such equations are relativistic version of nonlinear Schrödinger equations. The operator above corresponds to the quantization of the kinetic energy for a relativistic particle and is also called the relativistic free-particle Hamiltonian operator. We use a local interpretation of the relativistic operator by considering the Dirichlet-to-Neumann type operator for the upper half-plane and study solutions for the equivalent local Neumann problem in one more space dimension via variational methods. (Received July 18, 2017)

1132-35-146 **Wen Feng*** (w262f820@ku.edu) and **Milena Ognianova Stanislavova**. *Stability of Vortex solitons for n-dimensional focusing NLS.*

We consider the nolinear Schrödinger equation in n space dimension

$$iu_t + \triangle u + |u|^{p-1}u = 0,\ x \in \mathbb{R}^n,\ t > 0$$

and study the existence and stability of standing wave solutions of the form

$$\begin{cases} e^{iwt}e^{i\sum_{j=1}^k m_j\theta_j}\,\phi_w(r_1, r_2, \cdots, r_k), & n = 2k \\ e^{iwt}e^{i\sum_{j=1}^k m_j\theta_j}\,\phi_w(r_1, r_2, \cdots, r_k, z), & n = 2k+1 \end{cases}$$

for $n = 2k$, (r_j, θ_j) are polar coordinates in $\mathbb{R}^2$, $j = 1, 2\cdots, k$; for $n = 2k+1$, (r_j, θ_j) are polar coordinates in $\mathbb{R}^2$, (r_k, θ_k, z) are cylindrical coordinates in $\mathbb{R}^3$, $j = 1, 2\cdots, k-1$. We show the existence of such solutions as minimizers of a constrained functional and use the index theory to conclude that such standing waves for radial perturbation are stable if $1 < p < 1 + 4/n$. (Received July 19, 2017)

1132-35-149 **Inwon C Kim*** (ikim@math.ucla.edu). *Capillary Drops on Rough Surfaces.*

We will discuss the problem of a liquid droplet resting on a solid surface, described with the interfacial free energy. We will discuss existing literature on both equilibrium drops and dynamic models. The main challenge arises due to possible singularities at the "contact line", where the droplet boundary meets the surface. (Received July 19, 2017)

1132-35-159 **Barbara Prinari*** (bprinari@uccs.edu), 1420 Austin Bluffs Pkwy, Colorado Springs, CO 80918. *Inverse scattering transform for a square matrix nonlinear Schrödinger equation with nonzero boundary conditions.*

In this talk we discuss the Inverse Scattering Transform (IST) under nonzero boundary conditions for a square matrix nonlinear Schrödinger equation which was proposed as a model to describe hyperfine spin $F = 1$ spinor Bose- Einstein condensates with either repulsive interatomic interactions and anti-ferromagnetic spin-exchange interactions, or attractive interatomic interactions and ferromagnetic spin-exchange interactions. We formulate the IST in terms of a suitable uniformization variable, which allows to define the direct and inverse problems on the complex plane, instead of a two-sheeted Riemann surface or the cut plane with discontinuities along the cuts. Finally, we discuss the soliton solutions. (Received July 20, 2017)

1132-35-168 **Gang Zhou***, gzhou@math.binghamton.edu. *on the neckpinch of mean curvature flow.*

In this talk I will present some recent progress on the study of neckpinch of mean curvature flow, by combining methods of studying blowup of nonlinear heat equation, the classical methods for mean curvature flow, and recent new ideas. (Received July 20, 2017)

1132-35-169 **Tristan Buckmaster** (buckmaster@cims.nyu.edu) and **Steve Shkoller** (shkoller@math.ucdavis.edu), CA , and **Vlad Vicol*** (vvicol@math.princeton.edu), Princeton, NJ 08544. *Nonuniqueness of weak solutions to the SQG equation.*

We prove that weak solutions of the inviscid and the dissipative SQG equations are not unique, thereby answering an open problem posed by De Lellis and Székelyhidi Jr. In view of the well-known global existence of weak solutions for the dissipative SQG equation with datum at the level of the Hamiltonian, our work is the first to show that weak solutions constructed via convex integration can exist in a regularity class in which the nonlinearity is weakly compact. (Received July 20, 2017)

1132-35-179 **Wenrui Hao** and **King-Yeung Lam*** (lam.184@math.ohio-state.edu), Columbus, OH 43210, and **Yuan Lou**. *Stationary Dirac Concentrations in an Integro-PDE arising from Evolution of Dispersal.*

We consider an integro-PDE model for a population structured by the spatial variables and a trait variable affecting the dispersal coefficients. Competition for resource is local in spatial variables, but nonlocal in the trait variable. We focus on the asymptotic profile of positive steady state solutions. Our result shows that in the limit of small mutation rate, the solution remains regular in the spatial variables and yet concentrates in the trait variable and forms Dirac concetrations (i) at one boundary point; (ii) the interior; or (iii) at both boundary points. In particular, evolutionary branching is found in spatially heteogeneous but temporally constant environment. Other connections to notions and concepts in evolutionary game theory will also be discussed. This is joint work with Wenrui Hao (MBI) and Yuan Lou(Ohio State). (Received July 21, 2017)

1132-35-183 **Burak Erdogan**, **Michael Goldberg*** (goldbeml@ucmail.uc.edu) and **William Green**. *A Limiting Absorption Principle for Dirac Operators in Two and Higher Dimensions.*

We prove uniform resolvent bounds for Dirac operators with a large short-range potential in $\mathbb{R}^n$, $n \geq 2$. Analysis at the low-energy threshold is based on resolvent expansions for the Laplacian, and behaves differently depending on whether the mass of the Dirac operator is positive or zero. Uniform estimates at high energy are closely related to magnetic Schrödinger operators, with the caveat that many techniques for the latter do not apply in two dimensions. As a consequence of these results, the perturbed Dirac equation satisfies the same local L^2 bounds and Strichartz inequalities as the free case. (Received July 21, 2017)

1132-35-185 **Gino Biondini**, **Sitai Li*** (sitaili@buffalo.edu) and **Dionyssios Mantzavinos**. *Universal behavior of modulationally unstable media with non-zero boundary conditions.*

I will first briefly review the inverse scattering transform for the focusing nonlinear Schrodinger (NLS) equation with nonzero boundary conditions at infinity, and I will describe the interactions of soliton solutions on a non-zero background. Then I will describe in detail the properties of the asymptotic state of modulational instability for the NLS equation, including the number of oscillations and the local structure of the solution near each peak, showing in particular that in the long-time limit the solution tends to an ensemble of classical (i.e., sech-shaped) solutions of the NLS equation. Finally, I will show that a similar asymptotic state is shared among a broad class of systems of NLS-type possessing modulational instability. (Received July 21, 2017)

1132-35-192 **Deniz Bilman** (bilman@umich.edu) and **Peter D. Miller*** (millerpd@umich.edu). *A Robust Inverse Scattering Transform for the Focusing Nonlinear Schrödinger Equation.*

We propose a modification of the standard inverse scattering transform for the focusing nonlinear Schrödinger equation (also other equations by natural generalization). The purpose is to deal with arbitrary-order poles and potentially severe spectral singularities in a simple and unified way. As an application, we use the modified transform to place the Peregrine solution and related "rogue wave" solutions in an inverse-scattering context for the first time. This allows one to directly study the stability of such solutions. The modified transform method also allows rogue waves to be generated on top of other structures by elementary Darboux transformations, rather than the generalized Darboux transformations in the literature. (Received July 21, 2017)

1132-35-225 **Tristan Buckmaster**, **Pierre Germain** and **Zaher Hani*** (hani@math.gatech.edu), Atlanta, GA 30332, and **Jalal Shatah**. *The nonlinear Schrodinger equation on large domains.*

In this talk, we will be mainly concerned with the following question: Suppose we consider a nonlinear dispersive or wave equation on a large domain of characteristic size L: What is the effective dynamics when L is very large? This question is relevant for equations that are naturally posed on large domains (like water waves on an ocean), and in turbulence theories for dispersive equations. We will discuss several recent results, obtained in collaboration with Tristan Buckmaster, Pierre Germain, and Jalal Shatah (all at Courant Institute, NYU), that are aimed at addressing the above question for the nonlinear Schrodinger equation. (Received July 23, 2017)

1132-35-226 **Ugur G. Abdulla***, 150 West University Blvd., Melbourne, FL 32901. *The Wiener Test on the Removability of the Logarithmic Singularity for the Elliptic PDEs with Measurable Coefficients and Its Consequences.*

This paper introduces the notion of *log*-regularity (or *log*-irregularity) of the boundary point ζ (possibly $\zeta = \infty$) of the arbitrary open subset Ω of the Greenian deleted neigborhood of ζ in $\mathbb{R}^2$ concerning second order uniformly elliptic equations with bounded and measurable coefficients, according as whether the *log*-harmonic measure of ζ is null (or positive). A necessary and sufficient condition for the removability of the logarithmic singularity, that is to say for the existence of a unique solution to the Dirichlet problem in Ω in a class $O(\log|\cdot-\zeta|)$ is established in terms of the Wiener test for the *log*-regularity of ζ. From a topological point of view, the Wiener test at ζ presents the minimal thinness criteria of sets near ζ in minimal fine topology. Precisely, the open set Ω is a deleted neigborhood of ζ in minimal fine topology if and only if ζ is *log*-irregular. From the probabilistic point of view, the Wiener test presents asymptotic law for the *log*-Brownian motion near ζ conditioned on the logarithmic kernel with pole at ζ. (Received July 23, 2017)

1132-35-227 **Dan Andrei Geba*** (dangeba@math.rochester.edu) and **Manoussos G. Grillakis** (mggrlk@math.umd.edu). *Large data global regularity for quasilinear generalizations of the wave map system.*

In this talk, we will be discussing new large data global regularity results for the equivariant case of the classical Skyrme and $2+1$-dimensional Faddeev models, which improve upon previous ones obtained by Li and Creek, respectively. The two models appear as physically motivated generalizations of nonlinear sigma theories (whose associated Euler-Lagrange equations form wave map systems). The method of proof relies on the verification of a continuation criterion for local-in-time solutions, thus transforming them into global ones. (Received July 23, 2017)

1132-35-233 **Junping Shi** and **Yixiang Wu*** (yixiang.wu@vanderbilt.edu), Nashville, TN 37212, and **Xingfu Zou**. *Coexistence of competing species for intermediate dispersal rates in a reaction-diffusion chemostat model.*

In this talk, we consider a diffusive chemostat model with two competing species. We first present various results on the single species model, and show that small diffusion rate is beneficial to the species. We then prove the existence of stable steady states of the two species model within certain parameter ranges. We explore the dynamics of the model, including proving that there is no coexistence steady state when the diffusion rate is small. Our result demonstrates that coexistence is possible only for intermediate diffusion rates. (Received July 23, 2017)

1132-35-239 **Manoussos G. Grillakis*** (mng@math.umd.edu), M. G. Grillakis, Dept. of Mathematics, University of Maryland, College Park, MD 20742, and **Matei Machedon**. *Pair excitations and the mean field approximation of interacting Bosons.*

We consider a large number (N) of interacting Bosons. The mean-field is a wave-function describing the "typical" particle and it satisfies a non-linear Schrödinger equation. In joint work with M. Machedon I will describe a novel method on how to derive a correction to the mean-field. This correction describes pair excitations and has Physical significance. The derivation gives rise to a singular system of coupled equations and I will explain a method for proving local existence with estimates independent of the number of particles (N). (Received July 23, 2017)

1132-35-240 **Guo Deng*** (guodeng@buffalo.edu), 218PA south lake village, Buffalo, NY 14261, **Gino Biondini** (biondini@buffalo.edu), 324 Mathematics building, Buffalo, NY 14260-2900, and **Stefano Trillo** (trlsfn@unife.it), Dipartimento di Ingegneria, Via Saragat 1, 44122 Ferrara, Ferrara, Italy. *Small dispersion limits of integrable nonlinear PDEs with cosine initial condition.*

We employ the WKB method to study the scattering problem of the Korteweg-deVries equation in order to analytically characterize the Zabusky-Kruskal numerical experiment. We obtain explicit asymptotic expressions for the number of solitons as well as their amplitudes. We confirm the results by comparing them with recent shallow water experiments. We then generalize our approach to study the defocusing nonlinear Schrodinger equation, and we apply the corresponding results to characterize some recent experiments in nonlinear optics. This is joint work with G. Biondini and S. Trillo. (Received July 23, 2017)

1132-35-243 **Fabio Pusateri*** (fabiop@math.princeton.edu) and **Yu Deng**. *Asymptotics and blow-up at infinity for quasilinear wave equations.*

We consider a class of quasilinear wave equations in 3 space dimensions that satisfy the so-called weak-null condition. We derive precise asymptotics for large times and, in particular, show how blow-up occurs as time goes to infinity. (Received July 23, 2017)

1132-35-246 **Avy Soffer*** (avy.soffer@gmail.com), math dept, piscataway, NJ 08854. *Large solution to super-critical Wave and Schroedinger equations.*

It is shown that super critical wave and Schroedinger type equations have global solutions and scattering. The method of construction relies on new constructions of projections on outgoing waves. (Received July 23, 2017)

1132-35-249 **Gino Biondini** and **Dionyssios Mantzavinos*** (mantzavinos@ku.edu). *The asymptotic stage of modulational instability under the presence of a discrete spectrum.*

The long-time asymptotics of the focusing cubic nonlinear Schrödinger (NLS) equation on the line supplemented with *nonzero* boundary conditions at infinity were characterized via the Deift-Zhou nonlinear steepest descent method in [BM]. The analysis in [BM] was performed under the assumption of *no* discrete spectrum, thereby excluding the possibility for soliton-type solutions. The problem is now revisited after dropping this assumption, allowing for initial conditions which generate a non-trivial discrete spectrum. Apart from the intrinsic interest of this problem from a mathematical point of view, its analysis is important also from a physical point of view, since it enables one to study the interaction between solitons and radiation in a modulationally unstable medium. The same framework would further allow one to investigate the stability of solitons on nonzero background in modulationally unstable media.

