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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
1106	January 10–13, 2015	San Antonio, TX	EXPIRED	Vol 36, No. 1
1107	March 7–8, 2015	Washington, DC	January 20	Vol 36, No. 2
1108	March 14–15, 2015	East Lansing, MI	January 20	Vol 36, No. 2
1109	March 27–29, 2015	Huntsville, AL	February 4	Vol 36, No. 2
1110	April 18–19, 2015	Las Vegas, NV	February 24	Vol 36, No. 2
1111	June 10–13, 2015	Porto, Portugal	TBA	NONE
1112	October 3–4, 2015	Chicago, IL	August 11	Vol 36, No. 3
1113	October 17–18, 2015	Memphis, TN	August 25	Vol 36, No. 3
1114	October 24–25, 2015	Fullerton, CA	September 1	Vol 36, No. 4
1115	November 14–15, 2015	New Brunswick, NJ	September 22	Vol 36, No. 4

SAN FRANCISCO, CA, October 25–26, 2014

Abstracts of the 1104th Meeting.

00 ► General

1104-00-13 **Jim Simons***, 160 Fifth Avenue, 9th floor, New York, NY 10010. *Mathematics, common sense, and good luck* Preliminary report.

Ruminations on Science, Finance, and Philanthropy (Received April 30, 2014)

1104-00-51 **Gezahagne Mulat Addis*** (buttu412@yahoo.com), 419 Dilla, Dilla, Ethiopia. *Fundamental Theorem of Functions.* Preliminary report.

From the fundamental theorem of homomorphisms, it is well known that any homomorphism of groups can be decomposed as a composition of a monomorphism and an epimorphism. This result can also be extended to general functions defined on abstract sets; that is, any function can be expressed as a composition of an injection and a surjection. The main theorem in this paper called 'Fundamental theorem of Functions' provides the uniqueness of such a decomposition of functions as a composition of an injection and a surjection. The uniqueness in this theorem is proved upto the level of associates by introducing the notion of an associate of a function. The Fundamental Theorem of Homomorphisms of groups, rings, modules, vector spaces and of general universal algebras are derived by applying the Fundamental Theorem of Functions and various isomorphism theorems are also deduced. (Received August 13, 2014)

1104-00-161 **Elina M Robeva*** (erobeva@gmail.com). *Orthogonal Tensor Decomposition.*

Orthogonal tensor decomposition has recently been used in finding the parameters of certain latent variable models. It is a type of symmetric tensor decomposition in which one expresses a given $\underbrace{n \times n \times \cdots \times n}_{d \text{ times}}$ tensor T as $T = v_1^{\otimes d} + \cdots + v_k^{\otimes d}$, where the vectors $v_1, ..., v_k$ are pairwise orthogonal. We give equations defining the variety of orthogonally decomposable tensors. If $T = v_1^{\otimes d} + \cdots + v_k^{\otimes d}$ is orthogonally decomposable, it is easy to see that $v_1, ..., v_k$ are eigenvectors of T. We give a formula for the remaining eigenvectors of T in terms of the special ones $v_1, ..., v_k$. (Received August 29, 2014)

1104-00-189 **Ronen Eldan*** (roneneldan@gmail.com). *On Talagrand's convolution conjecture in Gaussian space.*

We prove the following logarithmic anti-concentration result in Gaussian space: let X be a random vector in $\mathbb{R}^n$ with law μ and let $f(x)$ be the density of μ with respect to the Gaussian measure. Suppose that $Hess(\log(f(x))) >$

$-10\mathrm{Id}$ for all x, in the positive definite sense. Then one has for all $t > 0$, $P(logf(X) \in [t, t+1]) < t^{-c}$ where c is some positive constant (depending on the number 10 above). An immediate consequence of this result is a positive answer to Talagrand's question about the regularization of L_1 functions under the convolution operator in Gaussian space. This is a joint work with James Lee. (Received September 01, 2014)

05 ► Combinatorics

1104-05-20 **Josephine Yu*** (jyu@math.gatech.edu), School of Mathematics, Skiles Building, 686 Cherry St, Atlanta, GA 30332. *Tropicalizing the positive semidefinite cone.*

A tropical positive semidefinite matrix is the valuation of a semidefinite matrix over the field of real Puiseux series. The tropical PSD matrices coincides with the normal cone at a vertex of the Newton polytope of the symmetric determinant. We find generators and defining inequalities of the cone. The PSD tropical quadratic forms are those that induce the trivial subdivision on the standard simplex dilated by two. We also show that the tropical PSD cone is the tropical convex hull of the set of symmetric matrices of tropical rank one and that every tropical PSD matrix can be factored as a tropical product of a matrix and its transpose. (Received June 06, 2014)

1104-05-52 **Bruno Benedetti*** (bruno@zedat.fu-berlin.de) and **Matteo Varbaro** (varbaro@dima.unige.it). *Connectivity of dual graphs of algebraic varieties.*

The dual graph of an algebraic variety is defined as follows, the nodes are just the irreducible components; two components are joined by an edge iff they intersect in codimension one. Hartshorne proved that the dual graph of any Cohen-Macaulay algebra is connected. Here we present a quantitative version: The dual graph of any Gorenstein subspace arrangement is r-connected, where r is the Castelnuovo–Mumford regularity. Note that the Stanley-Reisner ring of any simplicial (r-1)-dimensional sphere is a Gorenstein subspace arrangement of regularity r. So in this very special case, our result boils down to Balinski's theorem ("the graph of every r-polytope is r-connected"). (Received August 13, 2014)

1104-05-58 **Alexander Engstrom*** (alexander.engstrom@aalto.fi), Aalto University, Department of Mathematics, P.O. Box 11100, 00076 Aalto, Finland. *Algebraic Graph Limits.*

Random graphs are important both in theory and applications. In the most basic model edges are added independently with the same probability. That model is easy to analyse and feature many interesting phenomena, but most random graphs in nature doesn't look like that. Applied scientists have started the field of 'Complex Networks' that features random graph models that behave more like in nature, but are harder to analyse. One huge class of random graph models that captures many of these exotic applied models is called graph limits, and it's been developed by Lovasz and coauthors. The only drawback with graph limits in practice is that the infinite dimensional space of parameters provide ample freedom to overfit parameters and make bad model choices in practice. In this talk I will discuss how to restrict the graph limits to an algebraic setting where the number of parameters become reasonable for applied statistics and identifiability results can be proved using real algebraic geometry. (Received August 17, 2014)

1104-05-61 **Kaie Kubjas*** (kaie.kubjas@gmail.com), Aalto Science Institute, PO Box 15500, 00076 Aalto, Finland, and **Christopher Manon** (chris.manon@gmail.com). *Berenstein-Zelevinsky triangles and group-based models.*

Berenstein-Zelevinsky (BZ) triangles are used for counting $\mathrm{SL}_m(\mathbb{C})$ tensor product multiplicities. Group-based models are toric varieties associated with statistical models of evolution. Work of Buczynska, Wisniewski, Sturmfels, Xu, and Manon has linked the binary group-based model with the algebra of $\mathrm{SL}_2(\mathbb{C})$ conformal blocks. There is also a close relationship between the algebra of $\mathrm{SL}_m(\mathbb{C})$ conformal blocks and the representation theory of $\mathrm{SL}_m(\mathbb{C})$ established by Ueno. Motivated by these results, we study the relationship between the semigroup of $\mathrm{SL}_m(\mathbb{C})$ BZ triangles and the affine semigroup associated with the $\mathbb{Z}/m\mathbb{Z}$ group-based model. (Received August 18, 2014)

1104-05-67 **Robert Davis*** (davis.robert@uky.edu), Department of Mathematics, 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506. *Integrally Closed Polytopes and an Application to Symmetric Magic Squares.* Preliminary report.

It is an open question in Ehrhart theory to determine when the h^*-vector of a rational polytope is unimodal. While unimodality is difficult to prove in even highly restrictive situations, if the polytope is integrally closed then tools from commutative algebra can be useful. We will discuss new applications of toric algebra to certain families of integer polytopes formed from symmetric magic squares. (Received August 19, 2014)

1104-05-102 **Zvi H Rosen*** (zhrosen@math.berkeley.edu), 970 Evans Hall, Berkeley, CA 94720-3840. *Matrix Completion for the Independence Model.*

(joint work with K. Kubjas) We investigate the problem of completing partial matrices to rank-1 probability matrices. The motivation for studying this problem comes from statistics: A lack of desired completion can provide a falsification test for partial observations to come from the independence model.

For each type of partial matrix, we give an inequality in the observed entries which is satisfied if and only if a desired completion exists. We explain how to construct such completions and, in case a partial matrix has more than one rank-1 probability completion, we look at completions that minimize a distance function. (Received August 25, 2014)

1104-05-106 **Fu Liu***, fuliu@math.ucdavis.edu. *The lecture hall parallelopiped.*

The s-lecture hall polytopes P_s are a class of integer polytopes defined by Savage and Schuster which are closely related to the lecture hall partitions of Eriksson and Bousquet-Mélou. We define a half-open parallelopiped Par_s associated with P_s and give a simple description of its integer points. We use this description to recover earlier results of Savage et al. on the δ-vector (or h^*-vector) and to obtain the connections to s-ascents and s-descents, as well as some generalizations of these results.

This is joint work with Richard Stanley. (Received August 25, 2014)

1104-05-112 **Alexander Engström** (alexander.engstrom@aalto.fi) and **Matthew T. Stamps*** (stamps@math.kth.se). *An Orlik-Solomon theorem for matroids.*

The Brieskorn and Orlik-Solomon theorems state that the cohomology ring of the complement of a complex hyperplane arrangement is isomorphic to the Orlik-Solomon algebra of its underlying matroid. In this talk, we will show that the homotopy sphere arrangements arising as homotopy colimits of diagrams of spaces on the geometric lattice of a matroid are embeddable into topological spheres when the codimension is greater than or equal to two. From this we obtain a Goresky-MacPherson type formula for the cohomology groups of the complements of these arrangements and provide a cohomological interpretation for the Orlik-Solomon algebra of any matroid. (Received August 26, 2014)

1104-05-131 **Sarah Brodsky**, **Michael Joswig** and **Ralph Morrison*** (ralphmorrison@berkeley.edu), Department of Mathematics, University of California, Berkeley, 970 Evans Hall, Berkeley, CA 94720-3840, and **Bernd Sturmfels**. *Moduli of Hyperelliptic Tropical Plane Curves.*

Smooth curves in the tropical plane correspond to unimodular triangulations of lattice polygons, and each curve contains a metric graph called the skeleton. Triangulating every polygon with a fixed number of interior lattice points, all of which lie on a line segment, we obtain a space of metric graphs we call *the moduli space of hyperelliptic tropical plane curves*. We show that this space arises from a single polygon, and explain the relationship between our space and the moduli space of abstract hyperelliptic graphs. (Received August 27, 2014)

1104-05-136 **Iskander Aliev*** (alievi@cf.ac.uk), School of Mathematics, Cardiff University, Cardiff, CF24 4AG, United Kingdom. *Lattice programming gaps, circulant graphs and Frobenius numbers.*

Given a full-dimensional lattice $\Lambda \subset \mathbb{Z}^k$ and a cost vector $l \in \mathbb{Q}^k_{>0}$, we are concerned with the family of the group problems

$$\min\{l \cdot x : x \equiv r \bmod \Lambda, x \geq 0\}, \quad r \in \mathbb{Z}^k.$$

The *lattice programming gap* $\mathrm{gap}(\Lambda, l)$ is the largest value of the minima above as r varies over $\mathbb{Z}^k$. We show that computing the lattice programming gap is NP-hard when k is a part of input. We also obtain lower and upper bounds for $\mathrm{gap}(\Lambda, l)$ in terms of l and the determinant of Λ. The proofs are build on a relation between the group problems, circulant graphs and Frobenius numbers. (Received August 28, 2014)

1104-05-140 **Anton Dochtermann*** (anton.dochtermann@gmail.com). *Face rings of cycles, associahedra, and standard tableaux.*

Let J_n denote the quadratic monomial ideal generated by the diagonals of an n-gon (i.e. the Stanley-Reisner ideal of an n-cycle). We show that a free resolution of J_n is encoded by a natural monomial labeling of the (dual) associahedron - a polytope whose faces correspond to non-crossing diagonals. This resolution is not minimal if $n > 5$.

On the other hand, some years ago Richard Stanley gave a simple bijection between the faces of the associahedron and standard Young tableaux (SYT) of certain shapes. We show that the Betti numbers of J_n (the

ranks of the free modules in a minimal resolution) are given by the number of SYT of certain sub-shapes. While we do not have a good description of the the differentials with this basis, a natural partial matching suggests a poset structure on the set of SYT. (Received August 28, 2014)

1104-05-162 **Fu Liu***, fuliu@math.ucdavis.edu. *On bijections between rooted trees and the comb basis for the cohomology of the weighted partition poset.*

Recently, González D'León and Wachs studied the (co)homology of the poset of weighted partitions, introduced by Dotsenko and Khoroshkin, and showed the rank of (co)homology of the interval $(0, [n]^i)$ is the size of $T_{n,i}$, the set of rooted trees on $[n]$ with i descents. They discussed three families of bases for the cohomology: the bicolored comb basis, the bicolored Lyndon basis, and the Liu-Lyndon basis.