Reference

[BM] G. Biondini and D. Mantzavinos, *Long-time asymptotics for the focusing nonlinear Schrödinger equation with nonzero boundary conditions at infinity and asymptotic stage of modulational instability.* Comm. Pure Appl. Math. (2017), doi: 10.1002/cpa.21701. (Received July 24, 2017)

1132-35-267 **Mihai H Tohaneanu*** (mihaitohy@gmail.com). *Scattering for the defocusing critical wave equation on Schwarzschild backgrounds.*

We prove global existence, uniqueness and scattering for the defocusing energy-critical wave equation on Schwarzschild spacetimes $\Box_{g_S} u = u^5$ with large initial data. The result follows from combining uniform energy bounds and Morawetz-type estimates on backward/forward light cones with Strichartz estimates previously proved by the author and collaborators. (Received July 24, 2017)

1132-35-271 **Alexander Tovbis*** (alexander.tovbis@ucf.edu), Department of Mathematics, University of, Central Florida, Orlando, FL 32816. *Semiclassical limit of the focusing nonlinear Schrödinger equation: multiphase (finite-gap) solutions and formation of rogue waves.*

We discuss some recent results on multiphase solutions of the NLS and some of their applications, related to rogue waves formation (Received July 24, 2017)

1132-35-285 **Matthew Creek*** (mc.creek@assumption.edu), Dept. of Mathematics and Computer Science, Assumption College, 500 Salisbury St, Worcester, MA 01609-1296. *Global Well-Posedness Results for Generalizations of the Nonlinear Sigma Model.*

The classical nonlinear sigma model of Gell-Mann and Levy, which describes interactions between nucleons and pions, has given rise to several generalizations. Among these are the Skyrme and Faddeev models, which are quasilinear generalizations that admit topological solitons. The global well-posedness of the equations of motion associated with these models has been studied intensely in recent years, in both the small- and large-data regimes. In this presentation, I shall discuss a novel technique which has been instrumental in helping to prove several large-data global well-posedness results for the Skyrme and Faddeev models. I shall also discuss current efforts in which I try to understand and apply this technique more broadly in order to unite these several results under the rubric of one more general result. (Received July 24, 2017)

1132-35-292 **Willie W.Y. Wong*** (wongwwy@member.ams.org). *Linear stability of the catenoid under the VMC flow outside of symmetry.*

Ini a previous joint work with Donninger, Krieger, and Szeftel, the author studied the stability of the catenoid under the vanishing mean curvature flow in Minkowski space, under the assumption that the perturbations exhibit both a reflection symmetry and an axial symmetry. Under these symmetry assumptions we showed that the only linear instability mechanism is the presence of a negative potential in the linearized dynamics driving

a one-dimensional exponential instability; we were further able to upgrade this to a co-dimension 1 *nonlinear stability* statement.

In this talk, based on joint work of the author and Szeftel, we analyze the situation for the linearized dynamics outside of the axial symmetry class. More precisely, we prove uniform dispersive decay of higher angular momentum perturbations, using a modification of the methods introduced by Blue and Sterbenz. (Received July 24, 2017)

1132-35-295 **Alexei Rybkin*** (arybkin@alaska.edu), Depart of math and statistics, UAF, Fairbanks, AK 99775-6660. *On the Cauchy problem for the KdV equation with initial data beyond standard assumptions.*

We apply techniques of Hankel operators to identify an optimal (in certain sense) class of initial data for the KdV equation that produce classical solutions. Such solutions can be obtained by a suitable generalization of the inverse scattering transform. The main feature of this class is that only decay at $+\infty$ is required and only essential boundedness from below is assumed at $-\infty$. This gives a partial answer to the open problem on the KdV equation with non-decaying and non-periodic initial data. Based upon joint research with S. Grudsky. (Received July 24, 2017)

1132-35-302 **Numann Malik*** (numann@math.brown.edu). *Linearization of the Gross-Pitaevskii Equation around a Vacuum State and the Black Soliton: Low Frequency Effects in 1D.* Preliminary report.

Consider the cubic defocusing NLS

$$i\partial_t u(t,x) + \partial_x^2 u(t,x) - 2(|u(t,x)|^2 - 1)u(t,x) = 0,$$

subject to the non-vanishing boundary conditions $|u(t,x)| \to 1$ as $|x| \to \infty$.

Linearizing around $\tanh(x)$ yields the evolution equation

$$\partial_t \begin{bmatrix} w \\ \bar{w} \end{bmatrix} = -i\mathcal{L} \begin{bmatrix} w \\ \bar{w} \end{bmatrix} + O(w^2)$$

where

$$\mathcal{L} = \begin{bmatrix} -\partial_x^2 + 2 & 2 \\ -2 & \partial_x^2 - 2 \end{bmatrix} + \begin{bmatrix} -4 & -2 \\ 2 & 4 \end{bmatrix} \operatorname{sech}^2(x)$$

and $w = w(t,x) = u(t,x) - \tanh(x)$ is a complex-valued perturbation. We explicitly calculate a formula for the propagator $e^{-it\mathcal{L}}$ obtained from explicit squared Jost solutions.

In the case of linearizing around the vacuum state 1, we end up with $\mathcal{L}$ minus the local terms. The propagator consists of a regular Fourier transform with a singularity at zero frequency. When considering the case of the black soliton we instead get a distorted Fourier transform modulo projection, arising from the presence of an end-point resonance embedded in the continuous spectrum. Analyzing different space-time regions we describe the long-time asymptotics for both cases. (Received July 25, 2017)

1132-35-309 **Marius Beceanu*** (mbeceanu@albany.edu), Math. Stat. Dept., SUNY Albany, 1400 Washington Ave., 110 Earth Science, Albany, NY 12206, and **Gong Chen**. *Strichartz estimates for the Klein-Gordon equation in three dimensions.*

In this talk I shall present some recent results about direct and reversed Strichartz estimates for the Klein-Gordon equation in three dimensions.

Everything about this talk is subject to change, including the title, the abstract, and the number of authors. (Received July 25, 2017)

1132-35-310 **Benoit Pausader***, 791 Tremont Street, Boston, MA 02118. *Growth of Sobolev norms for the Nonlinear Schrodinger equation.*

We consider the cubic nonlinear Schrodinger equation on a waveguide and show that for any $s > 0$, $s \neq 1$, there exists a global solution in H^s whose norm grows unboundedly. This is a joint work with N. Tzvetkov. (Received July 25, 2017)

1132-35-313 **Edwin James Beggs*** (e.j.beggs@swansea.ac.uk), Dept of Mathematics, Swansea University, Singleton Park, Swansea, SA2 8PP, United Kingdom. *A possible geometric solution mechanism for higher dimensional solitons.* Preliminary report.

The inverse scattering method for solving soliton equations (sine Gordon, principal chiral, affine Toda) can be put in a general algebraic framework involving a group doublecross product (a group factoring into two subgroups). One of these subgroups is the phase space of the system, and has a symplectic form and classical observable

functions (energy, momentum etc.), and the other subgroup generates the dynamics, via the classical vacuum map, a map from space-time to the subgroup*.

While in principal this framework could be generalised, in practice it has proved difficult to get anything looking like higher dimensional solitons. In this talk I shall outline a provisional proposal for using codimension 2 singularities (usual poles being codimension 1) of meromorphic functions. If this works it would extend the geometric soliton solution mechanism to various 2+1 dimensional examples. I shall highlight the very real problems which would need to be overcome to do this, if it works at all.

* Loop groups and the symplectic form for solitons in integrable theories EJ Beggs, PR Johnson Nonlinearity 12 (4), 1053, 1999

Inverse scattering and solitons in An-1 affine Toda field theories II EJ Beggs, PR Johnson, Nuclear Physics B 529 (3), 567-587, 1998 (Received July 25, 2017)

1132-35-314 **Roland Donninger** and **Irfan Glogic***, Department of Mathematics, The Ohio State University, 231 W 18th Ave, Columbus, OH 43220. *Existence and stability of blowup for wave maps into a negatively curved target.*

We consider wave maps on $(1 + d)$-dimensional Minkowski space. For each dimension $d \geq 8$ we construct a negatively curved, d-dimensional target manifold that allows for the existence of a wave map which starts off smooth and blows up in finite time. Furthermore, such wave map is explicit and self-similar inside the backward lightcone of the blowup point and provides a stable blowup mechanism for the corresponding Cauchy problem. (Received July 25, 2017)

1132-35-315 **Shuang Miao*** (shuang.miao@epfl.ch), Route Cantonale, 1015 Lausanne, Vaud, Switzerland, and **Sohrab Shahshahani**. *On tidal energy in Newtonian two-body motion.*

In this talk I will present our recent work on tidal energy for the motion of two gravitating incompressible fluid balls with free boundaries, obeying the Euler-Poisson equations. The orbital energy of two-body motion is defined as the mechanical energy of the center of mass of the two bodies. When the fluids are replaced by point masses, the conic curve describing the trajectories of the bodies is a hyperbola when the orbital energy is positive and an ellipse when the orbital energy is negative. If the point masses are initially very far, then the orbital energy, which is conserved in the case of point masses, is positive corresponding to hyperbolic motion. However, in the motion of fluid balls the orbital energy is no longer conserved, as part of the conserved energy is used in deforming the boundaries of the bodies. This energy is called the tidal energy. If the tidal energy becomes larger than the total energy during the evolution, the orbital energy must change its sign, signaling a qualitative change in the orbit of the bodies. In this work we give a precise description for evolution of the tidal energy up to closest approach, and show that under appropriate conditions on the initial configuration this change of sign occurs. (Received July 25, 2017)

1132-35-324 **Mark Ablowitz** (mark.ablowitz@colorado.edu), Boulder, CO 80309, **Gino Biondini** (biondini@buffalo.edu), Buffalo, NY 14260, and **Qiao Wang*** (qiaowang@buffalo.edu), Buffalo, NY 14260. *Whitham modulation theory for (2+1)-dimensional evolution equations.*

The generalization of Whitham modulation theory to (2+1)-dimensional systems has been a long-standing open problem in nonlinear waves. This talk will discuss recent progress in this direction. In particular I will discuss how, a suitable multiple-scales expansion allows one to derive Whitham modulation systems for various physically relevant multi-dimensional systems such as the Kadomtsev-Petviashvili (KP) equation, the two-dimensional Benjamin-Ono (2DBO) equation and the modified Kadomtsev-Petviashvili equation. I will also discuss the basic properties of these systems and use these system to study the transverse stability of the periodic solution of the KP and 2DBO equations, as well as the formation of dispersive shock waves in 2 spatial dimensions. (Received July 25, 2017)

1132-35-325 **Xingfu Zou***, Department of Applied Mathematics, University of Western Ontario, London, Ontario N6A 3K7, Canada, and **Yixiang Wu** (yixiang.wu@vanderbilt.edu), Department of Mathematics, Vanderbil University, Nashville, TN TN 37212. *On a diffusive host-pathogen system with different dispersal rates and spatial heterogeneity.*

In this talk, I will report some recent results on a diffusive host-pathogen model with spatially heterogeneous parameters and distinct dispersal rates for the susceptible and infected hosts. In addition to global existence of solution, existence of a global attractor, we also discuss the threshold dynamics in terms of the basic reproduction number R0 which is identified as the spectral radius of a linear operator in the appropriate functions space. We show that if R0<1, the pathogen free equilibrium is globally stable, and if R0>1, the solution of the model is uniformly persistent and there exists a positive steady state. In the latter case, we also explore the asymptotic

profiles of the endemic steady state as the dispersal rate of the susceptible or infected hosts approaches zero. The results reveal some difference between the roles that the diffusion rates of susceptible and infectious hosts can play. (Received July 25, 2017)

1132-35-326 **A. David Trubatch*** (david.trubatch@montclair.edu), Department of Mathematical Sciences, Montclair State University, Montclair, NJ 07043. *Reduced models for recurrence in the Korteweg-de Vries equation and related systems.* Preliminary report.

The observation of repeated approximate recurrence of initial conditions for nonlinear systems goes back to groundbreaking numerical simulations by Fermi, Pasta, Ulam (and Tsingou). By restricting the number of modes considered, Infeld obtained a reduced model of the nonlinear Schrödinger equation that gave good estimates for the FPU-like recurrence observed in that system [PRL v. 47 (1981) p. 717]. We explore application of the reduced-model approach to the prediction of recurrences in the Korteweg-de Vries equation and related systems. (Received July 25, 2017)

1132-35-332 **Wojbor A Woyczynski*** (waw@case.edu), 10900 Euclid Avenue, Cleveland, OH 44106. *Nonlinear and nonlocal evolution equations driven by Levy diffusions.*

We will discuss the interplay between the nonlinear and nonlocal components of the evolution equations. In the particular case of supercritical multifractal conservation laws (CL) the asymptotic behavior, as $t \to \infty$, is dictated by the linearized case. For $\alpha < 1$, the equations driven by infinitesimal generators of Lévy α-stable diffusions the solution exhibit shocks (for bounded, odd, and convex on R+, initial data) which disappear over a finite time. For Lévy α-Linnik diffusions, $0 < \alpha < 2$, the local behavior is strikingly different. The relevant CLs display shocks that do not dissipate over time. (Received July 25, 2017)

1132-35-333 **Garrett Otto** (garrett.otto@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292, **Sharon Bewick** (sharon_bewick@hotmail.com), Department of Biology, University of Maryland, College Park, MD 20742, **Bingtuan Li*** (bing.li@louiville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292, and **William F Fagan** (bfagan@umd.edu), Department of Biology, University of Maryland, College Park, MD 20742. *How Phenological Variation Affects Species Spreading Speeds.*

We present a phenologically explicit reaction-diffusion model to discuss the spatial spread of a univoltine insect species. Our model assumes four explicit life stages: adult, two larval, and pupa, with a fourth, implicit, egg stage. To account for phenology (seasonal biological timing), we introduce four time dependent phenological functions describing adult emergence, oviposition and larval conversion, respectively. We show that the spreading speed of the linearized system is the same as that for non-linear system. We provide explicit formulas for the spreading speed for the cases where emergence and oviposition are impulsive, and in addition 1) larval conversion occurs at a constant rate, and larvae are immobile, 2) larval conversion occurs at a constant rate starting at a delayed time from egg hatch, and larvae are immobile, 3) larval conversion is impulsive. To consider other biological scenarios, including cases with emergence and oviposition windows of finite width as well as mobile larvae, we use numerical simulations. Our results provide a framework for understanding how phenology can interact with spatial spread to facilitate (or hinder) species expansion. (Received July 25, 2017)

1132-35-335 **Stephen Anco***, Department of Mathematics & Statistics, Brock University, St Catharines, ON L2S3A1, Canada. *Integrable multi-component peakon equations from a modified AKNS scheme.* Preliminary report.

The standard AKNS scheme for generating integrable evolution systems is modified to obtain integrable peakon systems. In the simplest case, which involves 2x2 matrices, the modified scheme yields a large family of integrable multi-component peakon equations, together with their recursion operators, and bi-Hamiltonian structures. (Received July 25, 2017)

1132-35-336 **Gro Hovhannisyan** and **Oliver Ruff*** (oruff@kent.edu). *Higher-dimensional Darboux transformations and solitons.*

We discuss applications of an n-dimensional Darboux transformation to various nonlinear dynamic equations, with our main motivation being the efficient generation of multisoliton solutions. Generalizations to time-scale equations are also considered. (Received July 25, 2017)

1132-35-344 **Luiz Gustavo Farah**, **Justin Holmer** and **Svetlana Roudenko*** (roudenko@gwu.edu), Department of Mathematics, The George Washington University, Washington, DC 20052. *Instabiity of solitons in Zakharov-Kuznetsov equation.* Preliminary report.

We revisit the instability of solitons in the critical generalized Korteweg-de Vries (gKdV) equation, and investigate a similar phenomenon in Zakharov-Kuznetsov equation, a higher dimensional generalizations of the gKdV equation. (Received July 25, 2017)

1132-35-346 **John P Albert*** (jalbert@ou.edu), Department of Mathematics, Norman, OK 73019. *On the problem of subadditivity in the concentration-compactness method.* Preliminary report.

Often, relative compactness of minimizing sequences for a constrained variational problem is proved by a simple application of Lions' concentration-compactness lemma, in which one first establishes that the minimum value of the objective functional depends strictly subadditively on the values of the constraint functionals. In some applications, however, the strict subadditivity is difficult to verify, or in fact does not hold. In such cases, results may still be obtained by using more refined versions of the concentration-compactness lemma, such as the "bubble decomposition" lemma of P. Gérard. Examples discussed here include the problem of proving existence of ground states for an NLS-KdV system (joint work with Santosh Bhattarai) and the variational characterization of KdV multisolitons (joint work with Nghiem Nguyen). (Received July 25, 2017)

37 ► Dynamical systems and ergodic theory

1132-37-170 **Subhadip Chowdhury*** (subhadip@math.uchicago.edu), 5429 S BLACKSTONE AVE, CHICAGO, IL 60615. *Rotation number, Ziggurat Fringes and Fractal boundary.*

In this talk, we show that Calegari-Walker *ziggurats* — i.e. the graphs of extremal rotation numbers associated to positive words in free groups — have interesting rigidity and rationality properties and specifically, have projectively self-similar fringes. This explains phenomena experimentally observed by Calegari-Walker and Gordenko, and gives an explicit formula for these extremal rotation numbers in a certain range. (Received July 20, 2017)

1132-37-229 **Muhammad U. Abdulla*** (abdullam2015@my.fit.edu), 150 West University Blvd., Melbourne, FL 32901, **Ugur G. Abdulla** (abdulla@fit.edu), 150 West University Blvd., Melbourne, FL 32901, **Naveed H. Iqbal** (nchaudhr@my.fit.edu), 150 West University Blvd., Melbourne, FL 32901, and **Jake Barrett** (barrettj2015@my.fit.edu), 150 West University Blvd., Melbourne, FL 32901. *Minimal Orbits, Sharkovski Ordering and Universality in Chaos.*

We prove the outstanding conjecture on the number of third minimal odd periodic orbits of continuous endomorphisms on the real line. In a recent paper *Abdulla et. al., International Journal of Bifurcation and Chaos,* **27***, 5, 2017*, it is proved that there are $4k-3$ types of second minimal $2k+1$-orbits, $k \geq 3$, each characterized with unique cyclic permutations and directed graphs of transitions with accuracy up to inverses. In this paper, we prove that there are $8k^2+32k-110$ types of third minimal $2k+1$ periodic orbits, $k \geq 4$, each characterized with unique cyclic permutations and digraphs with accuracy up to inverses. The primary application of this result is to the problem of identifying and classifying the distribution of superstable periodic windows within the chaotic regime of bifurcation diagrams of the one-parameter family of unimodal maps. It was revealed in the recent featured article [2], that by fixing the maximum number of appearances of periodic windows, a universal pattern of distribution arises. In particular, the second (or third) appearance of all orbits in the bifurcation diagrams were always a second (or third) minimal orbit, with both a Type 1 cyclic permutation (and respective digraph), and a unimodal topological structure. (Received July 23, 2017)

39 ► Difference and functional equations

1132-39-345 **Ping Liu*** (liuping506@gmail.com), Harbin Normal University, heilongjiang,China, Harbin, Heilongjia 150025, Peoples Rep of China. *PATTERN FORMATION OF THE ATTRACTION-REPULSION KELLER-SEGEL SYSTEM.*

In this paper, the pattern formation of the attraction-repulsion Keller-Segel (ARKS) system is studied analytically and numerically. By the Hopf bifurcation theorem as well as the local and global bifurcation theorem,we rigorously establish the existence of time-periodic patterns and steady state patterns for the ARKS model in the full parameter regimes, which are identi ed by a linear stability analysis. We also show that when the

chemotactic attraction is strong, a spiky steady state pattern can develop. Explicit time-periodic rippling wave patterns and spiky steady state patterns are obtained numerically by carefully selecting parameter values based on our theoretical results. The study in the paper asserts that chemotactic competitive interaction between attraction and repulsion can produce periodic patterns which are impossible for the chemotaxis model with a single chemical (either chemo-attractant or chemo-repellent). (Received July 25, 2017)

47 ► Operator theory

1132-47-334 **Gabriel T Prajitura*** (gprajitu@brockport.edu), NY. *Irregular sums of vectors.* Preliminary report.

We will discuss the possibility of representing an irregular vector of an operator as sum of non irregular vectors as well as the similar problem for hypercyclic vectors. (Received July 25, 2017)

51 ► Geometry

1132-51-107 **Yulan Qing*** (yulan.qing@utoronto.ca) and **Kasra Rafi** (rafi@math.toronto.edu). *Convexity of balls in outer space.*

In this talk we study the convexity properties of geodesics and balls in Outer space equipped with the Lipschitz metric. We introduce a class of geodesics called balanced folding paths and show that, for every loop α, the length α along a balanced folding path is not larger than the maximum of its lengths at the end points. This implies that out-going balls are weakly-convex. We then show that these results are sharp by providing several counter examples. (Received July 17, 2017)

1132-51-119 **Sarah C. Mousley*** (mousley2@illinois.edu). *Boundary maps for some hierarchically hyperbolic spaces.*

There are natural embeddings of right-angled Artin groups G into the mapping class group $Mod(S)$ of a surface S. The groups G and $Mod(S)$ can each be equipped with a geometric structure called a hierarchically hyperbolic space (HHS) structure, and there is a notion of a boundary for such spaces. In this talk, we will answer the following question: does every embedding $\phi : G \to Mod(S)$ extend continuously to a boundary map $\partial G \to \partial Mod(S)$? That is, given two sequences (g_n) and (h_n) in G that limit to the same point in ∂G, do $(\phi(g_n))$ and $(\phi(h_n))$ limit to the same point in $\partial Mod(S)$? No background in HHS structures is needed. (Received July 17, 2017)

1132-51-347 **KYEONG MIN KIM*** (nycrick@gmail.com), 32 Piermont Rd, Cresskill, NJ 07626, and **Richard Kyung** (nycrick@gmail.com), 32 Piermont Rd, Cresskill, NJ 07626. *Efficient Noise Removal Using Low-Pass Filter and Windows.*

In this paper, noise removal process was shown through LPF (Low-Pass Filter) and various windows. Through applying different combinations of LPF and several window types, we were able to execute efficient noise removal. Noise removal cuts out unnecessary frequencies in order to make the sounds smooth and clear, which is necessary for many audio files. The LPF reduces signals that are above the cutoff frequency while allowing the signals that fall below the cutoff. Through executing noise removal with various combinations of filters and windows, we searched for efficient models. The combinations applied include: the LPF alone and the Hanning Window alone, in addition to the combinations of the Hanning Window and LPF, Bartlett Window and LPF, and Blackman Window and LPF. We substantiated the efficiency of the filter and the windows through various comparisons.

For each combination of filters and windows, we began with a time domain graph of noise removal output and pure voice of the same sample. The different combinations yield different results in the amplitude of voice and noise. When LPF and the Hanning Window were applied together, the amplitude of voice increased while the amplitude of noise decreased notably. (Received July 25, 2017)

1132-51-348 **NAYEON KIM*** (nykim0112@gmail.com), 32 Piermont Rd, Cresskill, NJ 07626, and **RICHARD KYUNG** (nycrick@gmail.com), 32 Piermont Rd, Cresskill, NJ 07626. *Mapping Points on a Line Segment to Points in a Two Dimensional Domain Using the Hilbert Curve.*

Two dimensional SFC(Space Filling Curve) is defined as a continuous mapping from a closed, bounded line segment(t-domain) into two-dimensional domain. There is recursive division of a domain into four sub-squares. The sub-squares are regarded as affine transformations of the original unit-square.

Focusing on two-dimensional SFCs and mappings from one-dimensional domain onto two dimensional domain, we are capable of calculating the coordinates of the image point of any domain using parameter representation with an arithmetic description of the Hilbert curve. Using the Hilbert curve, entering numeric values for the t-coordinate on the segment or the x and y coordinates in the square allows one to plot the necessary points on the map.

Based on the fact that everything about the geometric generation is based on a recursive division of unit intervals, this paper shows that the procedure can be simplified when the parameter in t-domain is represented in quaternary notation. (Received July 25, 2017)

53 ► Differential geometry

1132-53-18 **Baris Coskunuzer*** (coskunuz@bc.edu), Boston College, Math Department, Chestnut Hill, MA 02467. *Embeddedness of the solutions to the H-Plateau Problem.*

In this talk, we generalize Meeks and Yau's embeddedness result on the solutions of the Plateau problem to constant mean curvature disks. In particular, we will show that any minimizing H-disk in an H_0-convex domain is embedded for any $H \in [0, H_0)$. For the unit ball $\mathbf{B}$ in $\mathbb{R}^3$, this implies that for any $H \in [0, 1]$, any Jordan curve in $\partial\mathbf{B}$ bounds an embedded H-disk in $\mathbf{B}$. arXiv:1504.00661 (Received June 01, 2017)

1132-53-46 **Xiaodong Cao*** (cao@math.cornell.edu) and **Hung Tran**. *Einstein four-manifolds with pinched sectional curvature.*

In this talk, I will start with an introduction to the Einstein 4-manifold. Then I will discuss some earlier result on classification of the positive case. Finally I will mention some recent development in this area. (Received July 06, 2017)

1132-53-51 **Ruxandra Moraru*** (moraru@uwaterloo.ca), 200 University Ave West, Waterloo, Ontario N2L 3G1, Canada. *Hermitian-Einstein equations on generalized Kähler manifolds.*

In this talk, we discuss an analogue of the Hermitian-Einstein equations for generalized Kähler manifolds. We explain in particular how these equations are equivalent to a notion of stability for generalized holomorphic bundles, and that there is a Kobayahsi-Hitchin-type correspondence between solutions of these equations and stable bundles. Time permitting, we will also describe moduli spaces of these stable generalized holomorphic bundles on some specific examples of generalized Kähler manifolds. (Received July 07, 2017)

1132-53-72 **Lu Wang*** (luwang@math.wisc.edu), 480 Lincoln Drive, Madison, WI 53706. *Asymptotic structure of self-shrinkers of mean curvature flow.*

Self-shrinkers are a special class of solutions to mean curvature flow, in which a later time slice is a scale-down copy of an earlier one. They arise in the study of singularity formation of the flow. In this talk, we will show that each end of a noncompact self-shrinker in Euclidean three-space of finite topology is asymptotic to a regular cone or a round cylinder. In particular the curvature of such a self-shrinker is uniformly bounded. (Received July 11, 2017)

1132-53-196 **Panagiotis Gianniotis*** (pgiannio@uwaterloo.ca). *Regularity theory for Type I Ricci flows.*

A Ricci flow exhibits a Type I singularity if the curvature blows up at a certain rate near the singular time. Type I singularities are abundant and in fact it is conjectured that they are the generic singular behaviour for the Ricci flow on closed manifolds.

In this talk, I will describe some new integral curvature estimates for Type I flows, valid up to the singular time. These estimates partially extend to higher dimensions an estimate that was recently shown to hold in dimension three by Kleiner–Lott, using Ricci flow with surgery.

In this work we use the monotonicity formula available for Type I Ricci flows, adapting the technique of quantitative stratification of Cheeger–Naber to this setting. (Received July 21, 2017)

1132-53-210 **Brett L Kotschwar*** (kotschwar@asu.edu) and **Lu Wang** (luwang@math.wisc.edu). *Asymptotic rigidity of noncompact shrinking gradient Ricci solitons.*

Shrinking gradient Ricci solitons are generalized fixed points of the Ricci flow equation and models for the geometry of a solution in the vicinity of a developing singularity. At present, all known examples of complete noncompact shrinkers are either asymptotic to a regular cone at infinity or are locally reducible as products, and growing evidence suggests that in four-dimensions these may be the only possible asymptotic geometries. I will discuss some recent uniqueness results obtained in part with Lu Wang which demonstrate that a shrinking

soliton which is smoothly asymptotic to a cone or to a generalized cylinder along some end in an appropriate sense is essentially uniquely determined by its asymptotic geometry. (Received July 22, 2017)

1132-53-259 **Stephen J Kleene***, Department of Mathematics, Hylan Building, University of Rochester, Rochester, NY 14627. *Non-degeneracy conditions perturbation constructions.*

We show that a highly symmetric compact surface satisfying a mean curvature type equation can be desingularized provided the linearization is non-degenerate at the surface. This condition is simpler and perhaps easier to verify in practice than others that we know of. It is not clear at this point how the highly symmetric case informs the case without symmetry. (Received July 24, 2017)

1132-53-263 **William Wylie*** (wwylie@syr.edu), Math Department, 215 Carnegie Building, Syracuse University, Syracuse, NY 13244. *Geometry of Riemannian manifolds with density.*

We survey a new approach to comparison geometry results for Riemannian manifolds with density (or measure) which takes a certain non-Riemannian torsion free affine connection as the fundamental object of study. We'll discuss the generalization of classical comparison results for Ricci and sectional curvatures. Some of these result are joint work with Dmytro Yeroshkin from Idaho State and Lee Kennard from Oklahoma. (Received July 24, 2017)

1132-53-277 **Huai-Dong Cao***, Department of Mathematics, Lehigh University, Bethlehem, PA 18015, and **Xiaofeng Sun**, **Shing-Tung Yau** and **Yingying Zhang**. *Deformations of Fano Manifolds.*

In this talk I shall describe a new necessary and sufficient condition on the existence of Kähler-Einstein (KE) metrics on small deformations of a Fano KE manifold with nontrivial automorphism group. I will also describe a canonical extension of pluri-anticanonical forms from a Fano KE manifold to its small deformations which leads to a simultaneous embedding of a family of Fano manifolds into projective spaces with effective control. This is a joint work with X. Sun, S.-T. Yau and Y. Zhang. (Received July 24, 2017)

54 ► General topology

1132-54-140 **William W Menasco*** (menasco@buffalo.edu), Department of Mathematics, University at Buffalo—SUNY, Buffalo, NY 14260, and **Joan Birman** (jb@math.columbia.edu), Barnard College of Columbia Univ., New York, NY 10027. *Efficient geodesics in the complex of curves and the complex of arcs and curves: Preliminary report.* Preliminary report.