They asked whether there are nice bijections between $T_{n,i}$ and the comb basis or the Lyndon basis. We give a natural definition for "nice bijections", and conjecture that there is a unique nice bijection between $T_{n,i}$ and the comb basis. We show the conjecture is true for the extreme cases where $i = 0, n-1$. (Received August 30, 2014)

1104-05-164 **Spencer Backman*** (spencerbackman@gmail.com). *Riemann-Roch theory for graph orientations.*

We introduce an equivalence relation on the set of partial orientations of a graph, which generalizes Gioan's cycle-cocycle reversal system. We explain how this setup allows for a new interpretation of the linear equivalence of divisors on graphs (chip-firing), and a new proof of Baker and Norine's combinatorial Riemann-Roch formula. Fundamental connections to the max-flow min-cut theorem will be highlighted. (Received August 30, 2014)

1104-05-169 **Rafael S. González D'León*** (rafaeldleon@uky.edu), Lexington, KY. *On the free Lie algebra with multiple brackets.*

It is a classical result that the multilinear component of the free Lie algebra is isomorphic (as a representation of the symmetric group) to the top (co)homology of the proper part of the poset of partitions Π_n tensored with the sign representation. We generalize this result in order to study the multilinear component of the free Lie algebra with multiple compatible Lie brackets. We introduce a new poset of weighted partitions Π_n^k that allows us to generalize the result. The new poset is a generalization of Π_n and of the poset of weighted partitions Π_n^w introduced by Dotsenko and Khoroshkin and studied by the author and Wachs for the case of two compatible brackets. We prove that the poset Π_n^k with a top element added is EL-shellable and hence Cohen-Macaulay. This and other properties of Π_n^k enable us to answer questions posed by Liu on free multibracketed Lie algebras. (Received August 30, 2014)

1104-05-173 **Steven Klee*** (klees@seattleu.edu) and **Isabella Novik**. *Lower bound theorems for balanced simplicial manifolds.*

A $(d-1)$-dimensional simplicial complex is called balanced if its underlying graph admits a proper d-coloring. Such a coloring imposes additional combinatorial structure on the face numbers of a balanced simplicial complex. We will show that many classical enumeration results for simplicial manifolds have balanced analogues and present a balanced version of the Generalized Lower Bound Conjecture for simplicial polytopes. (Received August 31, 2014)

1104-05-174 **Carla D Savage*** (savage@ncsu.edu), Department of Computer Science, Box 8206, North Carolina State University, Raleigh, NC 27695. *Inflated Eulerian Polynomials.* Preliminary report.

For a sequence $s = (s_1, \ldots, s_n)$ of positive integers, an *s-inversion sequence* is an integer sequence $e = (e_1, \ldots, e_n)$ where $0 \le e_i < s_i$. An *ascent* in e is an index i, $0 < i < n$, such that $e_i/s_i < e_{i+1}/s_i$. If $e_1 > 0$ then 0 is also an ascent.

The *s-Eulerian polynomials* are the ascent polynomials of s-inversion sequences. They are related through Ehrhart theory to *s-lecture hall partitions*. They generalize descent polynomials of Coxeter groups of type A and B. It has been shown that the s-Eulerian polynomials are all real-rooted.

In contrast, the *inflated s-Eulerian polynomials* weight an s-inversion sequence by its last entry as well as its ascent number. In this talk we review recent results about inflated Eulerian polynomials and Gorenstein lecture hall cones; we establish some new properties of inflated Eulerian polynomials; and we find relationships to polynomials arising in the study of the maxdrop statistic on permutations. (Received August 31, 2014)

1104-05-180 **Ellen Veomett*** (erv2@stmarys-ca.edu). *On Coloring Box Graphs.*

This talk concerns the chromatic number of a family of geometrically defined graphs we call box graphs, which arise from a box complex in n-space. It is straightforward to show that any box graph in the plane has an

admissible coloring with three colors, and that any box graph in n-space has an admissible coloring with $n+1$ colors. We show that for box graphs in n-space, if the lengths of the boxes in the corresponding box complex take on no more than two values from the set $\{1,2,3\}$, then the box graph is 3-colorable, and for some graphs three colors are required. We also show that box graphs in 3-space which do not have cycles of length four (which we call "string complexes") are 3-colorable. (Received August 31, 2014)

1104-05-182 **Hailong Dao** and **Jay Schweig***, 401 MSCS, Stillwater, OK 74078. *Projective Dimension and Domination in Graphs and Clutters.*

The projective dimension of a squarefree monomial ideal I is the minimal length of a free resolution of I. Via Hochster's formula, an ideal's projective dimension can also be defined in terms of homology. We show a far-reaching link between projective dimension and domination parameters; a class of complexity measures in graphs and clutters. Loosely speaking, a domination parameter measures how easy it is to "cover" a graph with various subgraphs. Using these parameters on an ideal's clutter of minimal non-faces, we can bound the ideal's projective dimension. This also allows us to obtain bounds on the non-vanishing homology of the associated Stanley-Reisner complex. (Received August 31, 2014)

1104-05-206 **Craig Timmons*** (craig.timmons@csus.edu). *On the chromatic number of the Erdős-Rényi orthogonal polarity graph.*

The Erdős-Rényi orthogonal polarity graph, denoted ER_q, is a well-known object in extremal graph theory. Results of Mubayi and Williford together with Hoffman's bound show that the order of magnitude of the independence number of ER_q is $q^{3/2}$. This implies a lower bound of order $q^{1/2}$ on the chromatic number of ER_q. Establishing a matching upper bound is an open problem. In this talk we present upper bounds on the chromatic number of ER_q, some of which are best possible up to a constant factor. This is joint work with Mike Tait and Xing Peng. (Received September 01, 2014)

1104-05-210 **Adam Boocher** and **Elina M Robeva*** (erobeva@gmail.com). *Robust toric ideals.*

We call an ideal in a polynomial ring robust if it can be minimally generated by a universal Gröbner basis. We show that robust toric ideals generated by quadrics are essentially determinantal. We then discuss two possible generalizations to higher degree, providing a tight classification for determinantal ideals, and a counterexample to a natural extension for Lawrence ideals. (Received September 01, 2014)

1104-05-211 **Federico Ardila*** (federico@sfsu.edu) and **Adam Boocher** (adam.boocher@ed.ac.uk). *The closure of a linear space in a product of lines.* Preliminary report.

Given a linear space L in affine n-space, we study its closure L' in the product of n projective lines. We show that the degree, multigraded Betti numbers, defining equations, and universal Grobner basis of its defining ideal I(L') are all combinatorially determined by the matroid of L. We also prove that I(L') and all of its initial ideals are Cohen-Macaulay with the same Betti numbers. Along the way we encounter the "external activity complex" and the "cocircuit polytope" of a matroid: two new combinatorial objects with interesting properties.

This is joint work with Adam Boocher (U. of Edinburgh) (Received September 01, 2014)

1104-05-218 **Henry Kvinge** and **Monica Vazirani***, Math Department, One Shields Ave, Davis, CA 95616. *Categorifying the tensor product of a level* 1 *highest weight and perfect crystal.*

The irreducible representations of the symmetric group S_n are parameterized by partitions of n. One can use the partition, viewed as being built up row by row, to construct the module algebraically, piece by piece.

Over a field of characteristic p, the irreducible representations of S_n are parameterized by the "p-regular" partitions.

However, the analogous construction of these modules fails. We give an alternate (algebraic) construction of the modules, motivated by viewing the crystal of the basic representation of $\widehat{\mathfrak{sl}}_p$ as a limit of tensor products of level 1 perfect crystals. This construction relies on the theorem of Grojnowski relating the crystal of the basic representation to the simple S_n-modules and their behavior under restriction to S_{n-1}.

These constructions work for the level 1 cyclotomic KLR algebras of type $A^{(1)}$, and can be extended to other classical types. (Received September 02, 2014)

1104-05-223 **John Shareshian** and **Russ Woodroofe*** (rwoodroofe@math.msstate.edu). *Coset lattices are noncontractible, even for groups with alternating factors.*

Ken Brown asked whether there is any finite group G such that the coset lattice of G is contractible. John Shareshian and I have recently completely settled this question — the answer is "no, there isn't". Our proof uses Smith Theory, the Classification of Finite Simple Groups, and results from group cohomology. I'll give an overview, with emphasis on how we handled the alternating groups. (Received September 02, 2014)

1104-05-224 **Ruriko Yoshida*** (ruriko.yoshida@uky.edu) and **Jin Xie** (jin.xie@uky.edu).
Distribution of k-Interval Cospeciation metric. Preliminary report.

In this talk we focus on a tree metric called k-interval cospeciation (k-IC). The notion of the k-IC came from the host-parasite analysis. Biologically, it is highly unlikely that a large number of consecutive speciations can accumulate in a host lineage, without any reactionary speciation in parasite. Thus, when reconstructing host and parasite trees, we might assume that only a bounded number of consecutive speciations can occur in any host lineage before a reactionary speciation in parasite (and vice versa). Combinatorially this implies that for each pair of host species A, B, and corresponding parasite species a, b, the number of edges between A, B is within k of the number of edges between a, b. We say such a cophylogeny satisfies k-interval cospeciation.

Here we will compare the k-IC tree distance with other tree metrics, and then we will discuss the distribution of the k-IC metric between two randomly generated trees if we fix n. (Received September 02, 2014)

1104-05-307 **Jianyuan Zhong*** (kzhong@csus.edu), California State University Sacramento, Department of Math. & Stat., 6000 J Street, Sacramento, CA 95819, and **Bin Lu**. *A revolute 9-chain can interlock with a flexible open 2-chain.* Preliminary report.

It is an open problem posed in [1], to find the minimum k such that a revolute k-chain can interlock with a flexible open 2-chain. In this paper, we present a revolute 9-chain in a triangular frame and prove that it interlocks with a flexible open 2-chain. We also discuss reasons that we believe 9 is the minimum k for the open problem.

Reference: [1] Interlocked open and closed linkages with few joints, Comp. Geom. Theory, Appl., 26(1): 37–45, 2003. (Received September 03, 2014)

1104-05-312 **Krishna B Thapa magar*** (kthapama@fau.edu), 777 Glades Road, Boca Raton, FL 33486, and **Spyros S Magliveras**. *Construction of Hoffman-Singleton graph using a well known peculiarity of $\mathbb{A}_6$.*

The Hoffman-Singleton graph H, a member of the small family of Moore graphs of diameter 2, is a well known 7-regular undirected graph with 50 vertices and 175 edges. We construct H as a rank 3 graph with subdegrees (1, k=7 and l=42), using the alternating group A7. There are 63 distinct A5's in A7 which fall into exactly two conjugacy classes of subgroups of sizes 21 and 42. An A5 of the first class of size 21 fixes two points, whereas an A5 of the second class of size 42 fixes one point and acts transitively on the remaining 6 points. We use the 42 A5's of the second class to construct the Hoffman-Singleton graph. This construction is possible because S6 is the only member of the family of symmetric groups Sn to possess outer-automorphisms.
(Received September 03, 2014)

06 ► Order, lattices, ordered algebraic structures

1104-06-18 **Yuri Movsisyan*** (yurimovsisyan@yahoo.com), Alex Manoogian 1, 0025 Yerevan, Armenia. *Boolean-like algebras and Boolean-like functions.*

It is commonly known that the free Boolean algebra on n free generators is isomorphic to the Boolean algebra of Boolean functions of n variables. The free distributive lattice on n free generators is isomorphic to the lattice of monotone Boolean functions of n variables. A problem posed by B.I. Plotkin in 1970 has required to find the varieties of algebras with analogous functional representations of free finitely generated algebras. In this talk we give a solution of this problem. (Received June 04, 2014)

08 ► General algebraic systems

1104-08-94 **Christopher ONeill*** (coneill@math.tamu.edu), **Vadim Ponomarenko**, **Reuben Tate** and **Gautam Webb**. *Catenary Degrees of Elements in Numerical Monoids.*

Nonunique factorization in commutative monoids is often studied through the use of factorization invariants. One such invariant, called the catenary degree, measures the distance between factorizations within a given monoid, and can be computed using a graph theoretic construction. In this talk, we discuss results from an undergraduate research project involving the catenary degree in additive submonoids of the natural numbers. (Received August 23, 2014)

11 ► Number theory

1104-11-2 **Kiran S. Kedlaya*** (kedlaya@ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gilman Drive #0112, La Jolla, CA 92093. *A brief history of perfectoid spaces.*

The theory of perfectoid spaces has recently emerged in arithmetic geometry as a bridge between characteristics, which makes it possible to take advantage in characteristic 0 of the existence of the Frobenius endomorphism in positive characteristic. We trace the evolution of this idea through the past half-century via results of Tate, Fontaine, Faltings, the presenter, and Scholze. (Received August 27, 2014)

1104-11-6 **Hung-ping Tsao*** (tsaohp.tsao6@gmail.com), 1151 Highland Drive, Novato, CA 94949. *Generalization of famous numbers.*

Bernoulli, Eulerian and Bell numbers (based on the natural sequence) are generalized to those based on arithmetically progressive sequences. (Received March 27, 2014)

1104-11-30 **Ivan E. Horozov*** (horozov@math.wustl.edu), Washington University in St. Louis, One Brookings Dr., Campus Box 1146, Saint Louis, MO 63130. *Non-commutative Hilbert Modular Symbols.*

In this paper we construct non-commutative Hilbert modular symbols, which are generalizations of Manin's non-commutative modular symbol. We use a generalization of iterated path integrals to higher dimensions, which we call iterated integrals on membranes. Manin examines similarities between non-commutative modular symbol and multiple zeta values both in terms of infinite series and in terms of iterated path integrals. Here we examine similarities in the formulas for non-commutative Hilbert modular symbol and multiple Dedekind zeta values both in terms of infinite series and in terms of iterated integrals on membranes. A key geometric ingredient is a "tetrahedron" with thickened edges, which resembles a 2-cocycle relation for the modular symbols. (Received July 05, 2014)

1104-11-165 **Anne M. Ho*** (ho@math.colostate.edu). *Counting Artin-Schreier Curves over Finite Fields.* Preliminary report.

A number of authors have considered the weighted sum of various types of curves with a certain genus g over a finite field $k := \mathbb{F}_q$ of a specific characteristic. These include elliptic curves (Howe), hyperelliptic curves (Van der Geer, Van der Vlught), and Artin-Schreier curves (Cardona, Nart, Pujolàs, Sadornil). We denote this weighted sum as $\sum_{[C]} 1/|\mathrm{Aut}_k(C)|$, where the sum is over k-isomorphism classes of the curves and $\mathrm{Aut}_k(C)$ is the automorphism group of C over k. We extend the work of these authors by considering a related weighted sum for Artin-Schreier curves with a given genus g over fields of any characteristic p. We will discuss our results and methods of counting, which include looking at ramification divisors, finding associated rational models $y^p - y = u(x)$, and examining the actions of $\mathrm{PGL}_2(k)$ on the models. In addition, we will discuss the geometric connections to the moduli space of Artin-Schreier covers. (Received August 30, 2014)

1104-11-187 **David Zureick-Brown*** (dzb@mathcs.emory.edu), 400 Dowman Dr, Atlanta, GA 30322. *Tropical geometry, p-adic integration, and uniformity.*

p-adic integrals on a curve with good reduction enjoy (surprisingly) a unique analytic continuation. In case of bad reduction the Berkovich analytification is generally no longer contractable, and the continuation is no longer unique. Stoll recently gave an explicit comparison between various approaches to continuation (due to Colmez and Berkovich), with a striking arithmetic consequence – uniformity of rational points on hyperelliptic curves (of fixed genus g and rank $< g - 3$).

I will describe a characterization of Stoll's work via tropicalizations. I will explain two applications: an extension of Stoll's uniformity result to non-hyperelliptic curves (with a central role played by linear systems on graphs), and an extension of the work of Balakrishnan and others on explicit computation of p-adic integrals. This is joint work with Eric Katz and Joe Rabinoff. (Received August 31, 2014)

13 ► Commutative rings and algebras

1104-13-44 **Tai Ha*** (tha@tulane.edu), **Ngo Viet Trung** and **Tran Nam Trung**. *Algebraic invariants of fiber products.*

Let X and Y be affine varieties over a field k, and let $Z = X \times_k Y$. We shall discuss bounds for algebraic invariants of Z in terms of those of X and Y. Our focus will be on the projective dimension and the regularity of powers (ordinary and symbolic) of their defining ideals. (Received August 07, 2014)

1104-13-55 **Stephen Sturgeon*** (stephen.sturgeon1@gmail.com). *Polar Self-Dual Polytopes and Simplicial Spheres.* Preliminary report.

Minimal cellular resolutions have been described for several families of ideals. Generally these families have been described by combinatorial conditions on the generating sets. In this talk we will explore how the duality of gorenstein rings can be used in relation with geometric duality to construct cellular resolutions. We will in particular construct a cellular resolution of the Bier Spheres defined by Murai. Lastly we will see how the geometric constructions used have potential to apply to a much larger category. (Received August 15, 2014)

1104-13-57 **Jonathan Montaño*** (jmontano@purdue.edu), Department of Mathematics, Purdue University, 150 North University Street, West Lafayette, IN 47907. *Artin-Nagata properties, minimal multiplicities, and depth of fiber cones.*

In the last few years, several results for $\mathfrak{m}$-primary ideals have been shown to hold for arbitrary ideals if the Hilbert-Samuel multiplicity is replaced by the j-multiplicity. In this talk, we introduce the notion of Goto-minimal j-multiplicity for ideals of maximal analytic spread. In a Cohen-Macaulay ring, inspired by the work of S. Goto, A. Jayanthan, T. Puthenpurakal, and J. Verma, we study the interplay among this new notion, the notion of minimal j-multiplicity introduced by C. Polini and Y. Xie, and the Cohen-Macaulayness of the fiber cone of ideals satisfying certain residual assumptions. (Received August 17, 2014)

1104-13-87 **Aldo Conca**, **Martina Kubitzke** and **Volkmar Welker*** (welker@mathematik.uni-marburg.de), Philipps-Universitaet Marburg, 35032 Marburg, Germany. *Betti numbers of barycentric and edgewise subdivisions.* Preliminary report.

We prove that syzygies of Stanley-Reisner rings of simplicial complexes under iterated barycentric subdivisions and edgewise subdivisions exhibit a similar behavior as syzygies of algebraic varieties under high Veronese embeddings (see the work of Ein, Lazarsfeld and Erman and Zhou). These two combinatorial operations on simplical complexes have some formal similarity (but also some important dissimilarity) with the formation of the Veronese subalgebras. In particular, the edgewise subdivision of a simplicial complex is closely related, via initial ideals, with the formation of Veronese subalgebras of the associated Stanley-Reisner ring, but this relation together with the results of Ein et. al. and Zou imply only some fraction of the nonvanishing of syzygies of edgewise subdivisions derived in our work. (Received August 22, 2014)

1104-13-92 **Anurag K Singh*** (singh@math.utah.edu). *Frobenius action on local cohomology.*

We will discuss some results on the injectivity of the Frobenius action on negatively graded components of local cohomology modules of hypersurfaces. (Received August 23, 2014)

1104-13-96 **Craig Huneke**, **Paolo Mantero**, **Jason McCullough*** (jmccullough@rider.edu) and **Alexandra Seceleanu**. *On the Projective Dimension of Four Quadrics.* Preliminary report.

Let S denote a polynomial ring over a field k and let $I = (f_1, \ldots, f_n)$ denote a homogeneous S-ideal. Set $d_i = \deg(f_i)$. Stillman posed the question as to whether the projective dimension of S/I, $\mathrm{pd}(S/I)$, is bounded above by a formula depending only on $d_1, \ldots, d_n$. The question remains open though special cases have been solved in the affirmative, notably the upper bound for quadrics given by Ananyan-Hochster. Even when upper bounds are known, they tend to be exponential in the number of generators and far from tight. In this talk I will describe how one can prove that the projective dimension of S/I, where I is generated by four quadrics is at most 6. Canonical examples show that this bound is optimal and gives a complete answer to Stillman's Question for this case. (Received August 24, 2014)

1104-13-99 **Paolo Mantero*** (mantero@math.ucr.edu), University of California at Riverside, and **Jason McCullough**, Rider University. *Projective dimension of ideals generated by 3 cubics.* Preliminary report.

Let R be a polynomial ring over a field and I an ideal generated by three forms of degree three. Motivated by Stillman's question, Engheta in a series of 3 papers proved that the projective dimension $\mathrm{pd}(R/I)$ is at most 36. Since the largest known example has $\mathrm{pd}(R/I) = 5$, for several years it has been asked what is the sharp upper bound for $\mathrm{pd}(R/I)$.

In this paper we prove $\mathrm{pd}(R/I) \leq 5$, which, by the above, is sharp. (Received August 25, 2014)

1104-13-119 **Kuei-Nuan Lin*** (kul20@psu.edu) and **Paolo Mantero**. *Projective Dimensions of Square-Free Monomial Ideals.* Preliminary report.

We associate square-free monomial ideals with hypergraphs that is first introduced by Kimura-Terai-Yoshida. We write the projective dimensions of hypergraphs in terms of invariants of hypergraphs. More precisely, we

describe the projective dimension of a hypergraph in terms of its 1-skeleton structure. This is joint work with Paolo Mantero. (Received August 26, 2014)

1104-13-127 **Sara Faridi*** (faridi@dal.ca). *Resolutions of monomial ideals and simplicial collapses.* Preliminary report.

To people who study free resolutions of monomial ideals, it is known that Betti numbers of a monomial ideal can be interpreted as dimensions of simplicial homology modules. In combinatorial topology, simplicial collapsing is a method of relating the homology of a simplicial complex D to that of a subcomplex of D. In this talk, we will use simplicial collapsing to demonstrated what Betti numbers may or may not be expected for a given monomial ideal. (Received August 27, 2014)

1104-13-153 **Jimmy Shan*** (shan15@illinois.edu), 1409 W Green, Urbana, IL 61801. *Resolutions of ideals of powers of linear forms.* Preliminary report.

A special class of ideals of powers of linear forms are constructed from graphs by Postnikov-Shapiro. They found the Hilbert series of these ideals and conjectured formulas for the Betti numbers. A special case of their conjecture is Schenck's conjecture. I will talk about an approach to their conjecture, focusing mainly on Schenck's conjecture. (Received August 29, 2014)

1104-13-155 **Uwe Nagel*** (uwe.nagel@uky.edu), Department of Mathematics, University of Kentucky, 715 Patterson Office Tower, Lexington, KY 40506. *Gorenstein Algebras and Lefschetz Properties.* Preliminary report.

If a standard graded algebra has the Weak or Strong Lefschetz Property, then this puts strong restrictions on its Hilbert function and graded Betti numbers. Several classes of algebras are expected to have a Lefschetz Property. However, establishing this fact is often difficult. In the talk this problem will be discussed for some classes of Gorenstein algebras. (Received August 29, 2014)

1104-13-171 **Jennifer Biermann*** (jbierman@mtholyoke.edu), **Elena Guardo** and **Adam Van Tuyl**. *Generalized edge and cover ideals.* Preliminary report.

We generalize the notion of the edge ideal to a t-edge ideal whose minimal monomial generators consist of a vertex and t of its neighbors. We study the algebraic properties of the t-edge ideal as well as the combinatorial properties of the associated Stanley-Reisner simplicial complex. (Received August 31, 2014)

1104-13-217 **Thomas Kahle** and **Robert Krone*** (krone@math.gatech.edu), Georgia Tech - School of Math, 686 Cherry Street, Atlanta, GA 30309, and **Anton Leykin**. *Equivariant lattice generators and Markov bases.*

It has been shown recently that monomial maps in a large class respecting the action of the infinite symmetric group have, up to symmetry, finitely generated kernels. We study the simplest nontrivial family in this class: the maps given by a single monomial. Considering the corresponding lattice map, we explicitly construct an equivariant lattice generating set, whose width (the number of variables necessary to write it down) depends linearly on the width of the map. In the case of of width two, we construct an explicit finite set of binomials generating the toric ideal up to symmetry. Both width and degree of this generating set are sharply bounded by linear functions in the exponents of the monomial. (Received September 02, 2014)

1104-13-219 **Jan Draisma**, **Rob Eggermont** and **Robert Krone*** (krone@math.gatech.edu), Georgia Tech - School of Math, 686 Cherry Street, Atlanta, GA 30309, and **Anton Leykin**. *Finite generation of symmetric toric ideals.*

Given a family of ideals which are symmetric under some group action on the variables, a natural question to ask is whether the generating set stabilizes up to symmetry as the number of variables tends to infinity. We answer this in the affirmative for a broad class of toric ideals, settling several open questions in work by Aschenbrenner-Hillar, Hillar-Sullivant, and Hillar-Martin del Campo. Our approach involves splitting an equivariant monomial map into a part for which we have an explicit degree bound of the kernel, and a part for which we can prove that the source, a so-called matching monoid, is equivariantly Noetherian. The proof makes use of matchings on bipartite graphs and well-partial orders. (Received September 02, 2014)

1104-13-259 **Jan Hofmann*** (jhofmann@math.uni-frankfurt.de) and **Christian Haase**. *Convex-normal (pairs of) polytopes.*

A lattice polytope P is k-convex-normal, if every rational multiple rP for $r \in [2, k]$ can be covered by certain copies of P. This notion was introduced by Gubeladze, who used it to prove that lattice polytopes with long edges are integrally closed. In previous work we showed that there is no difference between being 3- and k-convex

normal for $k \geq 3$ and improved the bound. In this talk we will introduce convex-normal pairs of polytopes, show how the previous results translate and talk about computational aspects. (Received September 02, 2014)

1104-13-275 **Daniel J. Hernandez**, **Luis Nunez-Betancourt*** (lcn8m@virginia.edu) and **Emily E. Witt**. *m-adic constancy of F-pure thresholds.*

The F-pure thresholds and the test ideals play an important role in the study of singularities in positive characteristic. In this talk, we will discuss their behavior with respect to the m-adic topology. (Received September 02, 2014)

1104-13-296 **William Heinzer** and **Youngsu Kim*** (kim455@purdue.edu), University of California, Riverside, and **Matthew Toeniskoetter**. *Blowing up finitely supported complete ideals in a regular local ring.*

Let R be a regular local ring and I a finitely supported R-ideal. We investigate singularities of $\operatorname{Proj} \overline{R[It]}$, where $\overline{R[It]}$ denotes the integral closure of the Rees algebra $R[It]$. We are able to prove that for a local ring S on $\operatorname{Proj} \overline{R[It]}$, if S is a UFD, then S is regular. This is a generalization of a result of Lipman and Huneke-Sally in dimension 2. Furthermore, we show that if $\operatorname{Proj} \overline{R[It]}$ is locally factorial, then it is the non-singular model obtained by a finite number of blowups at the non-singular closed points that correspond to the base points of I. In particular, if $\operatorname{Proj} \overline{R[It]}$ is locally factorial, then it is non-singular. (Received September 03, 2014)

1104-13-304 **Daniel J. Hernández** (dhernan@math.utah.edu) and **Emily E. Witt*** (witt@math.utah.edu). *Roots of Bernstein-Sato polynomials via characteristic $p > 0$ methods.*

An *F-threshold* is an invariant of singularities in characteristic $p > 0$. Mustaţă, Takagi, and Watanabe proved that if a special type of formula for an F-threshold can be found, then roots of the Bernstein-Sato polynomial (in characteristic zero) can be recovered. We discuss some results in this direction. This is joint work with Daniel Hernández. (Received September 03, 2014)

1104-13-306 **Daniel J Hernandez*** (dhernan@math.utah.edu) and **Pedro Teixeira**. *Syzygy gap fractals and F-thresholds.*

Using properties of syzygy gap fractals, we derive some structural results for F-pure thresholds (and, more generally, F-thresholds) of homogeneous polynomials in two variables over a field of positive characteristic. As a corollary, we are able to answer a question of Schwede regarding the denominator of an F-pure threshold when it differs from its "expected" value (i.e., the value of the log canonical threshold) in this special setting. (Received September 03, 2014)

1104-13-313 **Daniel Murfet*** (murfet@usc.edu), Los Angeles, CA. *Models of logic from commutative algebra.*

In one branch of mathematical logic, proofs and computer programs are represented as topological objects similar to cobordisms. These objects are organised into monoidal categories and the main problem of semantics is to construct representations of these categories. We discuss how commutative algebra and ideas from topological field theory can shed new light on this problem. (Received September 03, 2014)

1104-13-322 **Claudiu Raicu*** (craicu@nd.edu) and **Jerzy Weyman**. *The syzygies of some thickenings of determinantal varieties.* Preliminary report.