Let S_g denote a closed, connected, orientable surface of genus $g \geq 2$ and $\mathcal{C}(S_g)$ be the complex of curves. In recent work of the presenter with Joan Birman and Dan Margalit (*Efficient geodesics and an effective algorithm for distance*, **Mathematische Annalen** December 2016) a new preferred finite set of geodesics between any two vertices of $\mathcal{C}(S_g)$—*efficient geodesics*—was introduced. Efficient geodesics are different from the tight geodesics previously introduced by Masur and Minsky. Moreover, efficient geodesics yield an algorithm for determining the distance between two vertices of the complex of curves. While there already exist such algorithms, for example by Leasure, Shackleton, and Webb, this approach was, simple, and more effective for all distances accessible by computer.

In this preliminary report we discuss extending these earlier results to the complex of curves and the complex of arcs and curves for compact, connected, orientable surfaces with boundary. (Received July 19, 2017)

1132-54-165 **Robert E Tuzun*** (robert.e.tuzun@gmail.com), Department of Mathematics, University at Buffalo, Buffalo, NY 14260, and **Adam S Sikora** (asikora@buffalo.edu), Department of Mathematics, University at Buffalo, Buffalo, NY 14260. *Verification of the Jones unknot conjecture up to 22 crossings.*

We proved by computer enumeration that the Jones polynomial distinguishes the unknot for knots up to 22 crossings. Following an approach of Yamada, we generated knot diagrams by inserting algebraic tangles into Conway polyhedra, computed their Jones polynomials by a divide-and-conquer method, and tested those with trivial Jones polynomials for unknottedness with the computer program SnapPy. We employed numerous novel strategies for reducing the computation time per knot diagram and the number of knot diagrams to be considered. That made computations up to 21 crossings possible on a single processor desktop computer. (Received July 20, 2017)

1132-54-182 **William W Menasco*** (menasco@buffalo.edu), Department of Mathematics, University at Buffalo—SUNY, Buffalo, NY 14260. *Enhanced efficient geodesics in the complex of curves.* Preliminary report.

Let S_g denote a closed, connected, orientable surface of genus $g \geq 2$ and $\mathcal{C}(S_g)$ be the complex of curves. In recent work with Joan Birman and Dan Margalit (*Efficient geodesics and an effective algorithm for distance*, **Mathematische Annalen** December 2016) a new preferred finite set of geodesics between any two vertices of $\mathcal{C}(S_g)$, called *efficient geodesics*, was introduced. Efficient geodesics are different from the tight geodesics introduced by Masur and Minsky. Moreover, efficient geodesics yield an algorithm for determining the distance between two vertices of the complex of curves.

The existence of efficient geodesics is based upon the ability to always alter non-efficient edge-paths in $\mathcal{C}(S)$ using two path surgeries—the *box* and *hexagon* surgeries. We will discuss generalizations of these two surgeries and how they can be used to further limit the behavior of geodesic edge-paths in the complex of curves. This is a preliminary report. (Received July 21, 2017)

1132-54-203 **George C. Dragomir*** (dragomir@math.mcmaster.ca), McMaster University, 1280 Main Street West, Hamilton, ON L8S 4K1, Canada. *Metric-transforms of δ-hyperbolic spaces.* Preliminary report.

A real valued function of one variable φ is a called metric-transform if for every metric space (X, d) the composition $d_\varphi = \varphi \circ d$ is also a metric on X. We give a simple characterization of the class of the metric-transforms having the property that if (X, d) is δ-hyperbolic, then the metric d_φ is δ'-hyperbolic, for some $\delta' \geq 0$. This is based on joint work with Andrew Nicas. (Received July 21, 2017)

1132-54-231 **William W Menasco*** (menasco@buffalo.edu), Department of Mathematicstment of Mathematics, University at Buffalo—SUNY, Buffalo, NY 14260. *Future of braid foliation techniques.* Preliminary report.

Braid foliation techniques is a theory developed to study knots and links and related surfaces in 3-manifolds, and which from its inception has been intimately related to contact topology. Bennequin in the early 1980's first used these techniques to study transverse links and contact structures on $\mathbb{R}^3$, establishing the existence of non-contactomorphic contact structures. In the 1990's Birman-Menasco used these techniques in $\mathbb{R}^3$ and S^3 to probe the landscape of closed braids representing topological link types, with their work culminating in the Markov Theorem without Stabilization and accompanying applications to the study of link types whose transverse classification is non-trivial. Researchers have applied braid foliation techniques to solve problems in braid theory and contact topology: Dynnikov-Prasolov's proved of the Legendrian grid number conjecture and the generalized Jones conjecture; Ito and Malyutin-Netsvetaev discovered interplay between braid foliations and Dehornoy's ordering of braids; and, Ito and Keiko Kawamuro extended braid foliation techniques to closed 3-manifolds.

This talk will briefly review the key component of braid foliation techniques, and suggest new directions and problems that the technology might be pushed. (Received July 26, 2017)

1132-54-316 **Elizabeth Denne**, **John M. Sullivan** and **Nancy C. Wrinkle*** (n-wrinkle@neiu.edu). *The ribbonlength of knot diagrams.* Preliminary report.

The ropelength problem asks to minimize the length of a knotted space curve such that a unit tube around the curve remains embedded. A two-dimensional analog has a much more combinatorial flavor: we require a unit-width ribbon around a knot diagram to be immersed with consistent crossing information. The ribbonlength is the length of the diagram divided by its width. Attempting to characterize critical points for ribbonlength leads us to new results about the medial axis of an immersed disk in the plane, including a certain topological stability for thin disks. This is joint work with Elizabeth Denne and John M. Sullivan. (Received July 25, 2017)

55 ► *Algebraic topology*

1132-55-10 **Shaun V. Ault*** (svault@valdosta.edu), Valdosta State University, Department of Mathematics, 1500 N. Patterson St., Valdosta, GA 31698. *Homology Operations in Symmetric Homology.*

The symmetric homology of a unital associative algebra is defined using the covariant symmetric bar construction of Fiedorowicz and is shown to admit homology operations as well as a Pontryagin product structure. In this talk, we outline the proof of the above and then explore some methods for computation of symmetric homology in the case of finite-dimensional algebras over the integers. (Received April 14, 2017)

1132-55-25 **Renaud Detcherry*** (renaud.detcherry@gmail.com), MI , and **Effie Kalfagianni**. *Turaev-Viro invariants and Gromov norm.*

The Turaev-Viro volume conjecture of Chen and Yang states that the asymptotics of the Turaev-Viro invariants of a 3-manifold predicts its hyperbolic volume. We show a compatibility between Turaev-Viro invariants and JSJ-decomposition and get an inegality relating Turaev-Viro invariants and volume. (Received June 24, 2017)

1132-55-41 **Dirk Schuetz***, Dept of Mathematical Sciences, Durham University, Durham, DH1 3LE, United Kingdom. *Morse moves in framed flow categories.*

Framed flow categories were introduced by Cohen-Jones-Segal with the goal of describing a stable homotopy type for Floer homology, and were used by Lipshitz-Sarkar to define a stable homotopy type for Khovanov homology. In this talk we describe certain Morse moves on flow categories and how they can be used to algorithmically describe their stable homotopy type. This is joint work with A Lobb and P Orson. (Received July 05, 2017)

1132-55-50 **Yuri Berest*** (berest@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14850-4201, **Ajay C. Ramadoss** (ajcramad@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405, and **Wai-kit Yeung** (wy236@cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14850-4201. *Representation homology of topological spaces.*

Let G be a finite-dimensional affine algebraic group defined over a field k. For any (discrete) group Γ, the set of all representations of Γ in G has a natural structure of an affine k-scheme called the representation scheme $\mathrm{Rep}_G(\Gamma)$. If X is a (based) topological space, the representation scheme $\mathrm{Rep}_G[\pi_1(X)]$ of its fundamental group is an important algebro-geometric invariant of X that plays a role in many areas of mathematics. In this talk, I will discuss a natural extension of this construction, called *representation homology*, that takes into account a higher homotopy information about spaces and has very good functorial properties. Time permitting, I will explain the relation of representation homology to other homology theories associated with spaces, including higher Hochschild homology, S^1-equivariant homology of free loop spaces and stable homology of automorphism groups of f.g. free groups $\mathbb{F}_n$.

The talk is based on the paper arXiv:1703.03505. (Received July 07, 2017)

1132-55-103 **Krzysztof R Kapulkin*** (kkapulki@uwo.ca), Department of Mathematics, Middlesex College 116, University of Western Ontario, London, Ontario N6A 5B7, Canada, and **Vladimir A Voevodsky**. *Cubical sets and the homotopy coherent nerve.* Preliminary report.

I will report on the joint work with V. Voevodsky on the cubical approach to the homotopy coherent nerve and Lurie's (straightening, unstraightening)-adjunction. Specifically, we construct a functor from cubical categories to simplicial sets and show that the homotopy coherent nerve factors through it. In addition, we construct the analogs of straightening and unstraightening functors, yielding for a simplicial set S, an adjoint pair :

$$\mathrm{sSet}/S \rightleftarrows \mathrm{N}(\mathrm{cSet})^S,$$

and once again show that Lurie's version factors through our. (Received July 16, 2017)

1132-55-141 **Julia E. Bergner**, **Angélica M. Osorno**, **Viktoriya Ozornova*** (ozornova@math.uni-bonn.de), **Martina Rovelli** and **Claudia I. Scheimbauer**. *2-Segal spaces.* Preliminary report.

2-Segal spaces are a recent generalization of Segal spaces, due to Dyckerhoff-Kapranov and, independently, Gálvez–Carrillo-Kock-Tonks. An important class of examples comes from Waldhausen's $S_\bullet$-construction for exact categories. In a joint work with Bergner, Osorno, Scheimbauer, Rovelli, we show that basically all 2-Segal spaces arise this way if we slightly modify the input. (Received July 19, 2017)

1132-55-163 **A. Salch*** (asalch@math.wayne.edu), Dep't of Mathematics, 1150 F/AB, 656 W. Kirby, Detroit, MI 48202. *The Leopoldt conjecture via computational stable homotopy theory.* Preliminary report.

We give a (very) brief introduction to the well-known Leopoldt conjecture from number theory, that is, the conjecture that the p-adic regulator of a number field K is nonzero. We show how, whenever the orders of appropriately Bousfield-localized stable homotopy groups of finite spectra admit a description in terms of rational special values of Artin L-functions, we can extract information about p-adic regulators using Colmez's p-adic class number formula. As an application, we use the KU-local homotopy groups of Moore spectra to prove Leopoldt's conjecture (at p) for the subextension of $Q(\zeta_p)/Q$ in which p ramifies wildly. (Leopoldt's conjecture was already known to be true in these cases, by work of Brumer, but the topological approach is new.) If time allows, we will describe the state of ongoing work, and partial results, to prove Leopoldt's conjecture for some

families of nonabelian extensions of Q—cases in which the conjecture is not already known—using v_2-periodic families in stable homotopy. (Received July 20, 2017)

1132-55-173 **Akhil Mathew*** (amathew@math.uchicago.edu), Department of Mathematics, 5734 S University Ave., Chicago, IL 60637, and **Bhargav Bhatt** (bhargav.bhatt@gmail.com), 2074 East Hall, 530 Church St., Ann Arbor, MI 48109-1043. *Nonconnective simplicial commutative rings.*

Simplicial commutative rings are one of the first steps into "derived" rings that one can take. Many constructions for general E_∞-ring spectra or even $\mathbb{Z}$-algebras are simpler in the world of simplicial commutative rings; however, from a purely homotopy-theoretic or categorical picture they are slightly mysterious. I will explain ongoing work on an extended theory of "generalized rings" which extends this category to allow nonconnective objects. Many "equational" constructions which cannot work with E_∞-rings extend well to generalized rings. (Received July 20, 2017)

1132-55-174 **Douglas C Ravenel*** (dcravenel@gmail.com), Department of Mathematiocs, University of Rochester, Rochester, NY 14627. *Equivariant stable homotopy theory: how does it work and what is it good for?*

The past decade has seen an increase in the interest in equivariant stable homotopy theory, in part because of its use in the solution of the Kervaire invariant problem. In this expository talk I will describe some of its tools and indicate how they are used. I will not assume any previous familiarity with the subject. (Received July 21, 2017)

1132-55-176 **Ross Geoghegan*** (ross@math.binghamton.edu). *Parametrized Fixed Point Theory and Traces.*

I was lucky to work with Andy Nicas between 1986 and 2000 on 1-parameter fixed point theory; I'll discuss that work. In classical Nielsen theory a self-map $f : X \to X$ of a finite complex defines the Reidemeister trace - a souped-up Lefschetz number. It gives complete information about minimal number of fixed points of maps homotopic to f. For the certain kinds of maps this invariant can be interpreted as, roughly, the Hattori-Stallings trace (from K_0 to 0-dimensional Hochschild homology). In dimension 1, the map f is replaced by a homotopy $F : X \times I \to X$. We found a neat analog of the Reidemeister trace which gives significant information about the minimal possible number of "circles of fixed points" in homotopies homotopic to F. For certain kinds of homotopies our invariant can be interpreted as, roughly, the Dennis trace (from K_1 to 1-dimensional Hochschild homology). Among many results, this gave an elegant variation on the s-cobordism Theorem, saying that if the "trace of the Whitehead torsion" is non-zero then it is impossible to deform the top of the cobordism to the bottom without creating a circle of fixed points along the way. I'll describe this and some of our other theorems (quite widespread) having this general flavor. (Received July 21, 2017)

1132-55-181 **Sara Kalisnik***, sara.kalisnik@gmail.com, and **Davorin Lesnik** and **Vitaliy Kurlin**. *A Higher-Dimensional Homologically Persistent Skeleton.*

A data set is often given as a point cloud, i.e. a non-empty finite metric space. An important problem is to detect the topological shape of data — for example, to approximate a point cloud by a low-dimensional non-linear subspace such as a graph or a simplicial complex. Classical clustering methods and principal component analysis work very well when data points split into well-separated groups or lie near linear subspaces.

Methods from topological data analysis detect more complicated patterns such as holes and voids that persist for a long time in a 1- parameter family of shapes associated to a point cloud. These features were recently visualized in the form of a 1-dimensional homologically persistent skeleton, which optimally extends a minimal spanning tree of a point cloud to a graph with cycles. I will talk about a generalization of this 1-skeleton to higher dimensions and optimality results that we proved. (Received July 21, 2017)

1132-55-194 **Elizabeth Vidaurre*** (elizabeth.vidaurre@rochester.edu). *On Some Applications of Topology Based on Polyhedral Product Spaces.*

Certain subspaces of a product of spaces whose factors are labeled by the vertices of a simplicial complex are referred to as "polyhedral product spaces". Polyhedral products are given by taking the union of subproducts depending on the face category of a fixed simplicial complex on m vertices and a labelled family of m topological pairs. Such polyhedral products are realized by objects studied in combinatorics, commutative algebra and algebraic geometry. Real moment-angle complexes, where the pairs are intervals and their boundaries, play a key role. We will study how the cohomology of polyhedral products can be given in terms of the underlying simplicial complex. We will illustrate this by considering different classes of simplicial complexes. (Received July 21, 2017)

1132-55-206 **Cary Malkiewich*** (cmalkiewich1@gmail.com), Department of Mathematical Sciences, Binghamton University, PO Box 6000, Binghamton, NY 13902. *The transfer map of free loop spaces.*

To any fiber bundle $E \to B$ with finite CW-complex fibers F, there are classical wrong-way or "transfer" maps on the homology groups $H_*(B) \to H_*(E)$, and simiarly on cohomology as well. If LE and LB denote the spaces of free loops in E and in B, respectively, then there is a second transfer map $H_*(LB) \to H_*(LE)$, whose very existence is surprising, because the fiber LF of $LE \to LB$ is no longer finite. This map is constructed so as to be compatible with classical transfers in Waldhausen K-theory, but this makes its definition mysterious. I will discuss a joint result with John Lind that relates this free loop transfer to a certain generalization of the Reidemeister trace. We end with a fairly concrete geometric model that can be used for calculations. (Received July 22, 2017)

1132-55-207 **Cary Malkiewich***, Department of Mathematical Sciences, Binghamton University, PO Box 6000, Binghamton, NY 13902. *Periodic orbits and topological restriction homology.* Preliminary report.