The space of $m \times n$ matrices admits a natural action of the group $GL_m \times GL_n$ via row and column operations on the matrix entries. The invariant closed subsets are the determinantal varieties defined by (reduced) ideals of minors of the generic $m \times n$ matrix. The minimal free resolutions for these ideals are well-understood by work of Lascoux and others. There are however many more invariant ideals which are non-reduced, and whose syzygies are quite mysterious. These ideals correspond to nilpotent structures on the determinantal varieties, and they have been completely classified by De Concini, Eisenbud and Procesi. I will recall the classical description of syzygies of determinantal varieties, and explain how this can be extended to a large collection of their thickenings. Joint work with Jerzy Weyman. (Received September 03, 2014)

1104-13-335 **Jesse Burke***, jburke@math.ucla.edu. *BGG equivalence for complete intersections.*

Let Q be a commutative ring, V a free Q-module and A the Koszul complex of a linear map $l : V \to Q$. Let S be the symmetric algebra on $V^*[-1]$. There is an equivalence between the derived category of the dg-algebra A and the derived category of the curved dg-algebra (S, l). This generalizes the BGG correspondence between dg-modules over the exterior and symmetric algebras. When the image I of l is generated by a Q-regular sequence, the derived category of A is equivalent to the derived category of Q/I, and through this, the BGG equivalence can

be applied to complete intersection rings. We use it to show that there is a duality between higher homotopies on Q-free and Q/I-free resolutions. We also use the equivalence to give evidence for an analogy between the equivariant cohomology of spaces with a torus action and homological algebra over a complete intersection. This gives a heuristic for some classical results and a guide for new conjectures. (Received September 03, 2014)

14 ► Algebraic geometry

1104-14-1 **Kai Behrend*** (behrend@math.ubc.ca), 1984 Mathematics Rd, Vancouver, B.C. V6T 1Z2, Canada. *The virtual fundamental class and 'derived' symplectic geometry.*

We review how the virtual fundamental class gives rise to enumerative invariants. In the case of virtual counts of sheaves on a Calabi-Yau threefold, these counts beg to be categorified. Pursuing this, leads into the realm of derived symplectic geometry. We describe this particular avenue to this new geometry. (Received July 10, 2014)

1104-14-4 **Burt Totaro*** (totaro@math.ucla.edu). *The fundamental group of an algebraic variety, and hyperbolic complex manifolds.*

It is a mystery which groups can occur as fundamental groups of smooth complex projective varieties. It is conceivable that whenever the fundamental group is infinite, the variety must have some "negative curvature" properties. We discuss a result in this direction, in terms of "symmetric differentials". There are interesting open questions even about the special case of compact quotients of the unit ball in $\mathbf{C}^n$. (Joint work with Yohan Brunebarbe and Bruno Klingler.) (Received June 03, 2014)

1104-14-19 **Sarah Brodsky**, **Michael Joswig**, **Ralph Morrison** and **Bernd Sturmfels*** (bernd@berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720. *Curves in the Tropical Plane.*

Smooth curves in the tropical plane correspond to unimodular triangulations of lattice polygons. The skeleton of such a curve is a metric graph whose genus is the number of lattice points in the interior of the polygon. In this lecture we report on work concerning the following realizability problem: Characterize all metric graphs that admit a planar representation as a tropical curve. For instance, 20 percent of metric graphs with genus 3 have this property. (Received June 04, 2014)

1104-14-27 **S. T. Edward Fan*** (sfan@caltech.edu), 1200 E California Blvd., MC 253-37, PASADENA, CA 91125. *Equivariant bigraded cohomologies on Grothendieck sites, equivariant higher regulators and their arithmetic applications.* Preliminary report.

I will give a preliminary report on my current work of unifying the definitions for equivariant version of bigraded cohomologies on Grothendieck sites, including those corresponding to the classical theory of higher Chow groups, higher K-theory, Delgine-Beilinson cohomology, ℓ-adic cohomology and so on. In particular, it facilitates a functorial construction for various higher regulator maps via techniques from simplicial homotopy theory. In particular, it enables us to define equivariant higher arithmetic Chow groups as an extension of the higher arithmetic Chow groups of Burgos-Feliu. Some basic functorial properties will be listed, and we will see as an example on how to reduce the computation for smooth toric varieties to those of their base fields. On the other hand, various arithmetic conjectures can be formulated into equivariant versions, which open up possible testing ground for statements concerning non-representable quotients. (Received July 04, 2014)

1104-14-31 **Angelynn R Alvarez*** (aalvarez@math.uh.edu), University of Houston, 641 Philip G Hoffman Hall, 4800 Calhoun Road, Houston, TX 77004, **Gordon Heier** (heier@math.uh.edu), University of Houston, 641 Philip G Hoffman Hall, 4800 Calhoun Road, Houston, TX 77004, and **Ananya Chaturvedi** (ananya@math.uh.edu), University of Houston, 641 Philip G Hoffman Hall, 4800 Calhoun Road, Houston, TX 77004. *Optimal Pinching for the Holomorphic Sectional Curvature on Hirzebruch Surfaces.* Preliminary report.

In 1975, N. Hitchin proved that the Hirzebruch surfaces $\mathbb{F}_n = \mathbb{P}(\mathcal{O}_{\mathbb{P}^1}(n) \oplus \mathcal{O}_{\mathbb{P}^1})$, $n \geq 0$, admit (Hodge) metrics of positive holomorphic sectional curvature K. In this talk, I will determine explicit positive pinching constants c, C such that $c \leq K \leq C$ for these metrics. I will also discuss possible extensions of our methods to projectivized vector bundles of higher rank. This is joint work with Dr. Gordon Heier (University of Houston) and Ananya Chaturvedi (University of Houston). (Received July 06, 2014)

1104-14-40 **Dan Abramovich*** (abrmovic@math.brown.edu), Brown University Department of Mathematics, 151 Thayer Street, Providence, RI 02912, and **Michael Temkin**.
Factorization of birational maps for qe schemes in characteristic 0. Preliminary report.

We generalize the weak factorization theorem for birational maps from varieties to the context of qe schemes. This allows us to prove weak factorization for maps in various categories where there are enough "affinoids" and having a relative GAGA theorem, such as formal, complex analytic, and nonarchimedean spaces. Surprisingly, for complex spaces this approach requires generalizing Serre's GAGA theorem. (Received August 04, 2014)

1104-14-50 **Noah S. Daleo*** (nsdaleo@ncsu.edu), **Jonathan D. Hauenstein** and **Dhagash Mehta**.
Algebraic geometrization of the Kuramoto model: equilibria and stability analysis.

The Kuramoto model is a fascinating tool for describing the behavior and synchronization of a set of coupled phase oscillators. It has a wide variety of applications in physics, chemistry, biology, and electrical engineering. The equilibrium conditions of the Kuramoto model depend sinusoidally on the phase difference between pairs of oscillators, and this nonlinearity poses a significant computational challenge when one wishes to find equilibria. To deal with this challenge, we translate it into an algebraic geometry problem, which we are able to solve using numerical algebraic geometric techniques. In doing so, we unify the problem of finding equilibria at various values of coupling constants, natural frequencies, and on different graphs. (Received August 12, 2014)

1104-14-64 **Dan Abramovich*** (abrmovic@math.brown.edu), Department of Mathematics, Brown University Box 1917, 151 Thayer Street, Providence, RI 02912. *Artin fans.* Preliminary report.

Artin fans are 0-dimensional algebraic stacks which encode the combinatorial structure of a subvariety of a toric variety, or more generally of a logarithmic structure. They are closely related to Olsson's stack of logarithmic structure. For tropical geometry, Artin fans have the appealing feature that superabundance evaporates. I will explain how this was used in work with Chen, Marcus, and Wise on logarithmic Gromov-Witten theory. I will describe other potentially appealing features of Artin fans and their analytification, that arise in ongoing and future work with these people as well as Gross and Siebert and Martin Ulirsch. (Received August 19, 2014)

1104-14-75 **Renzo Cavalieri**, **Hannah Markwig** and **Dhruv Ranganathan*** (dhruv.ranganathan@yale.edu), Yale University, Department of Mathematics, 10 Hillhouse Avenue, New Haven, CT 06511. *Skeletons of spaces of maps and Hurwitz theory.*

The Berkovich skeletons of spaces of stable maps are combinatorially rich objects, that interact intricately with tropical geometry and degeneration techniques. In this talk, I will report on recent and ongoing work with Renzo Cavalieri and Hannah Markwig in which we study spaces of maps to target curves. The skeleton of the analytification of spaces of relative stable maps and admissible covers admit (tropical) modular interpretations. These interpretations allow us to use combinatorial methods to compute certain relative Gromov–Witten invariants and Hurwitz numbers. In the genus 0 case, we use these techniques to study tropicalizations of double Hurwitz loci, and explain piecewise polynomiality properties of the tropical Hurwitz cycle. (Received August 20, 2014)

1104-14-76 **Martí Lahoz Vialta** (marti.lahoz@imj-prg.fr), Bâtiment Sophie-Germain. Case 7012, 75205 Paris, France, **Zhi Jiang** (zhi.jiang@math.u-psud.fr), Bâtiment 425, 91405 Orsay, France, and **Sofia Tirabassi*** (sofia@math.utha.edu), 155 South 1400 East, JWB 233, Salt Lake City, UT 84112. *Varieties with Euler Characteristic 1.*

We study the geometry of varieties of maximal Albanese dimension with Euler characteristic equal to 1. On one hand we give a characterization of product of theta-divisors. On the othe hand we present a complete classification whne such varieties have irregularty $2 \dim X - 1$ extending to higher dimension results of Hacon–Pardini. (Received August 20, 2014)

1104-14-77 **John Calabrese*** (calabrese@rice.edu). *Gabriel's Theorem and Points.*

A well known theorem of Gabriel says that a variety X can be reconstructed by the category Coh(X) of coherent sheaves on it. This result has seen a few generalizations over the years. I will present a different and more geometric proof, with new generalizations. The idea being that X can be recovered as a moduli space of "points" in Coh(X). This is joint work with Michael Groechenig. (Received August 20, 2014)

1104-14-97 **Colby Long*** (celong2@ncsu.edu) and **Seth Sullivant**. *Identifiability of 3-Class Jukes-Cantor Mixtures.*

A phylogenetic model is an algebraic statistical model of the evolutionary relationships among a group of taxa. A standard feature of these models is a tree parameter which is meant to encode the common ancestry of the taxa under consideration. Due to certain biological phenomena, portions of the data derived from the same group of

taxa may conform to different evolutionary trees. To account for this, mixture models weight the distributions from multiple tree parameters to create a single probability distribution. For consistent inference one would like to be able to determine if the tree parameters of such a model are identifiable. Recent work has established the identifiability of the tree parameters for 2-class mixtures of both the Jukes-Cantor and Kimura 2-parameter models. In this talk, we show that the tree parameters of the 3-class Jukes-Cantor mixture model are identifiable. The result is obtained using ideas from algebraic statistics, in particular: finding phylogenetic invariants that separate the varieties associated to different triples of trees; computing dimensions of the resulting phylogenetic varieties; and using the disentangling number to reduce to trees with a small number of leaves. (Received August 25, 2014)

1104-14-101 **Y.P. Lee**, **Nathan Priddis** and **Mark Shoemaker*** (markshoe@math.utah.edu). *A proof of the Landau-Ginzburg/Calabi-Yau correspondence via the crepant resolution conjecture.*

Let W be a homogeneous degree-five polynomial in five variables. We may view W as defining a quintic hypersurface in $\mathbb{P}^4$ or, alternatively, as defining a singularity in $[\mathbb{C}^5/\mathbb{Z}_5]$, where the group action is diagonal. In the first case, one may consider the Gromov-Witten invariants of $\{W = 0\}$. In the second case one considers the FJRW invariants of the singularity. The LG/CY correspondence conjectures a relationship between these two sets of invariants. In this talk I will explain this correspondence, and its relation to a much older conjecture, the crepant resolution conjecture. We prove that the crepant resolution conjecture in fact implies the LG/CY correspondence in many cases using a generalization of the "quantum Serre-duality" of Coates-Givental. (Received August 25, 2014)

1104-14-103 **Yoav Len*** (yoav.len@yale.edu), 498 Orange St, New Haven, CT 06511. *Martens' theorem and the tropical Brill-Noether locus.* Preliminary report.

I will discuss ongoing work on the geometry of the Brill-Noether locus of a tropical curve, and consequence for a tropical version of Martens' theorem. The Brill-Noether locus classifies divisors of degree d and rank at least r, for some fixed integers r and d. It is a polyhedral complex contained in the Jacobian of the tropical curve. The classical version of this space satisfies an inequality known as Martens' theorem: its dimension is bounded above by $d - 2r$, and equality holds only if the curve is hyperelliptic.

Tropically, we expect that the same is true for the Brill-Noether rank of a curve. In my talk I will describe the relation between this inequality and the polyhedral structure of the Brill-Noether locus. I will present evidence that the theorem should hold, and partial results towards a solution for the problem. (Received August 25, 2014)

1104-14-108 **Daniel Litt*** (dalitt@stanford.edu). *Non-Abelian Lefschetz Hyperplane Theorems.*

Work of Lefschetz (in 1924) and Grothendieck (in SGA II) provides many relationships between properties of a smooth projective variety X and a smooth ample divisor D in X. For example, the singular or ℓ-adic cohomology of X agrees with that of D in low degree; X and D have the same Picard group if X has dimension at least 4; and X and D have the same π_1^{et} if X has dimension at least 3. I'll describe a general result which encompasses some of these Lefschetz hyperplane theorems and many new ones, comparing maps out of X to maps out of D. The case when the target of these maps is a moduli scheme or stack is of particular interest; for example, one may take the target to be M_g, and thus compare families of curves over X to families over D. (Received August 25, 2014)

1104-14-109 **Brian Osserman***, Department of Mathematics, One Shields Ave, University of California, Davis, CA 95616. *Recent progress on limit linear series.*

Linear series are fundamental to the study of algebraic curves, and the most powerful technique to date for studying linear series is the theory of limit linear series, a degeneration technique introduced by Eisenbud and Harris. However, for the past nearly 30 years, several foundational questions relating to limit linear series have remained open, including how to generalize them from curves of compact type to more general nodal curves. I will describe how the discovery of an equivalent definition of limit linear series has opened the door to solutions of many of these questions. (Received August 25, 2014)

1104-14-121 **Katrina Honigs*** (honigska@math.berkeley.edu). *Zeta Functions of Derived Equivalent Varieties.*

In this talk, I will present results demonstrating that derived equivalence between varieties over finite fields that are either abelian or surfaces implies equality of zeta functions. (Received August 26, 2014)

1104-14-124 **Noah Giansiracusa*** (noah@math.uga.edu) and **Jeffrey H Giansiracusa**. *Tropical schemes and the Berkovich analytification.*

In "Equations of tropical varieties" we introduced a scheme-theoretic framework for tropicalization and tropical geometry. In this talk I'll discuss recent developments in this program. Specifically, we introduce a canonical embedding of any scheme in an F_1-scheme (in essence, a non-finite type toric variety) such that the corresponding tropicalization is the inverse limit of all tropicalizations and its $\mathbb{T}$-points form the space underlying Berkovich's analytification. This is related to Payne's topological inverse limit result. (Received August 27, 2014)

1104-14-135 **Tyler Foster*** (tyfoster@umich.edu). *Some calculations with vector bundles.* Preliminary report.

This will be a talk on current work in progress, joint with Yoav Len. I'll do some calculations, of a loosely combinatorial nature, involving vector bundles on the special fibers of degenerating curves. (Received August 28, 2014)

1104-14-138 **Shahrzad Jamshidi*** (jamshidi@math.psu.edu), Penn State University Mathematics Dept., McAllister 419, University Park, PA 16801, and **Jason Morton** (morton@math.psu.edu), Penn State University Mathematics Dept., McAllister 219B, University Park, PA 16801. *Algebraic geometry of tree tensor network states.*

Tree tensor networks have been used to model the ground states of Hamiltonians in condensed matter physics and quantum chemistry. Exactly which quantum states can be represented by a tree tensor network with a given topology and given restrictions on the parameter tensors? When the restrictions are algebraic, the set of states is a projective algebraic variety. We describe those varieties, using techniques originally developed for phylogenetics. (Received August 28, 2014)

1104-14-141 **Eric Miles*** (ewmiles@morris.umn.edu) and **Daniele Arcara**. *Projectivity of Moduli Spaces of Bridgeland Semistable Objects on Del Pezzo Surfaces.* Preliminary report.

Bridgeland Stability Conditions can be thought of as tools for creating and varying moduli spaces parameterizing objects in the derived category of a variety X. For us, X will be S, a surface. Unlike more classical notions of stability, little is known in general about the spaces of Bridgeland semistable objects. To gain knowledge of the structure of these spaces, one can look to exploit the relationship that certain Bridgeland stability conditions share with representations of a quiver. This was done by Arcara-Bertram-Coskun-Huizenga for $S = \mathbb{P}^2$ and we carry out the program on the surfaces $\mathbb{P}^1 \times \mathbb{P}^1$ and $Bl_p\mathbb{P}^2$. Understanding the Bridgeland stability of line bundles and certain torsion sheaves is crucial to this adaptation. (Received August 28, 2014)

1104-14-142 **Martin Ulirsch*** (ulirsch@math.brown.edu), Box 1917, Brown University, Providence, RI 02912. *Artin fans in tropical geometry.* Preliminary report.

Recent work by J. and N. Giansiracusa, myself, and O. Lorscheid suggests that the tropical geometry of a toric variety X, or more generally of a logarithmic scheme X, can be formalized as a "Berkovich analytification" of a scheme over the field $\mathbb{F}_1$ with one element that is canonically associated to X.

The goal of this talk is to introduce the theory of Artin fans, originally due to D. Abramovich and J. Wise, which can be used to lift rather unwieldy $\mathbb{F}_1$-geometric objects to the more familiar realm of algebraic stacks. Artin fans are étale locally isomorphic to quotient stacks of toric varieties by their big tori and their glueing data has a completely combinatorial description in terms of Kato fans.

I am going to explain how to use the ideas surrounding the notion Artin fans to study tropicalization maps associated to toric varieties and logarithmic schemes. Surprisingly these techniques allow us to give a reinterpretation of Tevelev's theory of tropical compactifications that can be generalized to compactifications of subvarieties in logarithmically smooth compactifcations of smooth varieties. (Received August 28, 2014)

1104-14-145 **Lek-Heng Lim** and **Ke Ye*** (key@math.uchicago.edu), The department of Mathematics, University of Chicago, Chicago, IL 60637. *Schubert varieties and the distance between linear subspaces of different dimensions.* Preliminary report.

The distance between linear subspaces of the same dimension is well known. It is determined by the Riemannian geometry of Grassmannians. In practice, we always want to compare linear subspaces of different dimensions. Based on the Geometry of Grassmannians and Schubert varieties, we find a natural way to compare the distance between linear subspaces of different dimensions. In fact, there are two candidates for the distance between linear subspaces of different dimensions, but in this talk we will show that they are the same. We will also present an explicit formula for the distance between linear subspaces of different dimensions, which involves only the SVD of a matrix. At the end of the talk, we will ask some open problems related to this topic. (Received August 28, 2014)

1104-14-147 **Qile Chen** (q_chen@math.columbia.edu), Rm 628, MC 4421, 2990 Broadway, New York, NY 10027, and **Yi Zhu*** (yzhu@math.utah.edu), Math Department, 155 S 1400 E ROOM 233, Salt Lake City, UT 84112. *Log rational curves on log pairs.*

Iitaka's philosphy claims that whenever we have a theorem for proper varieties, we should have a counter-theorem for open varieties. In this talk, first I will introduce this philosophy with several examples. Then I will report the recent progress on the theory of "log rational curves" on log pairs. As another piece of evidence of Iitaka's philosophy, this theory generalizes the classical theory of rational curves on proper varieties. (Received August 29, 2014)

1104-14-150 **Eric Katz*** (eekatz@uwaterloo.ca), 200 University Avenue West, Waterloo, Ontario N2L 3G1, Canada. *Ehrhart theory of subdivisions and mixed Hodge theory.*

In this talk based on joint work with Alan Stapledon, we discuss how to enlarge the scope of Ehrhart theory from lattice polytopes to subdivisions of lattice polytopes. Lattice polytopes naturally correspond to generic hypersurfaces in toric varieties by the Newton polytope construction, and the Ehrhart-theoretical lattice point-counting invariants can be matched with topological and algebraic geometric invariants of the hypersurface. Regular subdivisions of lattice polytopes correspond to degenerations of hypersurfaces whose cohomology has a mixed Hodge structure. We discuss the invariants of the subdivision inspired by the mixed Hodge structure, making connections with Stanley's theory of subdivisions and h-vectors. (Received August 29, 2014)

1104-14-151 **Dustin Cartwright***, Department of Mathematics, 227 Ayres Hall, Knoxville, TN 37996-1320. *A quantitative version of Mnev's theorem.*

Mnev's theorem says that, roughly speaking, the geometry of any set of polynomial equations can be captured by a system of point-line incidences in the plane. I will talk about a version of Mnev's theorem over the integers, for which the size of the point-line configuration can be made explicit. In the process, I will explain some of the ingredients which go into the construction, and I will end with an application to tropical geometry. (Received August 29, 2014)

1104-14-167 **Maria Angelica Cueto*** (macueto@math.columbia.edu), Mathematics Department - Columbia University, 2990 Broadway, MC 4403, New York, NY 10027, and **Mathias Haebich** and **Annette Werner**. *Faithful tropicalization of the Grassmannian of planes.*

The purpose of this talk is to explain the close connection between analytification of algebraic varieties over non-Archimedean fields and tropical geometry, and how we can use the combinatorics of tropical varieties to understand the topology of analytic spaces. More precisely, we show that the tropical projective Grassmannian of planes is homeomorphic to a closed subset of the analytic Grassmannian in Berkovich's sense by constructing a continuous section to the tropicalization map.

Our proof is constructive and it relies on the combinatorial description by Speyer-Sturmfels of the tropical Grassmannian (inside the split torus) as a space of phylogenetic trees. We also show that both sets have piecewise linear structures that are compatible with our homeomorphism and characterize the fibers of the tropicalization map as affinoid domains with a unique Shilov boundary point. Our homeomorphism identify each point in the tropical Grassmannian with the Shilov boundary point on its fiber. Time permitted, we will discuss the combinatorics of the aforementioned space of trees inside tropical projective space. (Received August 30, 2014)

1104-14-183 **Melanie Matchett Wood** and **Ravi Vakil*** (vakil@math.stanford.edu). *From combinatorics to motives: Cutting and pasting in algebraic geometry.*

Given some class of "geometric spaces", we can make a ring as follows.

(i) *(additive structure)* When U is an open subset of such a space X, $[X] = [U] + [(X \setminus U)]$; and

(ii) *(multiplicative structure)* if X and Y are two such spaces, then $[X \times Y] = [X][Y]$.

In the algebraic setting, this ring (the "Grothendieck ring of varieties") contains surprising structure, connecting geometry to arithmetic and topology. I will discuss some remarkable statements about this ring (both known and conjectural), and present new statements (again, both known and conjectural). A motivating example will be polynomials in one variable. The key to these results is understanding the combinatorial structure related to "symmetric powers". This talk is intended to be understandable to a combinatorial audience. (Received August 31, 2014)

1104-14-186 **Andrew J Dudzik*** (adudzik@math.berkeley.edu). *Spectral Spaces.* Preliminary report.

A well-known combinatorial duality between finite lattices and posets generalizes to a correspondence between lattices and spectral spaces, with applications in many areas of geometry. I will discuss this perspective in the context of manifolds, varieties, and rigid analytic spaces. (Received August 31, 2014)

1104-14-203 **Nathan Pflueger*** (pflueger@brown.edu). *Young tableaux and Brill-Noether theory.*
Embeddings of algebraic curves in projective space are often studied using Brill-Noether varieties $G^r_d(C)$, which parameterize linear series on C. When $G^r_d(C)$ is finite set, its size can be computed as the number of standard young tableaux on a certain partition. I will describe how the combinatorics of young tableaux can be used to compute topological invariants of $G^r_d(C)$ when it has positive dimension, and several related results at the intersection of Brill-Noether theory and the combinatorics of tableaux. (Received September 01, 2014)

1104-14-214 **Nicolette Meshkat*** (ncmeshka@ncsu.edu) and **Seth Sullivant**. *Identifiability of Linear Models.*
Identifiability concerns finding which unknown parameters of a model can be quantified from given input-output data. Many linear ODE models, used primarily in Systems Biology, are unidentifiable, which means that parameters can take on an infinite number of values and yet yield the same input-output data. Unidentifiable models are generally undesirable to work with since not all of the parameters can be determined (or approximated). We study a particular class of linear models using a differential algebra approach and find sufficient conditions to obtain identifiability. In particular, we show how local identifiability can be determined by simply looking at the graphical structure of these models. (Received September 01, 2014)

1104-14-221 **Ye Luo*** (luoye@rice.edu), Rice University, Math department, MS136, 6100 S. Main St, Houston, TX 77251, and **Madhusudan Manjunath**. *Characterizing the smoothability of limit linear series of rank one on metrized complexes by integral points in polyhedrons.*
In a recent work, the authors have developed a theory to fully characterize the smoothability of pre-limit linear series of rank-one on saturated metrized complexes. The settings of this work requires the smoothing to be over an algebraically closed field with valuation group being $\mathbb{R}$ and the saturated metrized complexes to have curves associated to all the points in the underlying metric graph. In real applications, some people are more interested in the setting of discrete valued field and metrized complex (instead of saturated metrized complex). In this talk, I will present how the smoothing problem in this new setting can be solved by looking at the integral points inside certain polyhedrons defined by the limit linear series. (Received September 02, 2014)

1104-14-226 **Alberto Chiecchio*** (alberto.chiecchio@gmail.com), 400 N Coral Canyon Loop, Apt 209, Fayetteville, AR 72704. *About an MMP without flips.* Preliminary report.
We will present the recent progress in the construction of a Minimal Model Program without flips, or, equivalently, of a non-$\mathbb{Q}$-Gorenstein MMP: what can be done, what are the obstructions, what is yet to be done. In particular, we will recall some results about positivity for Weil divisors, and we will discuss about a cone and a contraction theorem. (Received September 02, 2014)

1104-14-253 **Melody Chan***, One Oxford Street, Cambridge, MA 02138, and **Pakawut Jiradilok**. *Tropical K_4 quartics.* Preliminary report.
Let X be a smooth, proper curve of genus 3 over a complete and algebraically closed nonarchimedean field. We say X is a *K_4-curve* if the nonarchimedean skeleton Γ of X is a metric K_4, i.e. a complete graph on 4 vertices.

We prove that X is a K_4-curve if and only if X has an embedding in $\mathbb{P}^2$ whose tropicalization has a strong deformation retract to a metric K_4. We then use such an embedding to show that the 28 odd theta characteristics of X are sent to the seven odd theta characteristics of Γ in seven groups of four. We give an example of the 28 bitangents of a *honeycomb plane quartic*, computed over the field $\mathbb{C}\{\{t\}\}$, which shows that in general the 4 bitangents in a given group need not have the same tropicalizations. (Received September 02, 2014)

1104-14-274 **Aaron Bertram** and **Cristian Martinez*** (martinez@math.utah.edu), 155 South 1400 East Room 233, Salt Lake City, UT 84112. *Change of polarization for moduli spaces of sheaves on surfaces as Bridgeland wall-crossing.* Preliminary report.
The notion of stability for torsion-free sheaves on a smooth projective complex surface S depends on the choice of an ample class $H \in \mathrm{Amp}(S)$. The moduli spaces $M_H(v)$ of H-semistable sheaves with Chern character v are projective and can be constructed via GIT. There is a wall and chamber decomposition of $\mathrm{Amp}(S)$ defined by the condition that $M_H(v)$ and $M_{H'}(v)$ are isomorphic for H and H' in the same chamber. In the 90's there was a great deal of interest in studying how moduli spaces relate for polarizations in different chambers. Results obtained independently by Matsuki and Wentworth, Ellingsrud and Göttsche, and Friedman and Qin, show that when crossing a wall in $\mathrm{Amp}(S)$, the moduli space $M_H(v)$ goes through a sequence of Thaddeus flips in the category of moduli spaces of twisted sheaves. We give an interpretation of this result in terms of stability conditions. Indeed, every wall in $\mathrm{Amp}(S)$ corresponds to a finite sequence of Bridgeland walls, each producing a single Thaddeus flip of the corresponding moduli space. (Received September 02, 2014)

1104-14-279 **Daniel Plaumann**, **Rainer Sinn**, **David Speyer** and **Cynthia Vinzant*** (vinzant@umich.edu). *Hermitian determinantal representations of plane curves.*

If a Hermitian matrix of linear forms is positive definite at some point, then its determinant is a hyperbolic hypersurface. In 2007, Helton and Vinnikov proved a converse in three variables, namely that every hyperbolic plane curve has a definite Hermitian determinantal representation. In this talk I will discuss a concrete proof of this statement and a method for computing these determinantal representations in practice. This involves relating the definiteness of a matrix to the real topology of its minors and extending a classical construction of Dixon from 1902. (Received September 03, 2014)

1104-14-283 **Brent R Davis*** (davisb@math.colostate.edu) and **Joseph Rusinko** (rusinkoj@winthrop.edu). *Numerical methods to analyze phylogenetic tree models.* Preliminary report.

Computational Phylogenetics studies computational methods to analyze and construct phylogenetic tree models. In this talk, we discuss distance-based criterions to accept or reject topologically equivalent evolutionary tree models from prescribed data. Our findings were largely based on analyzing data generated from the software package Paramotopy. Throughout, we highlight the four quartet evolutionary tree model. (Received September 03, 2014)

1104-14-286 **Daniel Chan**, **Kenneth Chan**, **Louis de Thanhoffer de Volcsey**, **Colin Ingalls*** (cingallls@unb.ca), **Kelly Jabbusch**, **Sandor Kovacs**, **Rajesh Kulkarni**, **Boris Lerner** and **Basil Nanayakkara**. *Decorated Minimal Model Program.* Preliminary report.