I will talk about a project to import trace methods, usually reserved for algebraic K-theory computations, into the study of periodic orbits of continuous dynamical systems (and vice-versa). Our main result is a solution to a conjecture of Klein and Williams, showing that a certain fixed-point invariant built using equivariant spectra can be "unwound" into a more classical invariant that detects periodic orbits. As a simple consequence, the problem of removing periodic orbits by a homotopy can be reduced to the problem of equivariantly removing fixed points. Our result also allows us to interpret Klein and Williams' invariant as a class in topological restriction homology (TR), coinciding with a class defined earlier in the thesis of Iwashita and separately by Luck. This is joint work with Kate Ponto. (Received July 22, 2017)

1132-55-208 **Robert D Thompson*** (robert.thompson@hunter.cuny.edu), Department of Mathematics and Statistics, Hunter College, 695 Park Ave, New York, NY 10065. *The Bousfield-Kan spectral sequence for Morava E-theory.*

The Bousfield-Kan (or unstable Adams) spectral sequence can be constructed for various homology theories such as Brown-Peterson homology theory BP, Johnson-Wilson theory $E(n)$, or Morava E-theory E_n. For nice spaces the E_2-term is given by Ext in a category of unstable comodules. We show that these Ext groups can be interpreted as Ext in the category of comodules over a certain bialgebra - the bialgebra of the monoid of endomorphisms of the Honda formal group law. This is by analogy with the stable setting in which one only considers the group of automorphisms. This has implications for the convergence of the Bousfield-Kan spectral sequence. (Received July 22, 2017)

1132-55-212 **Carl McTague*** (carl.mctague@rochester.edu), Mathematics Department, University of Rochester, Rochester, NY 14627. *Genus-2 arithmetic and homotopy theory.* Preliminary report.

I will report on ongoing work to compute the ring of string bordism invariants $\pi_*\mathrm{MO}\langle 8\rangle \to \mathbf{Q}$ which are multiplicative for any fiber bundle with connected structure group. Based on calculations I have done involving the Cayley plane (the projective plane over the octonions), I conjecture that it is the ring of genus-2 Siegel modular forms for a certain congruence subgroup of the genus-2 modular group Sp(2), a subgroup whose cusp structure (under the Satake compactification) corresponds (under the Hirzebruch correspondence) to the union of Ochanine and Witten genera meeting with multiplicity 2 at the $\hat{A}$-genus, analogous to how the Ochanine genus itself has two cusps, identified with the $\hat{A}$-genus and signature. (Received July 23, 2017)

1132-55-217 **Yan Zou*** (yzou7@ur.rochester.edu). *Mackey functor homotopy in equivariant homotopy theory.*

Equivariant homotopy theory carries naturally more abundant content than classical homotopy theory. To establish the equivariant information, Mackey functors are used for the roles in the classical homotopy theory. In this talk we will briefly introduce Mackey functor in equivariant homotopy theory and examples of computations. (Received July 22, 2017)

1132-55-219 **Mona Merling*** (mmerling@jhu.edu), 1931 17th St, apt 302, Washington, DC 20009. *Equivariant A-theory.* Preliminary report.

Waldhausen's introduction of A-theory of spaces revolutionized the early study of pseudo-isotopy theory. Waldhausen proved that the A-theory of a manifold splits as its suspension spectrum and a factor Wh(M) whose first delooping is the space of stable h-cobordisms, and its second delooping is the space of stable pseudo-isotopies.

I will describe a joint project with C. Malkiewich aimed at telling the equivariant story if one starts with a manifold M with group action by a finite group G. (Received July 23, 2017)

1132-55-220 **Mingcong Zeng*** (mzeng6@ur.rochester.edu). *$RO(G)$-graded Homotopy Mackey Functor of $H\underline{\mathbb{Z}}$ for cyclic p-groups.*

In this talk, I will show how one can compute $RO(G)$-graded homotopy Mackey functor of $H\underline{\mathbb{Z}}$, the Eilenberg-Mac Lane spectrum of constant Mackey functor of integers, for $G = C_{p^n}$.

The computation is made through Tate diagram. However, if time permits, I will talk about several different methods of attacking this problem and how they interacts with each other, including an application to homological algebra of Mackey functors. (Received July 23, 2017)

1132-55-230 **Angélica M Osorno***, aosorno@reed.edu, and **Anna Marie Bohmann**. *A multiplicative comparison of Segal's K-theory and Waldhausen's K-theory.*

Segal's K-theory machine (based on Γ-spaces) can be used to produce spectra from symmetric monoidal categories, while Waldhausen's $S_\bullet$-construction is used to get spectra from Waldhausen categories. Waldhausen produced a natural transformation connecting the two constructions, and showed it is an equivalence in certain cases. Multiplicative versions of both functors were developed by Elmendorf-Mandell and Blumberg-Mandell, respectively. In this talk I will explain how the multiplicative constructions can be related. In order to do this, we will have to use the language of multicategories. (Received July 23, 2017)

1132-55-234 **Brenda Johnson*** (johnsonb@union.edu), Department of Mathematics, Union College, Schenectady, NY 12308. *Directional derivatives and chain rules in abelian functor calculus.*

The abelian functor calculus associates to a functor of abelian categories a sequence of functors and natural transformations that is analagous to the Taylor series of a real-valued function. Within this framework, one can also define the analog of a directional derivative for a functor. We show that this directional derivative gives a particular category of functors of abelian categories the structure of a cartesian differential category, as defined by Blute, Cockett, and Seely. We use the cartesian differential category structure to derive chain rules for higher order derivatives in abelian functor calculus. This is joint work with Kristine Bauer, Christina Osborne, Emily Riehl, and Amelia Tebbe. (Received July 23, 2017)

1132-55-262 **Gregory Arone** and **Kathryn Lesh***, leshk@union.edu. *Tits buildings and decomposition spaces.*

The space of decompositions of complex n-space into proper orthogonal decompositions has a natural action of the unitary group U(n), and makes an appearance in M. Weiss's orthogonal calculus, among other places. Until recently, relatively little has been known about its equivariant homotopy type. I will describe how the Tits buildings for the general linear group and the symplectic group make an important appearance in the fixed point sets of certain p-toral subgroups of U(n). (Received July 24, 2017)

1132-55-268 **Eva Belmont*** (ebelmont@mit.edu). *Localizing the E_2 term of the Adams spectral sequence.* Preliminary report.

The Adams spectral sequence is one of the central tools for calculating the stable homotopy groups of spheres, one of the motivating problems in stable homotopy theory. In this talk, I will discuss an approach for localizing its E_2 page by the non-nilpotent element b_{10} at the prime 3; this localization is isomorphic to the E_2 page itself above a line of slope $\frac{1}{23}$. This approach relies on computing an analogue of the Adams spectral sequence in Palmieri's stable category of comodules, which can be regarded as an algebraic analogue of stable homotopy theory. This computation fits in the framework of chromatic homotopy theory in the stable category of comodules. (Received July 24, 2017)

1132-55-287 **John McCleary*** (mccleary@vassar.edu), Box 69 Vassar College, Poughkeepsie, NY 12604-0069. *What we don't know about free loop spaces and closed geodesics.*

The homology of the free loop space of a manifold and the existence of closed geodesics on the manifold are related by a theorem of Gromoll and Meyer: Let M be a closed compact manifold of dimension at least two, and $\mathbb{F}$ is a field. Let LM denote the free loop space of M. When the set $\{\dim H_n(LM;\mathbb{F}) \mid n = 2, 3, \ldots\}$ is unbounded, there are infinitely many closed geodesics on M in any Riemannian manifold. I will report on recent work with John Jones on conditions on M that guarantee the unboundedness of the dimensions of $H_*(LM;\mathbb{F}_p)$. And I will outline the remaining open cases of interest where a homotopy theoretic argument is possible. (Received July 24, 2017)

1132-55-321 **Sarah Yeakel*** (syeakel@math.umd.edu). *A chain rule in Goodwillie calculus.*
In Goodwillie's calculus of functors, a homotopy functor can be filtered by polynomial approximations where the homogeneous fibers are classified by certain spectra, called the derivatives of the functor. For functors between spaces and spectra, these derivatives assemble to form modules over operads, and the derivatives of composable functors satisfy a chain rule. We will discuss these results and possible extensions to functors between other categories. (Received July 25, 2017)

57 ► Manifolds and cell complexes

1132-57-12 **Charles Frohman*** (charles-frohman@uiowa.edu), **Joanna Kania-Bartoszynska** and **Thang Le**. *Representation Theory of the Kauffman Bracket Skein algebra.*
Let ζ be an nth root of unity, and F be a finite type oriented surface. The Kauffman bracket skein algebra $K_\zeta(F)$ is an algebra over the complex numbers with basis the simple diagrams on F and multiplication given by stacking and resolving crossings using the Kauffman bracket skein relations. We prove a conjecture of Bonahon and Wong about irreducible represetations of $K_\zeta(F)$.

An irreducible representation $\rho : K_\zeta(F) \to M_N(\mathbb{C})$ is a surjective homomorphism to a matrix algebra. We prove generically, the irreducible representations of $K_\zeta(F)$ are determined by their central characters, and those generic representations all have the same dimension, which is the rank of $K_\zeta(F)$ as a module over its center.

The heart of the proof is a unicity theorem for representations of a prime algebra over an algebraically closed field, that has finite rank over its center. (Received May 01, 2017)

1132-57-13 **Charles Frohman*** (charles-frohman@uiowa.edu), **Joanna Kania-Bartoszynska** and **Thang Le**. *Generic Dehn-Thurston Coordinates.*
Let F be a closed oriented surface. A simple diagram on F is a disjoint collection of essential simple closed curves.

Dehn-Thurston coordinates for the simple diagrams on F are determined by a pants decomposition $\mathcal{P} = \{P_i\}$ where the P_i is a collection of disjoint simple closed curves that cut F into pairs of pants,and an embedding $\mathcal{D}$ of the dual graph of the decomposition. The coordinates consist of a $6g-6$-tuple of numbers $(n_1, \ldots, n_{3g-3}, t_1, \ldots, t_{3g-3})$. If S is a simple diagram then $n_i(S)$ is the geometric intersection number of S with P_i and $t_i(S)$ is the number of times that a standard model of S twists around P_i with sign.

We say the diagram S is triangular if whenever P_i,P_j and P_k bound a pair of pants, the numbers $n_i(S)$,$n_j(S)$ and $n_k(S)$ satisfy all triangle inequalities.

In this talk I will prove that given any finite collection of simple diagrams there is a choice of Dehn-Thurston coordinates so that all the diagrams are triangular. (Received May 01, 2017)

1132-57-19 **Charles Frohman*** (charles-frohman@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Representations of Web Groups and Spider Evaluation.*
A web is an oriented trivalent planar graph so that all its vertices are sources and sinks. Greg Kuperberg defined an invariant of webs which is a Laurent polynomial with integer coefficients that we call the *spider evaluation* of the web. The web group is the fundamental group of the complement of the web, where we view the plane as lying in $\mathbb{R}^3$. A meridian of a web group is a loop that goes from the basepoint above the plane around one edge. We consider the variety of representations of the web group into $SU(3)$ so that the meridians are all sent to matrices of trace equal to -1. We prove that the process of spider evaluation selects a collection of irreducible components of the representation variety, and there is a subring of the rational cohomology ring of those components so that the spider evaluation of the web is the sum of the symmetrized Poincare polynomials of those components. (Received June 03, 2017)

1132-57-27 **Tian Yang***, TAMU, college station, TX 77843. *Volume conjectures for Reshetikhin-Turaev and Turaev-Viro invariants.*
In a joint work with Qingtao Chen, we conjecture that at the root of unity $exp(2\pi i/r)$ instead of the usually considered root $exp(\pi i/r)$, the Turaev- Viro and the Reshetikhin-Turaev invariants of a hyperbolic 3-manifold grow expo- nentially with growth rates respectively the hyperbolic and the complex volume of the manifold. This reveals a different asymptotic behavior of the relevant quantum invariants than that of Wittens invariants (that grow polynomially by the Asymp- totic Expansion Conjecture), which may indicate a different geometric interpretation of the Reshetikhin-Turaev invariants than the SU(2) Chern-Simons gauge theory. Recent progress toward

these conjectures will be summarized, including a joint work with Renaud Detcherry and Effie Kalfagianni. (Received June 27, 2017)

1132-57-108 **Yohsuke Watanabe*** (ywatanabe@math.hawaii.edu), 2565 McCarthy Mall, Keller 401A, Honolulu, HI 96822. *Pseudo-Anosov mapping classes from pure mapping classes.*

Nielson-Thurston classification says that an element of the mapping class groups is periodic, reducible, or pseudo-Anosov. Though pseudo-Anosov maps are the most generic elements, their constructions are not so well-known. Thurston constructed pseudo-Anosov maps by products of two certain Dehn twists. This construction was generalized and extended by Long, Penner, Long-Morton, and Fathi where they also deal with simple reducible maps, that are Dehn twists and multitwists. In this talk, we construct pseudo-Anosov maps by products of a given map and a large class of reducible maps, that are pure mapping class groups which include Dehn twists, multitwists, partial pseudo-Anosov maps, and their appropriate combinations. (Received July 17, 2017)

1132-57-114 **Louis H Kauffman***, 5530 South Shore Drive, Apt 7C, Chicago, IL 60637-1946. *Simplicial Homotopy Theory and Khovanov Homology.* Preliminary report.