We extend results of Chan and Ingalls concerning the minimal model program for orders over surfaces to all dimensions. A decoration gives a number for all divisors of all models of a variety. We show that every decorated variety has a terminal resolution. We further show that if one carries out log contractions then decorated terminal varieties remain decorated terminal. We show that one obtains a decoration from a Brauer class and that this can be used to give a minimal model program for orders over varieties in all dimensions. (Received September 03, 2014)

1104-14-290 **Jimmy Shan*** (shan15@uiuc.edu), 1409 W Green, Urbana, IL 61801. *Powers of linear forms and splines.*

I will talk about the algebraic approach to spline theory. This approach leads naturally to a class of ideals of powers of linear forms. In the case of splines on tetrahedral complexes, Macaulay Inverse System relates these ideals to another class of ideals of fat points on the projective space. The Hilbert function of these fat points leads to a formula for the dimension of the vector spaces of such splines. (Received September 03, 2014)

1104-14-292 **Atoshi Chowdhury***, atoshi@berkeley.edu. *Line bundles on degenerations of higher-dimensional varieties.* Preliminary report.

I will discuss stability conditions for line bundles on degenerations of higher-dimensional varieties, including combinatorial and moduli-theoretic issues that arise. (Received September 03, 2014)

1104-14-301 **Daniel A Brake*** (danielthebrake@gmail.com). *Printing Algebraic Surfaces with Singularities.*

Visualization has always been a great tool for mathematicians and scientists. The new art of 3D printing has opened exciting possibilities for ways to interact with mathematics in a very tangible way, for research, teaching, outreach, and aesthetics. This talk will discuss methods and challenges for printing algebraically defined surfaces, namely the computer program Bertini_real, and tactics for dealing with singularities and non-compactness. (Received September 03, 2014)

1104-14-315 **Eric M Hanson*** (hanson@math.colostate.edu), Department of Mathematics, 1874 Campus Delivery, Fort Collins, CO 80523-1874. *On Numerical Algebraic Geometry and Topological Neighborhoods of Spline Curves.*

Let V be an algebraic variety. A *doubly normal segment* to V is a line segment connecting two points on V such that the segment is normal to V at both of these points. These segments can be used to define a tubular neighborhood of the variety which is often useful in understanding the topology of V or perturbations of V. In particular, when spline curves are used for visualization it is useful to know a neighborhood of the curve in which specified movements preserve the topology. The tools of numerical algebraic geometry can be used to compute the endpoints of these doubly normal segments. This talk will focus on the specific case of applying these techniques to cubic spline curves. (Received September 03, 2014)

1104-14-320 **Zhiyuan Li*** (zhiy.lee@gmail.com), 450 SERRA MALL, BLDG 380, Stanford, CA 94305. *Hodge type questions on Shimura varieties of orthogonal type.*

Let Y be a connected smooth (non-compact) Shimura variety. There are many special algebraic cycles coming from sub-Shimura variety of the same type in all codimensions, called special cycles on Y. A Hodge type question is whether the fundamental class of these special cycles will exhaust the group of 'Hodge classes'. In this talk, I will explain when this question makes sense for and give a positive answer for orthogonal type Shimura varieties when the codimension of the special cycle is smaller than a constant. We will also give a conjectural sharp bound for this constant. This is a joint work with N.Bergeron. (Received September 03, 2014)

1104-14-331 **Samouil Molcho*** (smolho1317@gmail.com), 1623 19th Street, Boulder, CO 80302. *The Chow Quotient Stack.*

We enrich the Chow Quotient of a toric variety V by a subtorus H of its torus, constructed by Sturmfels, Kapranov and Zelevinsky, with the structure of a toric stack. The additional stack structure is natural and described by explicit combinatorial information. We then relate this Chow Quotient stack with the stack of logarithmic stable maps of Gromov-Witten theory and the stack of stable toric varieties of Alexeev and Brion. (Received September 03, 2014)

1104-14-334 **Jose Israel Rodriguez*** (jo.ro@nd.edu), Dept of Applied and Computational Math, 146 Hayes-Healy, University of Notre Dame, Notre Dame, IN 46556. *Solving the dual likelihood equations.*

We will consider maximum likelihood estimation (MLE) on statistical models for discrete data. We take an algebraic approach to the problem, meaning, we solve a polynomial system called likelihood equations.

The main result is an elegant formulation of the likelihood equations in terms of a classical algebraic geometry object called the dual variety. With this dual variety, we are able to define the dual likelihood equations whose solutions are in bijection with solutions to the standard likelihood equations. We will motivate the discussion with a gambler and 9 coins from 3 countries. (Received September 03, 2014)

1104-14-336 **Jose Israel Rodriguez*** (jo.ro@nd.edu), Dept of Applied and Computational Math, 146 Hayes-Healy, University of Notre Dame, Notre Dame, IN 46556, and **Xiaoxian Tang**. *Data discriminants of likelihood equations.*

Maximum likelihood estimation (MLE) is a fundamental computational problem in statistics. The goal is to maximize the likelihood function with respect to given data on a statistical model. The algebraic approach to this problem is to solve a very structured polynomial system called likelihood equations. For general choices of data, the number of complex solutions is finite and called the ML-degree of the model.

However, the number of real solutions is not characterized by the ML-degree. Instead, the number of real solutions is characterized by the data-discriminant of the model. In this talk, we investigate the data-discriminant of some statistical models to predict the number of real solutions to the likelihood equations for any choice of data. (Received September 03, 2014)

15 ► Linear and multilinear algebra; matrix theory

1104-15-111 **Pierre Youssef*** (pyoussef@ualberta.ca). *Minimizing the Hilbert-Schmidt norm of the inverse of submatrices.*

Given U an $n \times m$ matrix of rank n whose columns are denoted by $(u_j)_{j \leqslant m}$, we consider the problem of finding a subset $\sigma \subset \{1, \dots\}$ such that $\sqrt{\mathrm{Tr}\left(\left(\sum_{i\in\sigma} u_i u_i^t\right)^{-1}\right)}$ is minimized. We also consider the same problem under the constraint of preserving a block of columns inside U. The methods used develop into algorithms. (Received August 26, 2014)

1104-15-280 **Kourosh Modarresi*** (kouroshm@alumni.stanford.edu), P O Box 19544, Stanford, CA 94309. *Transformation of Data Matrix to Higher and Lower Dimensional Spaces for Data Identification.*

In modern data analysis, we are facing with the problem that a specific user may use many different online - and offline - venues and channels. As an example, a user may visit many different sites or may use many different devices while may try various online and offline sites and simultaneously may use many different browsers, and so on. Obviously, all of these user's activities may happen at different time periods. The challenge in all of these cases will be how to recognize the same user cross all of these different venues and channels. This recognition of the user is a necessary step in finding a comprehensive view of the user which helps a continuous communication

with the user - cross all channels, devices, and venues - and also makes possible to provide unique services designed for that specific user. All of these steps are performed by considering and protecting user's privacy.

In the first part of this project, a transformation (linear) of the data matrix to higher dimension space is performed to make all users uniquely identified. In the second part, the data matrix is transformed, using orthogonal transformation, to a lower dimensional space so every new user can be identified (recognized) by comparing (matching) of the new user to all known users. (Received September 03, 2014)

16 ► Associative rings and algebras

1104-16-3 **Julia Pevtsova***, julia@math.washington.edu. *Applications of Geometry to Modular Representation Theory.*

Modular representation theory studies representations of a finite group over a field of positive characteristic that divides the order of the group. The situation is very different from the more familiar case of representations over $\mathbb{C}$: modular representations need not be direct sums of irreducible representations. Except in a handful of cases, it is impossible to classify modular representations, making the theory "wild", even for a group of size 9! Modular representation theory, more broadly construed, includes the representation theory of numerous other algebraic objects, such as positive characteristic Lie algebras.

Associating geometric invariants living on an appropriate projective variety to modular representations allows one to give some structure to this wild territory and even parameterize naturally occurring classes of representations. We'll discuss the classical concept of support variety which has its roots in the seminal work of D. Quillen on group cohomology, as well as more recent developments which include local Jordan type and vector bundles associated to modular representations. Despite the general nature of the theory, many interesting phenomena occur even for the smallest examples of finite groups which will be used for illustration. (Received August 21, 2014)

1104-16-90 **Srikanth B Iyengar*** (iyengar@math.utah.edu) and **Ryo Takahashi**. *Annihilation of cohomology and decompositions of derived categories.*

The goal of my talk will be to explain a connection between annihilators of Ext modules, for modules over a ring and a certain kind of decomposition of its derived category. This will be based on joint work with Ryo Takahashi, available on the arXiv; see http://arxiv.org/abs/1405.5299 (Received August 23, 2014)

1104-16-156 **Aaron D Lauda*** (lauda@usc.edu), Department of Mathematics, University of Southern California, 3620 S. Vermont Ave, KAP 108, Los Angeles, CA 900892532. *Odd structures arising from categorified quantum groups.*

Khovanov homology is a categorification of the Jones polynomial that paved the way for other categorifications of quantum link invariants. The theory of categorified quantum groups provides a representation theoretic explanation of these homological link invariants via the work of Webster and others. Surprisingly, the categorification of the Jones polynomial is not unique. Ozsvath, Rasmussen, and Szabo introduced an "odd" analog of Khovanov homology that also categorifies the Jones polynomial, and the even and odd categorification are not equivalent. In this talk I will explain joint work with Alexander Ellis, Mikhail Khovanov, and Heather Russell that aims todevelop odd analogs of categorified quantum groups to give a representation theoretic explanation of odd Khovanov homology. These odd categorifications lead to surprising new "odd" structures in geometric representation theory including odd analogs of the cohomology of the Grassmannian and Springer varieties. (Received August 29, 2014)

1104-16-163 **S Paul Smith***, smith@math.washington.edu. *The classification of 3-Calabi-Yau potentials in $V^{\otimes 3}$ when $\dim(V) = 3$.*

This is joint work with Izuru Mori.

Let V be a 3-dimensional vector space over an algebraically closed field whose characteristic is not 2 or 3. Let w be a non-zero element in $V^{\otimes 3}$. Let $J(\mathsf{w})$ be the Jacobian algebra, i.e., the quotient of the tensor algebra TV by the ideal generated by the cyclic partial derivatives of w. We prove a result of the form $J(\mathsf{w})$ is a 3-Calabi-Yau algebra if and only if w is ... The classification is a little intricate but is effective in the sense that if you give me any w, then I can tell you whether $J(\mathsf{w})$ is 3-Calabi-Yau. The classification depends on how w transforms under the action of the symmetric group S_3 and on the nature of the cubic divisor that is the vanishing locus in the projective plane of the image of w in the symmetric algebra SV. (Received August 30, 2014)

1104-16-192 **Birge Huisgen-Zimmermann*** (birge@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *Irreducible components of varieties of representations.* Preliminary report.

Inspired by the generic representation theory developed by Kac and Schofield for hereditary algebras, we determine the irreducible components of module varieties over more general algebras. (Received September 01, 2014)

1104-16-235 **Eleonore Faber*** (efaber@math.toronto.edu), 1265 Military Trail, Toronto, Ontario M1A 1C4, Canada. *Computing the global spectrum of a commutative ring.* Preliminary report.

In this talk we consider the problem of computing the global spectrum $gs_{\mathrm{MCM}(R)}(R)$ of a commutative ring R, that is, the set of all possible global dimensions of endomorphism rings of Cohen–Macaulay-modules. This notion was motivated by the study of non-commutative resolutions of singularities: in short, non-commutative resolutions of a commutative ring R are endomorphism rings of certain R-modules of finite global dimension. However, it is not clear which values of finite global dimensions are possible. This leads us to consider the global spectrum $gs_{\mathrm{MCM}(R)}(R)$.

In particular we focus on rings R of low Krull-dimension, where one can use Auslander–Reiten theory to compute the global dimension of an endomorphism ring of a Cohen–Macaulay module. We will illustrate our methods with several examples, in particular the ADE-curves. This is joint work in progress with Hailong Dao and Colin Ingalls. (Received September 02, 2014)

1104-16-285 **Kenneth Chan*** (kenhchan@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350, and **Ellen Kirkman**, **Chelsea Walton** and **James Zhang**. *Noncommutative McKay correspondence.* Preliminary report.

Let G be a finite subgroup of $SL_2(\mathbb{C})$ acting linearly in $X = \mathbb{A}^2$ and $\sigma : \tilde{X} \to X$ be the minimal resolution. The McKay correspondence states that the reduced McKay graph of G, the intersection graph of the exceptional curves on $\tilde{X}$, and (underlying graph of) the reduced AR quiver of $\mathcal{O}(X)^G$ are all isomorphic. We will discuss a noncommutative version of this result for semisimple Hopf algebras acting on quantum planes. (Received September 03, 2014)

1104-16-310 **Peter Goetz*** (peter.goetz@humboldt.edu), Arcata, CA 95521, and **Andrew Conner**, Moraga, CA 94575. *Some non-Koszul algebras from rational homotopy theory.*

The McCool group, denoted $P\Sigma_n$, is the group of pure symmetric automorphisms of a free group of rank n. A presentation of the cohomology algebra $H^*(P\Sigma_n, \mathbb{Q})$ was determined by Jensen, McCammond and Meier. We prove that $H^*(P\Sigma_n, \mathbb{Q})$ is a non-Koszul algebra for $n \geq 4$, which answers a question of Cohen and Pruidze. (Received September 03, 2014)

1104-16-319 **Cody Holdaway*** (codyh3@math.washington.edu). *Equivalences of categories involving graded modules over path algebras of finite GK-dimension.*

Let k be a field, Q a finite quiver and kQ the path algebra of Q. Give kQ the natural grading where the arrows have degree 1 and let QGr kQ denote the category of graded right modules modulo the torsion modules. Given two quivers Q and Q', when is QGr $kQ \equiv$ QGr kQ'? When the path algebras have finite GK-dimension, there is an invariant which answers this question completely. The invariant takes the form of a finite quiver, denoted $E(Q)$, which is determined by the simple objects of the category QGr kQ and their extensions. Luckily, the quiver $E(Q)$ can be read from the quiver Q rather easily. The main theorem states that QGr $kQ \equiv$ QGr kQ' if and only if $E(Q) = E(Q')$. (Received September 03, 2014)

1104-16-330 **Shawn Baland*** (sbaland@math.washington.edu). *Computing vector bundles for modules of constant Jordan type.* Preliminary report.