We will discuss how simplicial models are related to Khovanov homology and how they can provide homotopy theories for link homology structures. (Received July 17, 2017)

1132-57-115 **Abhijit Champanerkar*** (abhijit@math.csi.cuny.edu), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Blvd, Staten Island, NY 10314, **Ilya Kofman** (ikofman@math.csi.cuny.edu), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Blvd, Staten Island, NY 10314, and **Jessica Purcell** (jessica.purcell@monash.edu), School of Mathematical Sciences, 9 Rainforest Walk, Room 401, Monash University, Melbourne, VIC 3800. *Geometry of biperiodic alternating links.*

In this talk we will discuss the hyperbolic geometry of alternating link complements in the thickened torus. For links whose projection is related to a biperiodic edge-to-edge Euclidean tiling with convex regular polygons, we will describe the complete hyperbolic structure on their complements explicitly, and also highlight some properties of such tilings. We will also discuss some conjectures related to determinant, volume and their limits. (Received July 17, 2017)

1132-57-116 **Oliver Dasbach** and **Adam Lowrance*** (adlowrance@vassar.edu). *Extreme Khovanov homology of almost alternating links.* Preliminary report.

An almost alternating link is a non-alternating link with diagram where one crossing change can transform the diagram into an alternating diagram. In this talk, we discuss recent work on the Jones polynomial and Khovanov homology of almost alternating links. In particular, we prove that if a link is almost alternating, then its Khovanov homology in either the maximum or minimum quantum grading has rank one. (Received July 17, 2017)

1132-57-118 **Hans U Boden*** (boden@mcmaster.ca), **Micah Chrisman** and **Robin Gaudreau**. *Concordance invariants of virtual knots.*

Virtual knot theory concerns knots in thickened surfaces, and Turaev introduced virtual concordance and several useful invariants of them. This talk is based on joint work in progress with Micah Chrisman and Robin Gaudreau, and our goal is to extend various classical concordance invariants to the virtual setting and apply them to determine the sliceness and the 4-genus for low crossing virtual knots. One of the obstacles in virtual knot theory is the absence of Seifert surfaces, and for that reason we focus on the subclass of virtual knots with homologically trivial representatives. These knots admit Seifert surfaces, and we use them to define the usual package of knot invariants, including Alexander-Conway polynomials, signatures, and twisted signatures. In general, the resulting invariants depend on the choice of Seifert surface, and they often (but not always) give rise to concordance invariants of long virtual knots. The untwisted signatures can be computed in terms of Goeritz matrices a la Gordon-Litherland, and using Manturov projection, signature invariants can be extended from the nomologically trivial knots to all virtual knots. We apply these and other invariants to determine sliceness for virtual knots with up to 6 crossings. (Received July 17, 2017)

1132-57-131 **Abhijit Champanerkar** and **Ilya Kofman***, ikofman@math.csi.cuny.edu, and **Jessica Purcell**. *Right-angled volume of alternating links.* Preliminary report.

For any prime alternating link K, Menasco and Thistlethwaite described a decomposition along invariant Conway spheres into alternating tangles. We extract from their decomposition a new geometric link invariant, the "right-angled volume" of K, which is the sum of volumes of right-angled checkerboard polyhedra associated to the

alternating tangles that constitute K. We describe a method to compute it from a link diagram and discuss some applications. (Received July 18, 2017)

1132-57-136 **Christopher W. Davis**, **Matthias Nagel*** (nagel@cirget.ca), **Patrick Orson** and **Mark Powell**. *Triple linking numbers and surface systems.*

We relate fillability of two link exteriors, and the question when two links admit homeomorphic surface systems to (a refinement) of Milnor's triple linking numbers. This extends a theorem of Davis-Roth to include also links with nonvanishing linking numbers. (Received July 18, 2017)

1132-57-137 **W. Edwin Clark** and **Masahico Saito*** (saito@usf.edu). *Quandle knot invariants from $SO(3)$.* Preliminary report.

The quandle 2-cocycle invariant was originally defined in state-sum form using colorings by finite quandles and 2-cocycles as weights. It has an interpretation as a partition of colorings, using colorings of long knots by the quandle extension associated with the cocycle. This interpretation is used towards generalizing the invariant to topological quandles. As an example, colorings of long knots by $SO(3)$ and spherical quandles of rotations are studied. Regular polygons on the sphere, for example, appear as coloring conditions of some torus knots, and contribute to non-trivial invariant values. (Received July 19, 2017)

1132-57-144 **Douglas J. LaFountain*** (d-lafountain@wiu.edu). *Interlocking solid tori in contact 3-manifolds.* Preliminary report.

Non-thickenable solid tori in contact 3-manifolds are exotic embeddings which have been used to establish knot types with non-destabilizable Legendrian and transverse representatives, and are also related to admissible transverse surgeries that do not preserve tightness of contact structures. In this talk we revisit another family of exotic embeddings of solid tori discovered by Pinciu and further studied by Menasco and Matsuda, namely interlocking solid tori. We show that every positive braid which is not an obvious stabilization supports interlocking solid tori, and also outline a number of open questions concerning these two classes of solid tori. (Received July 19, 2017)

1132-57-147 **Steven Boyer*** (boyer.steven@uqam.ca), Département de mathématiques, UQAM, PO Box 8888, Centre-ville, Montreal, Quebec H3C3P8, Canada, and **Cameron McA. Gordon** and **Michel Boileau**. *Branched Covers of Quasipositive Links and L-Spaces.*

We show that if L is an oriented strongly quasipositive link other than the trivial knot or a quasipositive link which is not smoothly slice, then the Alexander polynomial and signature function of L determine an integer $n(L) \geq 1$ such that $\Sigma_n(L)$, the n-fold cyclic cover of S^3 branched over L, is not an L-space for $n > n(L)$. If K is a strongly quasipositive knot with monic Alexander polynomial such as an L-space knot, we show that $\Sigma_n(K)$ is not an L-space for $n \geq 6$, and that the Alexander polynomial of K is a non-trivial product of cyclotomic polynomials if $\Sigma_n(K)$ is an L-space for some $n = 2, 3, 4, 5$. Our results allow us to calculate the smooth and topological 4-ball genera of, for instance, quasi-alternating quasipositive links. They also allow us to classify strongly quasipositive alternating links and 3-strand pretzel links. (Received July 19, 2017)

1132-57-157 **Christopher J Leininger*** (clein@illinois.edu), Champaign, IL , and **Alan W Reid**, Houston, TX. *Pseudo-Anosov homeomorphisms not coming from branched covers.* Preliminary report.

Franks-Rykken showed that a pseudo-Anosov homeomorphism with quadratic irrational stretch factor necessarily "comes from" a branched covers of a torus (see also Gutkin-Judge). In this talk, I'll explain why this doesn't extend to the situation when the stretch factor has algebraic degree greater than 2, answering a question of Farb. (Received July 20, 2017)

1132-57-158 **Richard G Hanlon** and **Eduardo Martinez-Pedroza*** (emartinezped@mun.ca), St John's, NL A1C 5S7, Canada. *The tower method and subgroups of non-positively curved groups.*

Towers is a geometric technique from 3–manifold topology introduced by Papakyriakopolous, and brought to combinatorial group theory by Howie. We extend the tower method to equivariant maps and prove the following statement. If $\mathcal{C}$ is a class of locally finite complexes closed under taking full subcomplexes and covers and $\mathcal{G}$ is the class of groups admitting proper and cocompact actions on one-connected complexes in $\mathcal{C}$, then $\mathcal{G}$ is closed under taking finitely presented subgroups. As a consequence the following classes of groups are closed under taking finitely presented subgroups: groups acting geometrically on regular $CAT(0)$ simplicial complexes of dimension 3, k-systolic groups for $k \geq 6$ (extending a result of D. Wise), and groups acting geometrically on 2-dimensional negatively curved complexes (extending a result of S. Gersten). (Received July 20, 2017)

1132-57-161 **Dror Bar-Natan*** (drorbn@math.toronto.edu). *The Dogma is Wrong.* Preliminary report.

It has long been known that there are knot invariants associated to semi-simple Lie algebras, and there has long been a dogma as for how to extract them: "quantize and use representation theory". We present an alternative and better procedure: "centrally extend, approximate by solvable, and learn how to re-order exponentials in a universal enveloping algebra". While equivalent to the old invariants via a complicated process, our invariants are in practice stronger, faster to compute (poly-time vs. exp-time), and clearly carry topological information.

This is joint work with Roland van der Veen and continues work by Rozansky and Overbay. (Received July 20, 2017)

1132-57-166 **Laurence R Taylor*** (taylor.2@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556. *Even manifolds.* Preliminary report.

Call a compact, orientable $4k$-dimensional manifold *even* if all squares from its middle dimensional integral cohomology to its top dimension are even. The starting point of this talk is to define a characteristic class for bundles, $\hat{v}_{2k}$, in dimension $2k$ such that a manifold is even if and only if this class is 0 for the tangent bundle.

Bundles with $\hat{v}_{2k} = 0$ can be classified by a space $BSO\langle\hat{v}_{2k}\rangle$. A lift of a bundle to $BSO\langle\hat{v}_{2k}\rangle$ is called a $\hat{v}_{2k}$-structure. A manifold is even if and only if its tangent bundle has a $\hat{v}_{2k}$-structure.

A manifold either is or is not even, but if it supports a $\hat{v}_{2k}$-structure, it typically supports many. By studying structures, evenness can sometimes be inferred from bundle computations.

Interesting results can also be obtained from studying $\hat{v}_{2\ell}$-structures on the tangent bundles of manifolds of dimension greater than 4ℓ. As an example, let M be a simply-connected, $(8k+4)$-dimensional compact *Spin* manifold with signature congruent to 16 mod 32. Suppose G is a finite 2-group which acts freely on M. Then $G = \mathbb{Z}/2\mathbb{Z}$ or $G = \mathbb{Z}/2\mathbb{Z} \oplus \mathbb{Z}/2\mathbb{Z}$. (Received July 20, 2017)

1132-57-178 **Thomas Kindred*** (thomas-kindred@uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52246. *Checkerboard plumbings.* Preliminary report.

Focusing on examples (with lots of pictures!), I will show that a checkerboard surface F decomposes under plumbing (Murasugi sum) only if "obviously" so, in the sense that F has a de-plumbing cap which intersects the complementary checkerboard surface in a single arc. This fact will enable the straightforward computation of a new "plumbwise" notion of essentiality for any spanning surface which can be realized as a checkerboard. (Received July 21, 2017)

1132-57-180 **Cynthia L. Curtis*** (ccurtis@tcnj.edu), Department of Mathematics and Statistics, The College of New Jersey, Ewing, NJ 08628. *The $SL(2,\mathbb{C})$-Casson invariant: a survey.*

We discuss the $SL(2,\mathbb{C})$-Casson invariant defined by the author in 2001. We investigate the computability of the invariant, applications of the invariant, and relationships to other invariants including the Culler-Gordon-Luecke-Shalen semi norms and the A-polynomial. Finally we discuss the difficulty in extending this definition to include contributions from higher dimensional components of the character variety. (Received July 21, 2017)

1132-57-187 **Tarik Aougab*** (tarik_aougab@brown.edu), 79 Overhill Road, Providence, RI 02906, and **Priyam Patel** and **Samuel Taylor**. *Lifting curve pairs simply via hyperbolic geometry.*

In this talk, we are interested in addressing the following question: given two simple closed curves alpha, beta which intersect each other many times on an orientable surface S of finite type, what is the minimum degree cover S' of S so that there exists lifts alpha', beta' which are disjoint? Algebraic properties of surface groups imply that such a cover always exists, and we use the geometry of hyperbolic 3-manifolds to give lower bounds on this degree in terms of the curve complex distance between alpha and beta. We then use this to prove lower bounds in terms of the intersection number between alpha and beta which hold "generically", meaning that the bound holds with probability converging to 1 as the length of an appropriately chosen random walk goes to infinity; interpreted in the right way, this parallels a result of Gupta-Kapovich in the setting of free groups. This represents joint work with Priyam Patel and Sam Taylor. (Received July 21, 2017)

1132-57-213 **Adam Coffman*** (coffmana@ipfw.edu), IPFW Dept. of Math. Sci., 2101 E. Coliseum Blvd., Fort Wayne, IN 46805, and **Jiří Lebl**. *Perturbations of maps with isolated zeros.* Preliminary report.

Suppose a continuous map $\vec{f}\colon \mathbb{R}^n \to \mathbb{R}^q$ has a level set with an isolated point, and that there is no topological obstruction to removing the isolated point by a small perturbation $\vec{g}$ near $\vec{f}$. An example is a vector field $\vec{f}: \mathbb{R}^2 \to \mathbb{R}^2$ with an isolated zero of index zero. We consider the problems of constructing such a $\vec{g}$, and a homotopy from $\vec{f}$ to $\vec{g}$, in cases where $\vec{f}$ is semialgebraic, real analytic, or polynomial. For $q = 2$, we use complex variable and PDE methods to establish existence and regularity. (Received July 22, 2017)

1132-57-244 **Radmila Sazdanovic*** (rsazdanovic@math.ncsu.edu), Department of Mathematics NC State, 2311 Stinson drive SAS Hall, Raleigh, NC 27605-8205, and **Vladimir Baranovsky**. *On factorization and chromatic graph homology.* Preliminary report.

Factorization homology, introduced by Ayala, Francis, and Tanaka, generalizes Hochschild homology. Helme-Guizon and Rong's chromatic graph homology of a circle approximates Hochschild homology. We show that chromatic homology can be obtained in a similar way as factorization homology. The main difference between the two constructions stems from using derived versus underived products. Therefore the chromatic homology of any graph can be thought of as an approximation of factorization homology. (Received July 23, 2017)

1132-57-296 **Katherine Raoux***, 619 Red Cedar Road, C212 Wells Hall, East Lansing, MI 48824. *τ-invariants for knots in rational homology spheres.*

Using the knot filtration on the Heegaard Floer chain complex, Ozsváth and Szabó defined an invariant of knots in the 3-sphere called $\tau(K)$, which they showed is a lower bound for the 4-ball genus of K. Generalizing their construction, I will show that for a (not necessarily null-homologous) knot, K, in a rational homology sphere, Y, we can define a collection of τ-invariants, one for each spin-c structure on Y. In addition, these invariants give a lower bound for the genus of a surface with boundary K properly embedded in a negative definite 4-manifold with boundary Y. (Received July 24, 2017)

60 ► Probability theory and stochastic processes

1132-60-288 **Yiming Yu** and **Richard O. Moore*** (rmoore@njit.edu), Department of Mathematical Sciences, NJIT, University Heights, Newark, NJ 07102, and **Cyrill Muratov**. *Sampling switching dynamics in micromagnetic devices.*

The use of ferromagnetic domains for nonvolatile random access memory has only recently become viable as an alternative to other nonvolatile memory technologies such as those based on floating-gate transistors (i.e., flash memory). The spin-torque transfer effect provides a fast and low-power mechanism for switching micromagnetic domains that are readable using the phenomenon of tunneling magnetoresistance.

The read and write error rates for these devices are modeled using a stochastically forced Landau-Lifshitz-Gilbert equation. They depend sensitively on temperature and configuration, and require significant computational resources to determine accurately. The flow is not along a gradient, precluding approximations based on quasi-stationarity. As an alternative to computing solutions to the Fokker-Planck equation, we show how importance sampling can be combined with computations of paths that minimize the Wentzell-Freidlin action in order to reliably estimate the read error rate for a macrospin model where the easy axis is perpendicular to the magnetic layer. (Received July 24, 2017)

62 ► Statistics

1132-62-71 **Mary DiCioccio*** (dici5646@fredonia.edu), 17 Glenside avenue, Buffalo, NY 14223. *A Generalized Linear Model of Passing in Courses Taken With Peer-Led Team Learning at CSU Channel Islands.*

This study of the peer-led team learning (PLTL) program at CSU Channel Islands investigated the correlation of gender, entry type, ethnicity, workshop, pell, and intensity with respect to passing. The workshops span from Fall 2012 to Fall 2016. Intensity was measured by the peer leaders' observation of the students' attendance and participation in weekly meetings. Passing was categorized as a grade of C or higher in the class corresponding to the PLTL program. Gender and entry type were found to have no significant correlation with passing. However, ethnicity, workshop, pell, and intensity were found to have a significant correlation with passing. (Received July 11, 2017)

65 ► Numerical analysis

1132-65-77 **Xiaofeng Cai**, Houston, TX 77004, **Wei Guo*** (wguo@math.msu.edu), East Lansing, MI 48824, and **Jing-Mei Qiu** (jingqiu@math.msu.edu), Houston, TX 77004. *A high order conservative semi-Lagrangian discontinuous Galerkin method for the Vlasov-Poisson simulations.*

In this talk, we will introduce a high order conservative semi-Lagrangian (SL) discontinuous Galerkin (DG) method for the Vlasov-Poisson (VP) simulation. The proposed method relies on a characteristic Galerkin weak formulation and a high order characteristics tracing mechanism. Unlike many existing SL methods, the high order accuracy and mass conservation of the method are realized in a non-splitting manner. Thus, the detrimental splitting error, which could significantly contaminate long term Vlasov simulations, will be not incurred. One key ingredient in the scheme formulation is the use of Green's theorem which allows us to convert volume integrals into a set of line integrals. The resulting line integrals are much easier to approximate with high order accuracy, hence facilitating the implementation. The desired positivity-preserving property is further attained by incorporating a high order bound-preserving filter. To assess the numerical performance, we benchmark the proposed SLDG scheme for simulating several transport problems and the VP system. The efficiency and efficacy are numerically verified when compared with other prominent transport solvers such as the Eulerian DG methods combined with Runge-Kutta time integrators. (Received July 12, 2017)

1132-65-98 **He Yang*** (yang.1671@osu.edu), 748 Math Tower, 231 W 18th Avenue, Columbus, OH 43210, and **Fengyan Li** (lif@rpi.edu), Amos Eaton 301, 110 8th Street, Troy, NY 12180. *Discontinuous Galerkin Methods for Relativistic Vlasov-Maxwell System.*

The relativistic Vlasov-Maxwell (RVM) system is a kinetic model that describes the dynamics of plasma when the charged particles move in the relativistic regime and their collisions are not important. In this talk, we present discontinuous Galerkin (DG) methods to solve the RVM system. When standard piecewise polynomial functions are used to define trial and test spaces, the methods conserve mass as expected. However the energy conservation does not hold due to the specific form of the total energy of the system. In order to obtain provable mass and energy conservation, we take advantage of the flexibility of DG discretizations and enrich the discrete spaces with some non-polynomial function. For the semi-discrete DG methods with standard and enriched spaces, stability and error estimates are established together with their properties in conservation. In actual implementation with the enriched space, special care is needed to reduce the loss of significance for better numerical stability. Numerical experiments, including streaming Weibel instability and wakefield acceleration, are presented to demonstrate the performance of the methods. Positivity-preserving limiter is also used in simulating wakefield acceleration to obtain physically more relevant solutions. (Received July 16, 2017)

1132-65-101 **Yingda Cheng**, **Fengyan Li*** (lif@rpi.edu), **Zhichao Peng** and **Jing-Mei Qiu**. *Stability of DG-IMEX Asymptotic-Preserving Schemes for Some Linear Kinetic Models.*

For some linear kinetic models in a diffusive scaling, we consider asymptotic-preserving methods that involve discontinuous Galerkin (DG) spatial discretizations and implicit-explicit (IMEX) Runge-Kutta temporal discretizations. The methods are unconditionally stable in the regime where the scale of the problem is relatively smaller than the discretization scale in space. The discussion will particularly focus on the stability analysis when the methods are of first order accuracy in time, while error estimates, rigorous asymptotic analysis, numerical illustrations are also available. (Received July 16, 2017)

1132-65-106 **Emmanuel Lorin*** (elorin@math.carleton.ca), 1125 Colonel By, Ottawa, K1S5B6, Canada. *Computational methods for the Dirac equation.*

In this talk I will give a short overview of some recent numerical methods for solving the stationary and time-dependent Dirac equation. (Received July 17, 2017)

1132-65-236 **Jian-guo Liu**, **Min Tang** and **Li Wang*** (lwang@buffalo.edu), 244 Mathematics Building, Buffalo, NY 14226, and **Zhennan Zhou**. *An accurate front capturing scheme for tumor growth models in the free boundary limit.*

We consider a class of tumor growth models under the combined effects of density-dependent pressure and cell multiplication. When the cell population is congested and expanding, and the free boundary model can be derived as an asymptotic limit. In this talk, I will introduce a numerical scheme based on a novel prediction-correction reformulation that can accurately approximate the front propagation when the nonlinearity is extremely strong. We show the connection of our scheme with the free boundary limit via a relaxation framework, which manifests the efficiency of our scheme in capturing the correct front speed. Though proper spacial discretization, our

scheme enjoys an improves stability, preserves positivity, and is easy to implement. Plenty of examples in both one and two dimensions will be provided in the end. (Received July 23, 2017)

1132-65-256 **Jingyang Guo** and **Jae-Hun Jung*** (jaehun@buffalo.edu), Department of Mathematics, SUNY Buffalo, Buffalo, NY 14068. *Radial basis function weighted essentially non-oscillatory methods for hyperbolic problems with optimal shape parameters.*

The weighted essentially non-oscillatory (WENO) method provides an efficient way of dealing with discontinuous solutions to nonlinear hyperbolic conservation laws. The key element of the WENO method is to adaptively choose the stencils based on the polynomial interpolations. In this talk, we consider non-polynomial bases for the interpolation and show that the non-polynomial bases can improve the classical WENO order of accuracy. For this, we adopt infinitely smooth radial basis functions (RBFs). The RBF-WENO finite difference and finite volume method slightly perturb the reconstruction coefficients with RBFs as the reconstruction basis and enhance accuracy in the smooth region by locally optimizing the shape parameters. The optimization is obtained by considering the local flow conditions. Consequently the RBF-WENO methods provide more accurate reconstruction than the classical WENO reconstruction and provide sharper solution profiles near the jump discontinuity. We present several numerical examples including weak shock reflections. (Received July 24, 2017)

1132-65-306 **Sulin Wang** and **Zhengfu Xu*** (zhengfux@mtu.edu). *Total variation bounded high order finite difference methods for one-dimensional conservation laws.*

Provable total variation bounded high order (at least third order) method based on variation measured on grid values will be discussed in this talk. Most of the conventional design of TVB methods is based on Harten's criteria. However, to strictly follow Harten's TVD criteria, one can only provide methods of at most second order. Popular ENO/WENO methods are very successful in producing robust numerical results with great performance of suppressing oscillations around discontinuities. However, it is still elusive to prove ENO/WENO methods are TVB. As one of the most important properties we desire for numerical methods solving conservation laws, provable TVB property is at the center of this talk. A new criteria will be provided to design TVB high order finite difference scheme for one-dimensional problems (Received July 25, 2017)

1132-65-329 **Misun Min*** (mmin@mcs.anl.gov), 9700 S. Cass Ave, Lemont, IL 60439.

High-Order Spectral Element Methods for Drift-Diffusion and Electromagnetic Systems.

With the motivation of solving problems on ion channels, ultra-flat metalens, and graphene-based two-dimensional materials, I will discuss high-order spectral element schemes developed for charge transport analysis for drift-diffusion systems and optical property analysis for electromagnetic systems. Discussion includes stable and efficient spatial/temporal discretizations and nonlinear steady state solver.

This is a collaborative work with Josh Wilson (U Minnesota), Ping-Hsuan (NTU/Taiwan), Yu-Hsuan (NTU/Taiwan), Abishek Venkit (UIUC), and Paul Fischer (UIUC/ANL).

(Received July 25, 2017)

1132-65-339 **Jae-Hun Jung**, **Christopher L Bresten*** (cbresten@umassd.edu), **Sigal Gottlieb**, **Saeja Oh Kim** and **Daniel Higgs**. *Recovery of High Order Accuracy in Radial Basis Function Approximations of Discontinuous Problems.*

Radial basis function (RBF) methods have been actively developed in the last decades. RBF methods are global methods which do not require the use of specialized points and that yield high order accuracy if the function is smooth enough. Like other global approximations, the accuracy of RBF approximations of discontinuous problems deteriorates due to the Gibbs phenomenon, even as more points are added. In this paper we show that it is possible to remove the Gibbs phenomenon from RBF approximations of discontinuous functions as well as from RBF solutions of some hyperbolic partial differential equations. Although the theory for the resolution of the Gibbs phenomenon by reprojection in Gegenbauer polynomials relies on the orthogonality of the basis functions, and the RBF basis is not orthogonal, we observe that the Gegenbauer polynomials recover high order convergence from the RBF approximations of discontinuous problems in a variety of numerical examples including the linear and nonlinear hyperbolic partial differential equations. Our numerical examples using multi-quadric RBFs suggest that the Gegenbauer polynomials are Gibbs complementary to the RBF multi-quadric basis. (Received July 25, 2017)

68 ► Computer science

1132-68-283 **Chaowen Guan*** (chaoweng@buffalo.edu), Department of CSE, University at Buffalo, 338 Davis Hall, Amherst, NY 14260-2500, and **Kenneth W Regan** (regan@buffalo.edu), Department of CSE, University at Buffalo (SUNY), 338 Davis Hall, Amherst, NY 14260-2500. *Efficient Reductions From Quantum Circuits to #SAT: Experiments With SAT Solvers.* Preliminary report.

We give new explicit conversions from a quantum circuit C into a small set of Boolean formulas ϕ_k such that the acceptance amplitude of C (on a given input) can be computed from the numbers of satisfying assignments to the ϕ_k. A pretty point is that each clause of each ϕ_k has the form $y = x \oplus (u \wedge v)$ where the only difference between the major quantum gates is whether v is free or constrained by another equation (or constant).

The reductions enable use of heuristic #SAT solvers to perform emulation of quantum circuits. They avoid the use of sparse representations of large matrices common to other emulators and also facilitates sampling from quantum distributions. The most ambitious goal is to drive the quantum inner loop of Shor's factoring algorithm, which is otherwise classical, and compare with other attacks on factoring which have largely worked by encoding the multiplication predicate into Boolean logic directly.

[Background needed is the first month-plus of a graduate or upperclass undergrad course in quantum computing, equivalent to chs. 1-2 of Nielsen-Chuang, 1-3 of Hirvensalo, 1-5 of Yanofsky-Mannucci, or 1-7 of Lipton-Regan. Will be updated at https://www.cse.buffalo.edu/~regan/papers/pdf/QCSAT.pdf] (Received July 24, 2017)

1132-68-341 **Richard J. Lipton** and **Kenneth W. Regan*** (regan@buffalo.edu), Department of CSE, University at Buffalo (SUNY), 338 Davis Hall, Amherst, NY 14260-2500. *Games With Oracles That Lie.* Preliminary report.

Liar puzzles in logic are combined with the alternating strategies of two-player games. The games have perfect information in theory but not in practice owing to the high computational complexity of determining whether there is a winning move and finding it if so. We postulate an all-powerful *oracle* that makes such determinations but occasionally *lies* about both the winnability of the position and the correct move. The main question is whether one can play the game perfectly even while relying on such an oracle.

Technically, our work transports classical fault-tolerance settings into the world of games and quantified not just propositional logic. Generalized forms of chess and related games are complete or hard for PSPACE, which stands for *polynomial space* and represents a level above the more commonly known class NP—while we still do not know whether PSPACE is different from P, that is. polynomial time. Perfect oracles A are known that make $\mathsf{P}^A = \mathsf{NP}^A = \mathsf{PSPACE}^A$; indeed, they constitute the first of several notorious *barriers* to proving $\mathsf{NP} \neq \mathsf{P}$. We show that error-free play is possible and similar relations hold for various cases of lying oracles. (Received July 25, 2017)

70 ► Mechanics of particles and systems

1132-70-188 **Surajit Sen*** (sen@buffalo.edu), **Michelle Przedborski** (michelle.przedborski2@brocku.ca) and **Thad A Harroun** (thad.harroun@brocku.ca). *Granular systems in 1D go to thermodynamic equilibrium.*

We show that a perturbation initiated in a chain of elastic spheres, which is a non-integrable dynamical system, devolves to thermodynamic equilibrium at late enough times. The results are consistent with the findings in the Fermi-Pasta-Ulam-Tsingou mass spring systems. (Received July 21, 2017)

1132-70-349 **JI WON ANDREA CHONG*** (ethan_chong@naver.com), 32 Piermont Rd, Cresskill, NJ 07626, and **RICHARD KYUNG** (nycrick@gmail.com), 32 Piermont Rd, Cresskill, NJ 07626. *Mechanical and Computational Analysis of Engine Torque and Dynamic Properties.*

Recently, the demand for the development of dynamic properties of internal combustion engine is continuously rising in order to find a new and efficient engine model. This research presents mathematical and computational analysis for a motion of a non-offset piston connected to a crank through a connecting rod in internal combustion engine This paper shows how the engine torque and other dynamic properties are found, and also shows the outcomes as different graphs. The force resulting from the pressure in the cylinder was calculated using factors such as the area of the piston, the indicated cylinder pressure, and the atmospheric pressure. Also the inertial forces of moving parts are considered in the calculation the total force, because it was necessary to know the effect of moving mass as well. Torque was found after checking the force acting in the axial direction of the

cylinder, and the force acting on the connecting rod axis was found in terms of connecting the rod angle. To obtain the torque of an engine, a coding was written using the Matlab software. (Received July 26, 2017)

74 ► Mechanics of deformable solids

1132-74-350 **Kyungmo Kim*** (kyungmokim0724@yahoo.com), 32 Piermont Rd, Cresskill, NJ 07626, and **Richard Kyung** (nycrick@gmail.com), 32 Piermont Rd, Cresskill, NJ 07626. *Dynamic Analysis of the Robot Arm Using the Forward Kinematics.*

To solve robot dynamics, there are two major methods: forward kinematics and backward kinematics. The forward recursion mechanism allows us to obtain a closed-form of equation of motion in the dynamic analysis of the robot arm.