Let k be an algebraically closed field of prime characteristic p and let E be an elementary abelian p-group of rank r. For a finite dimensional kE-module M, Benson and Pevtsova have defined coherent sheaves $\mathrm{F_i(M)}$ on projective (r-1)-space, where i ranges from 1 to p. They have also shown that if M has constant Jordan type, then each $\mathrm{F_i(M)}$ is a vector bundle. In this talk we discuss ways to compute these vector bundles for special classes of modules, using techniques from the theory of Chern classes. We also show that in the case where r equals 2, one may compute $\mathrm{F_i(M)}$ by restricting attention to certain subquotients of M that are related to its generic kernel filtration. (Received September 03, 2014)

1104-16-333 **Jason P Bell*** (jpbell@uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, Waterloo, ON N2L3G1, Canada, and **Colin Ingalls** and **Ritvik Ramkumar**. *Rings of differential operators on curves.* Preliminary report.

One of the interesting problems related to Artin's proposed birational classification of noncommutative surfaces is when D_1 embeds in D_2 for two division rings from his list. We consider division rings formed by taking quotients of rings of differential operators on curves and we show that if X and Y are two curves with the property that the quotient division ring of the ring of differential operators on X embeds in the corresponding division ring for Y then the genus of X is less than or equal to the genus of Y. (Received September 03, 2014)

17 ► Nonassociative rings and algebras

1104-17-33 **Brian Boe**, **Jonathan Kujawa*** (kujawa@math.ou.edu) and **Daniel Nakano**. *The Classification of Thick Tensor Ideals for Lie Superalgebras.*

Classifying the finite dimensional indecomposable representations of a classical Lie superalgebra is a wild problem. Consequently we must look for alternative coarse classifications which are more tractable. In the case of finite groups this is done by classifying the thick tensor ideals. With that result as a model, we provide a geometric classification of the thick tensor ideals in the case of gl(m,n). We discuss the classification along with the intriguing similarities, differences, and new challenges in this case. (Received July 10, 2014)

1104-17-89 **Vera Serganova*** (serganov@math.berkeley.edu), Department of Mathematics, UC Berkeley, Berkeley, CA 94720. *Deligne's category GL(t) and the general linear supergroup.* Preliminary report.

Deligne's category GL(t) is a Karoubian rigid symmetric tensor category generated by one object of dimension t. This category is semisimple if and only if t is not an integer.

We use representation theory of the general linear supergroup GL(m,n) with m-n=t to construct the abelian envelope of GL(t). (Received August 23, 2014)

18 ► Category theory; homological algebra

1104-18-28 **S. T. Edward Fan*** (sfan@caltech.edu), 1200 E California Blvd., MC 253-37, PASADENA, CA 91125. *Homotopy coherence for hypercovering functors on Grothendieck sites and its application to etale motivic regulators.* Preliminary report.

In this talk, a homotopy coherence problem for hypercovering functors on Grothendieck sites will be addressed. A sufficiency criterion will be given to the existence of homotopy coherent lifting of such functors. As a generalization of the Grothendieck-Verdier hypercovering theorem, we can compute a direct limit of hypercohomologies of simplicial schemes as the hypercohomology of certain homotopy colimit of the system of simplicial presheaves. As an application, this provides a construction of the etale motivic regulator maps on the derived level. (Received July 04, 2014)

1104-18-63 **Paul Balmer***, P.O. Box 951555, UCLA Math Department, Los Angeles, CA 90095-1555. *Separable extensions of triangulated categories.*

I will explain how separable extensions of triangulated categories generalize the broadly used technique of Bousfield localization. To some extent, this generalization resembles how the etale topology generalizes the Zariski topology in algebraic geometry. I will present examples, mostly related to representations of finite groups and explain how this approach can be helpful. (Received August 18, 2014)

1104-18-74 **Sabin Cautis*** (cautis@math.ubc.ca), Vancouver, BC V5Y1V8, Canada. *Rigidity in higher representation theory.*

We explain why quiver Hecke algebras (KLR algebras) are ubiquitous in the higher representation theory of quantum groups. (Received August 19, 2014)

1104-18-149 **Alexandru Chirvasitu*** (chirvasitua@gmail.com), 5507 1/2 26th Ave. NE, Seattle, WA 98105. *Semiperfect coalgebras as dualizable 2-abelian groups.*

Many of the usual algebraic or geometric objects (algebras, coalgebras, schemes, etc.) can be regarded as objects of a bicategory of so-called 2-abelian groups. It consists of (sufficiently nice) linear categories, left adjoints, and natural transformations. The examples above can be recovered by identifying an algebra with its module category, a coalgebra with its comodule category, a scheme with its category of quasicoherent sheaves, etc.

Dualizability of objects in higher categories is a condition that comes up naturally in the classification and construction of topological field theories; it is analogous to being e.g. a finite-dimensional vector space in the category of vector spaces or a locally free sheaf among quasicoherent sheaves on some scheme.

When regarded as 2-abelian groups, categories of modules over algebras are always dualizable, with the dual being the category of modules over the opposite algebra. We will see that by contrast, the category of comodules over a coalgebra is dualizable exactly when the coalgebra in question is semiperfect.

I will also mention other examples of (non)dualizability, such as for categories of quasicoherent sheaves on projective schemes or quotient stacks. (Received August 29, 2014)

1104-18-341 **Cris Negron*** (negron@uw.edu). *An Alternate Approach to the Lie Bracket on Hochschild Cohomology.*

Gerstenhaber's Lie bracket on Hochschild cohomology is a structure which is used to access the (formal) deformation theory of an algebra. One difficulty that arises in dealing with the Gerstenhaber bracket is that, at the cochain level, it is only defined on the standard Hochschild cochain complex. I will discuss how, for any "Koszul type" algebra A, one can define a family of brackets on the cochain complex associated to the Koszul resolution of A which all induce the Gerstenhaber bracket on cohomology. The class of algebras under consideration includes standard Koszul algebras as well as universal enveloping algebras and Down-Up algebras. This is joint work with Sarah Witherspoon. (Received September 04, 2014)

19 ► K-theory

1104-19-181 **Sanath K Devalapurkar*** (devalapurkarsanath@gmail.com), Apt. 47, Bon Anza, 20501, Anza Avenue, Torrance, CA 90503. *The K-theory of the Category of $\mathcal{O}$-module objects over an Algebra Object over an Unital Operad $\mathcal{C}^{\otimes}$.* Preliminary report.

Once one defines the K-theory (using Quillen's Q-construction) and the category $\mathrm{Mod}_A(\mathcal{C})$ of A-module objects of an exact 1-category $\mathcal{C}$, it is natural to ask how $\mathrm{Mod}_A(\Omega\mathrm{Q}(\mathcal{C}))$ relates to $\Omega\mathrm{Q}(\mathrm{Mod}_A(\mathcal{C}))$. This is given by an inclusion $\mathrm{Mod}_A(\Omega\mathrm{Q}(\mathcal{C})) \supseteq \Omega\mathrm{Q}(\mathrm{Mod}_A(\mathcal{C}))$. It is then natural to ask if this generalizes to higher categories. For a higher-categorical analog of the Quillen Q-construction, we will show that

$$\Omega\mathrm{Q}(\mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\cdots(\mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\mathcal{C}^{\otimes})^{\otimes})\cdots)^{\otimes})^{\otimes}) \simeq \Omega\mathrm{Q}(\mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\mathcal{C}^{\otimes})^{\otimes})$$

is a subcategory of

$$\mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\cdots(\mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\Omega\mathrm{Q}(\mathcal{C}^{\otimes}))^{\otimes})\cdots)^{\otimes})^{\otimes} \simeq \mathcal{M}\mathrm{od}_A^{\mathcal{O}}(\Omega\mathrm{Q}(\mathcal{C}^{\otimes}))^{\otimes} \subseteq \Omega\mathrm{Q}(\mathcal{C}^{\otimes}),$$

for $\mathcal{C}^{\otimes}$ a unital (∞, n)-operad. (Received September 01, 2014)

20 ► Group theory and generalizations

1104-20-22 **Shiang Tang*** (tang@math.utah.edu), 1028 E 500 S, SLC, UT 84112. *Principal Series Representations and Calculations of Intertwining Operators for $Mp(2)$ over local fields.*

Let F be a nonarchimedean local field, $Mp(2, F)$ be the metaplectic group over F, i.e, the double cover of $SL(2, F)$. We study the representation theory of $Mp(2, F)$. In particular, we define a character χ of the metaplectic torus T by using of the Weil index, so we have the principal series representation $I(\chi)$. We calculate the intertwining map from $I(\chi)$ to $I(w\chi)$ and get explicit formulas of Plancherel measures. We focus our attention on the wild ramified case, that is, when F is a 2-adic field. We study the Eisenstein series of $Mp(2, \mathbb{A})$ and get some global results, combining this with the results on archimedean and p-adic($p \neq 2$) fields, we understand the intertwining operators in the 2-adic case. (Received June 29, 2014)

1104-20-62 **Jared Warner*** (hjwarner@usc.edu). *The Category of Elementary Subalgebras of a Restricted Lie Algebra.*

For p a prime and Γ a finite group, Quillen's category of elementary abelian p-subgroups of Γ, denoted $\mathcal{E}(\Gamma)$, plays a central role in the cohomology and representation theory of Γ. For $\mathfrak{g}$ a restricted Lie algebra, abelian subalgebras with trivial restriction are the natural analogue to elementary abelian p-subgroups, and are thus referred to as elementary subalgebras. In this talk we will define $\mathcal{E}(\mathfrak{g})$, the category of elementary subalgebras of $\mathfrak{g}$, and in the case that $\mathfrak{g} = \mathrm{Lie}(G)$ for a connected, reductive group G defined over $\mathbb{F}_p$, we will state some results concerning the relationship between $\mathcal{E}(\mathfrak{g})$ and $\mathcal{E}(G(\mathbb{F}_q))$ for q a pth power. If time permits, we will also discuss applications of these results to the study of the G-variety of elementary subalgebras of $\mathfrak{g}$ as defined by Jon Carlson, Eric Friedlander, and Julia Pevtsova. (Received August 18, 2014)

1104-20-137 **Thomas Kahle*** (thomas.kahle@ovgu.de) and **Mateusz Michalek**. *Plethysm and lattice point counting.*

We show that the coefficient of the Schur functor S^λ in the decomposition of the plethysm $S^\mu(S^k)$ into irreducibles is the solution to a lattice point counting problem. Consequently, for each fixed μ, the solution to this problem is a piecewise quasi-polynomial in (λ, k). We show how to use computer algebra to determine this function explicitly when μ is a partition of 4 or 5. We also discuss asymptotics of the resulting piecewise quasi-polynomials. This is joint work with Mateusz Michałek. (Received August 28, 2014)

1104-20-240 **Robert Boltje*** (boltje@ucsc.edu) and **Philipp Perepelitsky**. *On p-permutation bimodules and equivalences between blocks of group algebras.*

Let F be a an algebraically closed field of characteristic $p > 0$ and let G and H be finite groups. An FG-module is called a *p-permutation module* if its restriction to a Sylow p-subgroup of G is a permutation module. Similarly one defines p-permutation bimodules for FG and FH. Assume now that A is a block of FG and B is a block of FH. Motivated by Rickard's notion of splendid chain complexes in connection with Broué's Abelian Defect Group Conjecture, we define a p-permutation equivalence between A and B to be a virtual p-permutation (A, B)-bimodule γ in an appropriate representation group such that $\gamma \otimes_H \gamma^\circ = [A]$ and $\gamma^\circ \otimes_G \gamma = [B]$. Every splendid Rickard equivalence between A and B (a finite chain complex of p-permutation (A, B)-bimodules) induces such an element γ by taking Lefschetz elements.

We investigate which invariants of blocks are preserved under p-permutation equivalences, prove some restrictive properties about their shape and present results on the group of p-permutation auto-equivalences of a block. (Received September 02, 2014)

1104-20-248 **Jim Stark*** (jstarx@uw.edu). *Detecting projectivity in sheaves associated to representations of restricted Lie algebras.*

Let k be an algebraically closed field of positive characteristic p and let $\mathfrak{g}$ be a restricted Lie algebra over k. The cohomology variety Spec $H^\bullet(\mathfrak{g}, k)$ is known to be homeomorphic to the restricted nullcone $\mathcal{N}_p$, i.e., the conical variety of p-nilpotent elements of $\mathfrak{g}$. Generalizing work of Carlson in the 80's, one can associate to a given $\mathfrak{g}$-module M sheaves over the projectivization $\mathbb{P}(\mathcal{N}_p)$ of the nullcone. Such work has resulted in the definition and study of modules of constant Jordan type.

In this talk we discuss the sheaf $\mathcal{H}^{[1]}(M)$. We will explain how its definition is motivated by looking at local Jordan type and we will describe some partial results in answering a question of Friedlander and Pevtsova on how $\mathcal{H}^{[1]}(M)$ does and does not detect the projectivity of M. (Received September 02, 2014)

1104-20-299 **Susan Montgomery***, smontgom@usc.edu, and **Andrea Jedwab**. *Modular representations and indicators for bismash product Hopf algebras.*

For a finite group G, Brauer characters give a way of studying irreducible representations over a field k of characteristic p, by lifting information to characteristic 0. In this work, we extend the notion of Brauer characters and some of their basic properties to the case of a bismash product Hopf algebra $H = k^G \# kF$ constructed from a factorization $L = FG$ of a finite group. We give an analog of the Cartan matrix and show that its determinant is a power of p, and then prove the analog of a theorem of J. Thompson (1986) on Frobenius-Schur indicators:
Theorem: Let k be an algebraically closed field of odd characteristic. Let $H_{\mathbb{C}} = \mathbb{C}^G \# \mathbb{C}F$ be a bismash product over $\mathbb{C}$ and $H_k = k^G \# kF$ the corresponding bismash product over k. Then if all irreducible $H_{\mathbb{C}}$-modules have Schur indicator $+1$ (respectively ± 1, or ≥ 0), the same is true for all irreducible H_k-modules.