In this paper, we found speed, acceleration, angular speed, and angular acceleration of the center of mass of each links using the forward kinematics. When the axis of rotation and the center of mass do not correspond with each other, we can calculate the moment of Inertia using the Parallel Axis Theorem.

We were able to further calculate the torque needed to obtain specific angular acceleration for each link, using the estimated speed and acceleration and dynamic equations.

Forward recursion is the process of calculating speed and acceleration in order from the base link to the end-effector link. To calculate the speed, acceleration of a link (i+1) using the forward kinematics, the information, such as speed and acceleration of the link(i) is needed. In the equations, the Joint angle, Joint's speed, and angular speed of the Joint from the reference (base) frame were found in order. (Received July 26, 2017)

76 ► Fluid mechanics

1132-76-20 **Kazuo Yamazaki*** (kyamazak@ur.rochester.edu), Hylan 1017, Department of Mathematics, University of Rochester, Rochester, NY 14627. *Gibbsian dynamics and ergodicity of stochastic micropolar fluid system.*

The theory of micropolar fluids emphasizes the micro-structure of fluids by coupling the Navier-Stokes equations with micro-rotational velocity, and is widely viewed to be well fit, better than the Navier-Stokes equations, to describe fluids consisting of bar-like elements such as liquid crystals made up of dumbbell molecules or animal blood. We discuss the existence of a unique stationary measure for the stochastic micropolar fluid system with periodic boundary condition, forced by only the determining modes of the noise and therefore a type of finite-dimensionality of micropolar fluid flow.

The talk may touch also on other equations of fluid mechanics such as magnetohydrodynamics (MHD) system as well as MHD-Hall system. (Received June 19, 2017)

1132-76-93 **Shu-Ming Sun*** (sun@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Exact theory of multi-hump waves on water of finite depth with small surface tension.*

The talk concerns the existence of multi-hump surface waves with small oscillations at infinity on a layer of fluid with finite depth using the exact governing equations (also called Euler equations). The fluid is assumed to be incompressible and inviscid with a constant density (one common example is water) and the flow is irrotational. The surface wave is propagating with a constant speed on the free surface under gravity and small surface tension. If the wave speed is near its critical value, it has been shown that the Euler equations have solitary-wave solutions of elevation with small oscillations at infinity, known as generalized solitary waves. In this talk, it will be discussed that under such conditions, the Euler equations will have two-hump solutions (i.e., two-solitary-wave solutions) of elevation with small oscillations at infinity. The amplitude of the oscillations is algebraically small comparing with the inverse of the wave-length for the part of single-solitary wave. The basic idea to prove such existence is to patch two appropriate generalized solitary-wave solutions together using some free parameters. The similar idea works for the existence of multi-hump solutions. (This is a joint work with S. Deng). (Received July 15, 2017)

1132-76-343 **Allen M. Tesdall*** (allen.tesdall@csi.cuny.edu). *Glancing weak reflection.*

We attempt to formulate problems which describe the glancing limit of weak shock reflection, in which the wedge angle approaches zero as the Mach number is held fixed. Our starting point is a problem for the unsteady transonic small disturbance equations (UTSDE) which describes weak shock reflection asymptotically. The reflected shock is weak in the glancing limit, so we obtain a first approximation of the solution by linearization.

The linearization of the weak shock reflection problem for the UTSDE results in an oblique-derivative boundary value problem for the solution behind the incident shock. This has an exact solution that can be found using a Busemann transformation. The method of matched asymptotic expansions then shows that the solution near the point where the reflected shock diffracts into the Mach shock is described asymptotically by a self-similar solution of the UTSDE, together with matching data which we can write down explicitly. The scaling involved in the asymptotics, however, is unusually delicate, and a straightforward dominant balance argument is not sufficient to determine the size of the region near the triple point where nonlinearity becomes important. In this talk we will outline our procedure. This is joint work with John Hunter. (Received July 25, 2017)

78 ► Optics, electromagnetic theory

1132-78-34 **Gregor Kovacic*** (kovacg@rpi.edu), Mathematical Sciences Department, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180-3590, and **Sitai Li** and **Gino Biondini**. *Optical pulses described by Maxwell-Bloch systems with non-zero boundary conditions.*

Maxwell-Bloch systems describe the propagation of light pulses through active optical media such as rarefied gasses. Systems with non-zero conditions for large positive and negative times describe pulses riding on top of continuous-wave background. This talk will report on recent results on scalar and vector Maxwell-Bloch equations with non-zero boundary conditions. It will be shown how the inverse scattering transform can be constructed, and a number of explicit soliton solutions will be discussed. (Received June 30, 2017)

91 ► Game theory, economics, social and behavioral sciences

1132-91-184 **Jess Abramson** (jrabramso@gmail.com), **Natalie Collina*** (ncollina@princeton.edu) and **William Gasarch** (gasarch@cs.umd.edu). *Maximizing Expected Profit In Final Jeopardy.* Preliminary report.

Let Alice, Betty and Carol be 3 Final Jeopardy! participants. Each can bet up to the money she has already earned on the final question. If a player answers the question correctly, she adds that amount to her previous total, and if she answers incorrectly she loses that amount from her total. The player with the most money after Final Jeopardy! wins and takes home her total, while all other players leave with 0 dollars. We assume each player knows her probability of answering the final question correctly and all players' amount of money. In some cases we assume she knows other players' probability of answering the final question correctly.

We define the payoff to be the expected amount of money a player will take home on that day, and an optimal bet as one which maximizes the payoff a player can guarantee herself (maximin). We determine a player's optimal bet in a variety of situations. Scenarios include only considering that day's winnings or including the possibility of future winnings in the payoff. Many of these scenarios result in equilibrium points among the players. We also incorporate historical Jeopardy! data into these findings in order to provide concrete advice to players. (Received July 21, 2017)

92 ► Biology and other natural sciences

1132-92-8 **Shawn D Ryan*** (s.d.ryan@csuohio.edu), 2121 Euclid Ave., RT 1542, Cleveland, OH 44115. *Kinetic PDE Models for Active Biosystems.*

We start by introducing two discrete coupled PDE/ODE models capable of exhibiting remarkable collective behavior. First, a bacterium is represented as a point dipole subject to hydrodynamic and excluded volume interactions. Simulations and analysis of the corresponding kinetic theory reveal the physical mechanisms behind the striking decrease in effective viscosity and the nontrivial correlations emerging during collective swimming. Second a model for foraging ants is introduced illustrating a transition to a collective state and local lane formation. Both are unified by the fact that a kinetic approach provides additional insight into the self-organization of these biosystems into mesoscopic groups possessing capabilities beyond that of an individual. (Received April 10, 2017)

1132-92-35 **Jonathan G Bell*** (jbell@umbc.edu). *Mathematical modeling of mechanisms making arterial plaques vulnerable.*

While most arterial plaques are stable, a percentage of plaques become vulnerable to rupture, causing heart attacks, strokes, or organ damage, depending on their location. The main question is to pin down trigger mechanisms that destabilize a plaque. Biochemical, mechanical and hemodynamic mechanisms are involved. We model the cellular and chemical dynamics in a maturing plaque, where a fibrous cap is developing and chemotaxis plays a significant role. We explain cross-chemotaxis, presenting some theory and simulations. As time permits, we then briefly discuss the role of blood shear stress on the endothelial cell layer, and how to incorporate this mechanism into our plaque model. (Received July 01, 2017)

1132-92-48 **Frithjof Lutscher*** (flutsche@uottawa.ca), Department of Mathematics and Statistics, University of Ottawa, 585 King Edward Avenue, Ottawa, Ontario K1N6N5, Canada. *Persistence and spread for an impulsive reaction-diffusion equations with non-local impulse.*

Typical models for the dynamics of a spatially extended biological population come in the form of reaction-diffusion equations in continuous time and space, or – more recently – as integrodifference equations in discrete time and continuous space. Many real populations, however, have life histories and/or experience seasonal changes in ways that are not fully represented by either of these two modeling frameworks. For example, many stream insects (e.g. mayflies) have (at least) two life stages: aquatic larvae and terrestrial adults, with different dispersal behavior: aquatic drift and winged flight.

I will present a hybrid, continuous-discrete model for the life cycle of such stream insects, show the existence of an asymptotic spreading speed and consider stability questions. I will apply the model to experimental data and show results of invading fronts. (Received July 07, 2017)

1132-92-78 **Jin Wang*** (jin-wang02@utc.edu). *Modeling the spatial dynamics of cholera.*

We present some recent work in modeling the spatial dynamics of cholera, a water-borne disease caused by the bacterium Vibrio cholerae, using a partial differential equation framework. An emphasis of this study is the interplay of different biological, environmental and physical factors, including the intrinsic bacterial growth, direct and indirect disease transmission pathways, host and bacterial diffusion, and bacterial convection, which shape the complex pattern of cholera epidemics. Traveling wave solutions and disease threshold dynamics will be discussed, and both analytical and numerical results will be presented. (Received July 12, 2017)

1132-92-82 **Robert Stephen Cantrell*** (rsc@math.miami.edu), Department of Mathematics, The University of Miami, Coral Gables, FL 33124, and **Xinru Cao**, **King Leung Lam** and **Tian Xiang**. *Fitness based prey dispersal and prey persistence in intraguild predation systems.*

We establish prey persistence in intraguild persistence systems in bounded habitats under mild conditions when the prey disperses using its fitness as a surrogate for the balance between resource acquisition and predator avoidance. The model is realized as a quasilinear parabolic system where the dimension of the underlying spatial habitat is arbitrary. (Received July 13, 2017)

1132-92-90 **Necibe Tuncer**, **Hayriye Gulbudak**, **Vincent Cannataro** and **Maia Martcheva*** (maia@ufl.edu), Departent of Mathematics, 358 Little Hall, University of Florida, Gainesville, FL 32611. *Structural and Practical Identifiability Issues of Immuno-Epidemiological Vector-Host Models with Application to Rift Valley Fever.*

We discuss the structural and practical identifiability of a nested immuno-epidemiological model of arbovirus diseases, where host-vector rates are governed by the within-host immune system. For the immunological model, we use Rift Valley Fever (RVF) time-series data obtained from livestock under laboratory experiments, and for the epidemiological model we incorporate a human compartment and use the number of human RVF cases reported by the CDC during the 2006-2007 Kenya outbreak. We show that the immunological model is not structurally identifiable from data of viremia concentrations in the host. We study a scaled versions of the immunological model and show that it is structurally globally identifiable. Fixing estimated parameter values for the immunological model, we fit observable RVF epidemiological data to the nested model for the parameters of the multi-scale system. Monte Carlo simulations indicate that only three parameters of the epidemiological model are practically identifiable in this case. Alternatively, we fit the multi-scale data to the multi-scale model simultaneously. Monte Carlo simulations for the simultaneous fitting suggest that the parameters of the immunological model and the parameters of the immuno-epidemiological model are practically identifiable. (Received July 15, 2017)

1132-92-152 **Govind Menon*** (govind_menon@brown.edu), Division of Applied Mathematics, Brown University, 182 George St, Providence, RI 02906. *Building polyhedra by self-assembly.*

An important goal in nanotechnology since the mid-1990s has been to build materials and devices by mimicking biological mechanisms of self-assembly. This is now a vast, interdisciplinary enterprise, but mathematical engagement in the area has been quite modest to date.

I will discuss how an important biological example – the self-assembly of icosahedral viruses – can inspire and guide the development of technology. In particular, I will discuss how a discrete geometric framework utilized to understand the self-assembly of a "simple" virus (the bacteriophage MS2), inspired us to design and analyze synthetic examples of sub-micron sized "self-folding" polyhedra. I will also describe the mathematical evolution of our work from rather primitive ideas about polyhedra, to computations of diffusion on algebraic varieties.

This talk is designed for a general mathematical audience. It includes joint work with several people, especially David Gracis's lab at Johns Hopkins, and work of my former students Ryan Kaplan, Joe Klobusicky and Daniel Johnson-Chyzhykov. (Received July 20, 2017)

1132-92-237 **Yanyu Xiao*** (yanyu.xiao@uc.edu). *Explore the impact of latency on the spread of some diseases.*

The purpose of this work is to study the spatial dynamics of some delayed nonlocal reaction-diffusion systems. We will mathematically examine the effects of the delay and nonlocality on the spreading speed of the non-quasi-monotone systems. (Received July 23, 2017)

1132-92-269 **Hermann J Eberl*** (heberl@uoguelph.ca), Dept. Mathematics and Statistics, University of Guelph, Guelph, ON N1G2W1, Canada. *Numerical treatment of degenrate cross-diffusion equations arising in biofilm modeling.* Preliminary report.

We present a mathematical model for multi-species biofilms and discuss its numerical treatment. The biologically relevant solutions have little regularity, as their gradient blows up at the biofilm/water interface. Further complications stem from a singularity of the density dependent diffusion coefficients, and from the fact that the cross-diffusion problem does not have a maximum principle. This poses severe challenges for numerical treatment. The method we present is a time-adaptive, error controlled Finite Volume method. (Received July 24, 2017)

1132-92-320 **Antonio Mastroberardino***, 1032 W. Sheridan Road, Chicago, IL 60660, and **Javed I Siddique**, **Richard J Braun** and **Daniel M Anderson**. *Tear Film Dynamics: Modeling the Glycocalyx as a Poroelastic Region.* Preliminary report.

The human tear film is a complex fluid structure composed of an aqueous layer, an outermost lipid layer, and the glycocalyx, a forest of large transmembrane mucins that provide stability to the ocular surface. We formulate a thin film model based on lubrication theory and mixture theory in order to understand the dynamics between the aqueous layer and the glycocalyx, which we treat as a poroelastic region. (Received July 25, 2017)

1132-92-323 **J Wu*** (wjh@yorku.ca), Laboratory for Industrial and Applied Math, York University, Toronto, Ontario M3J1P3, Canada, and **J Fang** and **Y Lou**. *How Host Invasion Impacts Pathogen Spread.* Preliminary report.

The presentation will start with some published work (SIAM J. Appl. Math., 2016) where we considered the Fisher-KPP equation in a wavelike shifting environment for which the wave profile of the environment is given by a monotonically decreasing function changing signs (shifting from favorable to unfavorable environment). This type of equation arises naturally from the consideration of pathogen spread in a classical susceptible-infected-susceptible epidemiological model of a host population. The published study concluded that there are three different ranges of the disease transmission rate where the disease spread has distinguished spatiotemporal patterns, here we discuss possible extensions while the environmental condition is subject to seasonal variation. (Received July 25, 2017)

2010 MATHEMATICS SUBJECT CLASSIFICATION

Compiled in the Editorial Offices of MATHEMATICAL REVIEWS and ZENTRALBLATT MATH

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01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
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14 Algebraic geometry
15 Linear and multilinear algebra; matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory; homological algebra
19 *K*-theory
20 Group theory and generalizations
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51 Geometry
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68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory; control
94 Information and communication, circuits
97 Mathematics education

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