We apply this theorem to obtain the char p analog of recent results on indicators in char 0 by the authors and by J. Timmer. (Received September 03, 2014)

1104-20-324 **Paul G Sobaje*** (sobaje@usc.edu). *One Parameter Subgroups of Reductive Groups.*

One-parameter additive subgroups have long played an important role in the representation theory of a reductive group G, starting with the root subgroups with respect to a maximal torus $T \leq G$. In characteristic p, more general one-parameter subgroups have been used to define interesting and useful invariants for G-modules. We will look at some recent developments in this area. (Received September 03, 2014)

22 ► Topological groups, Lie groups

1104-22-325 **Raphael Rouquier*** (rouquier@math.ucla.edu). *Perspectives in higher representation theory.*

This talk will discuss various connections of higher representation theory with representation theory, some conjectural, and speculate on possible new constructions. (Received September 03, 2014)

31 ► Potential theory

1104-31-82 **Alexander (Oleksandr) V Tovstolis*** (atovstolis@math.okstate.edu), Department of Mathematics, Oklahoma State University, 401 Mathematical Sciences, Stillwater, OK 74078. *On Riesz Decomposition of Super-Polyharmonic Functions.*

We consider a Riesz decomposition of a function u, which is m-superharmonic in $\mathbb{R}^n$. It is shown that u is a sum of the Riesz potential of the measure $\mu = (-\Delta)^m u$ and an m-harmonic function if and only if a particular linear combination of spherical means for u is bounded, and some mild condition is satisfied. Some easy-to-check sufficient conditions are also obtained.

The statement generalizes the results of K. Kitaura and Y. Mizuta (2006) for super-biharmonic functions. (Received August 21, 2014)

32 ► Several complex variables and analytic spaces

1104-32-194 **Zeljko Cuckovic** and **Yunus E. Zeytuncu*** (zeytuncu@umich.edu), 2014 CASL Building 4901 Evergreen Road, Dearborn, MI 48128. *Mapping Properties of the Bergman Projection on Reinhardt Domains.*

Let Ω be a Reinhardt domain with smooth boundary in $\mathbb{C}^n$ and let ρ be a smooth and radially symmetric defining function for Ω. Set $\lambda = \exp\left(\frac{1}{\rho}\right)$ as a weight on Ω. The weighted Bergman projection operator $\mathbf{B}_\Omega^\lambda$ is an operator defined initially between $L^2(\Omega,\lambda)$ and $L^2_a(\Omega,\lambda)$. In this preliminary report, we discuss mapping properties of $\mathbf{B}_\Omega^\lambda$ on $L^p(\Omega,\lambda)$ for $p \neq 2$. In particular, we observe a peculiar behavior due to exponential structure of the weight. This is joint work with Željko Čučković. (Received September 01, 2014)

1104-32-196 **Bingyuan Liu***, One Brookings Dr., Saint Louis, MO 63130. *Characterization of the complex domians by their holomorphic automorphism groups.*

Using holomorphic automorphism of a domain Ω to characterize the property of Ω dates back the time of Cartan. This point of view was developed since 1970s by many people, like Bedford, Greene,Pinchuk, Kim, Krantz, Pinchuk, Rosay, Verma and Wong. Specifically, Greene-Krantz gave a theorem about the property of the orbit accumulation point. In this talk, we consider the question from the global view. We discuss, in $\mathbb{C}^n$, the (global) pseudoconvexity of the domain Ω after assuming some conditions on the behaviors of the automorphism groups. We will also introduce a new theorem of Wong-Rosay type theorem for Kahler manifolds. (Received September 01, 2014)

1104-32-204 **Shiferaw Berhanu**, Deparment of Mathematics, Temple University, Philadephia, PA 19122, and **Ming Xiao*** (mingxiao@math.rutgers.edu), 110 Frelinghuysen Road, Department of Mathematics, Rutgers University, Piscataway, NJ 08854. *A smooth version of reflection principle for mappings between CR manifolds.*

We will present a smooth version of classical Schwarz principle for CR mappings between an abstract CR manifold and a strongly pseudoconvex real hypersurface in euclidean complex space proved in a recent paper by S.Berhanu and M.Xiao. As a consequence of their results, they settled a conjecture of X.Huang raised in 1994 and resolved a question of F.Forstneric. (Received September 01, 2014)

34 ► Ordinary differential equations

1104-34-332 **Vivek Shende*** (vivek@math.berkeley.edu). *The link of a linear meromorphic ordinary differential equation.* Preliminary report.

To a meromorphic connection on a disk, one can attach a link in the solid torus measuring the braiding of the asymptotics of solutions to the differential equation. The class of such links is the same as the links "at infinity" of algebraic plane curves. The wild Riemann-Hilbert theorem of Deligne and Malgrange identifies the moduli of

connections with a fixed formal type of irregular singularity with the moduli of sheaves with singular support in the link. Our study of this latter space with Treumann and Zaslow gives to a formula for the number of points over $\mathbb{F}_q$ of the 'wild character variety' parameterizing such sheaves – it is a certain coefficient of the HOMFLY polynomial of the link of the differential equation. (Received September 03, 2014)

35 ► Partial differential equations

1104-35-16 **Gang Zhou*** (gzhou@caltech.edu), California Institute of Technology, Mathematics, Mail Code 253 37, Pasadena, CA 91106, and **Juerg Froehlich**, Institut f. Theoretische Physik, HIT K 42.1, Wolfgang-Pauli-Str. 27, 8093 Zurich, Zurich, Switzerland. *motion of an invading heavy tracer particle in a Bose gas.*

I will present recent results on a non-relativistic Hamiltonian model of quantum friction, about the motion of an invading heavy tracer particle in a Bose gas exhibiting Bose Einstein condensate. We prove the following observations: if the initial speed of the tracer particle is lower than the speed of sound in the Bose gas, then in large time the particle will travel ballistically; if the initial speed is higher than the speed of sound, the it will converge to the speed of sound. In both regimes the system will converge to some inertial modes. Joint works with Juerg Froehlich, Michael Sigal, Avy Soffer, Daneil Egli and Arick Shao. (Received May 31, 2014)

1104-35-23 **Kazuo Yamazaki*** (kyamazaki@math.okstate.edu), 401 Mathematical Sciences Building, Dept. of Math., Oklahoma State University, Stillwater, OK 74078. *Regularity criteria of MHD system involving one velocity and one current density component.*

We discuss recent developments on the global regularity issue and the component reduction results on the Serrin and Beale-Kato-Majda criterions. Our discussion will concern the magnetohydrodynamics (MHD) related systems including the Navier-Stokes equations and micro-polar fluid system. In particular, we discuss how the Serrin-type regularity criteria of the three-dimensional MHD system may be reduced to only one velocity vector field component and one current density component. The proof requires a non-trivial decomposition of four non-linear terms which may be interesting in itself with further applications. (Received June 30, 2014)

1104-35-24 **Jesus R Oliver*** (jroliver@math.ucsd.edu), 9500 Gilman Dr., La Jolla, CA 92093. *A Vector Field Method for Non-trapping, Radiating Spacetimes.*

We study the global boundedness and decay properties of solutions to the linear wave equation in 3+1 dimensions on time-dependent, non-trapping, radiating space-times. Assuming a local energy decay estimate, we prove that sufficiently regular solutions to this equation have bounded conformal energy. As an application we also show a bound on conformal energy with vector fields as well as a global L^∞ decay estimate in terms of a weighted norm on initial data. (Received July 01, 2014)

1104-35-25 **Attou A. Miloua***, 4209 Haldane Street, Pittsburgh, PA 15207. *Point rupture solutions of singular elliptic equations in N-D.*

We consider the elliptic equation

$$\Delta u = f(u)$$

in a region $\Omega \subset \mathbb{R}^N$, $N \geq 3$, where f is a positive continuous and satisfying

$$\lim_{u \to 0^+} f(u) = \infty.$$

Motivated by the thin film equations, a solution u is said to be a point rupture solution if for some $p \in \Omega$, $u(p) = 0$ and $u(p) > 0$ in $\Omega \backslash \{p\}$. Our main result is a sufficient condition on f for the existence of radial point rupture solutions. Furthermore, we will prove that our results can be applied to the point rupture solutions for a class of quasi-linear elliptic equations of the form

$$\operatorname{div}(a(u)\Delta u) = \frac{a'(u)}{2}|\nabla u|^2 + f(u) \tag{1}$$

(Received July 01, 2014)

1104-35-45 **Avy Soffer*** (soffer@math.rutgers.edu) and **Hans Lindblad**. *"Long Range Scattering for the Klein-Gordon equation with nonhomogeneous nonlinearities".*

abstract:

The asymptotic stability of coherent states , like kinks in one dimension poses new great challenges. This is due to the long range nature of the dispersive equation. This talk will focus on one such problem. We study the 1D Klein-Gordon equation with quadratic and variable coefficient cubic nonlinearity. This problem exhibits

a striking resonant interaction between the spatial frequencies of the nonlinear coefficients and the temporal oscillations of the solutions. We prove global existence and (in L-infinity) scattering as well as a certain kind of strong smoothness for the solution at time-like infinity with the help of several new classes of normal-forms transformations. The analysis also shows the limited smoothness of the solution, in the presence of the resonances. (Received August 08, 2014)

1104-35-53 **Alexey Cheskidov** and **Mimi Dai*** (mdai@uic.edu). *The existence of a global attractor for the forced critical surface quasi-geostrophic Equation in L^2.*

We prove that the critical surface quasi-geostrophic equation driven by a force f possesses a compact global attractor in $L^2(\mathbb{T}^2)$ provided $f \in L^p(\mathbb{T}^2)$ for some $p > 2$. (Received August 14, 2014)

1104-35-56 **Marius Mitrea*** (mitream@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *A Unified Approach to Radiation Conditions for Helmholtz, Dirac, and Maxwell Operators.* Preliminary report.

We propose a general radiation condition for null-solutions of the Helmholtz operator which are Clifford algebra-valued. The latter is a context which naturally includes scalar-valued and vector-valued, functions, as well as differential forms. Our radiation condition reduces precisely to the classical Sommerfeld and Silver-Muller radiation conditions for the scalar Helmholtz operator and the Maxwell system, respectively, and it also encompasses as a particular case the radiation condition for perturbed Dirac operators introduced by McIntosh and Mitrea in 1999. As an upshot, we are able to unify what hetero have been perceived as distinct (yet mysteriously interconnected) theories and explain them as particular manifestation of a common, more general, principle. This is joint work with Emilio Marmolejo-Olea, Dorina Mitrea, and Irina Mitrea. (Received August 15, 2014)

1104-35-66 **Stefan Steinerberger*** (stefan.steinerberger@yale.edu), Department of Mathematics, Yale University, P.O. Box 208283, New Haven, CT 06520-8283. *Dispersion dynamics of the defocusing generalized Korteweg - de Vries equation.*

The defocusing generalized KdV is an evolution equation on the real line. H^1 initial data stays in H^1 and the L^2-norm is conserved. We are interested in the behavior of the solution: in contrast to the focusing KdV, which has traveling waves solutions, there is no reason to assume that any small interval will contain, say, 10% of the entire L^2 mass for a long time: things should spread out. We give some results in that direction, which complement earlier results of Tao and improve recent results of Kwon & Shao. (Received August 19, 2014)

1104-35-68 **Tristan Buckmaster*** (buckmaster@cims.nyu.edu). *Onsager's Conjecture.*

In 1949, Lars Onsager in his famous note on statistical hydrodynamics conjectured that weak solutions to the Euler equation belonging to Hölder spaces with Hölder exponent greater than 1/3 conserve energy; conversely, he conjectured the existence of solutions belonging to any Hölder space with exponent less than 1/3 which dissipate energy.

The first part of this conjecture has since been confirmed (cf. Eyink 1994, Constantin, E and Titi 1994). During this talk we will discuss recent work by Camillo De Lellis, László Székelyhidi Jr., Phil Isett and myself related to resolving the second component of Onsager's conjecture. In particular, we will discuss the construction of weak non-conservative solutions to the Euler equations whose Hölder $1/3 - \epsilon$ norm is Lebesgue integrable in time. (Received August 19, 2014)

1104-35-73 **Andrew Tapay***, atapay@indiana.edu, and **Nets Hawk Katz**. *A model for studying double exponential growth in the 2d Euler equations.*

We introduce a model for the 2d Euler equations which is designed to study whether or not double exponential growth can be achieved for a short time at an interior point of the flow. (Received August 19, 2014)

1104-35-78 **Benoit Pausader*** (pausader@math.princeton.edu), **Yu Deng** and **Alexandru Ionescu**. *Global existence for the Euler-Maxwell equation for electrons in dimension 2.*

The Euler-Maxwell equations for electrons describe the dynamics of a fluid of electrons interacting with its self-consistent electromagnetic field. We prove asymptotic stability of the simple neutral background at rest. (Received August 20, 2014)

1104-35-81 **Fabio Pusateri*** (fabiop@math.princeton.edu) and **Alexandru D. Ionescu**. *Global regularity for 2d water waves with surface tension.*

We consider the irrotational water waves system with surface tension and no gravity in dimension two, and prove global regularity for suitably small perturbations of a flat interface. (Received August 21, 2014)

1104-35-104 **Susan Friedlander*** (susan@math.northwestern.edu), Math Dept, USC, Los Angeles, CA 90089, **Nathan Glatt-Holtz** (negh@vt.edu), Math dept, Virginia Tech, Blacksburg, VA 24061, and **Vlad Vicol** (vvicol@math.princeton.edu), Math dept, Princeton university, Princeton, NJ 08540. *A Stochastic Shell Model for Turbulence.*

We discuss a shell model first introduced by Desnianskii and Novikov to simulate the cascade process of energy transmission in turbulent flows. We review results that reproduce Onsager's conjecture and Kolmogorov's Laws of turbulence in the case of this shell model with constant forcing. We then discuss recent results for the stochastically driven model. Here localized, Gaussian and white in time forcing serves as a proxy for generic large scale processes driving turbulent cascades. (Received August 25, 2014)

1104-35-107 **Brock Schmutzler*** (brock.schmutzler@mail.missouri.edu), University of Missouri, Columbia, MO. *Layer Potential Methods for Elliptic PDE's in Rough Subdomains of Riemannian Manifolds.* Preliminary report.

We study the effectiveness of the layer potential method for solving boundary value problems for scalar elliptic operators, such as the Laplace–Beltrami operator, as well as systems, such as the Stokes system, in rough subdomains of Riemannian manifolds. The novelty lies in the consideration of singular integral operators with variable-coefficient kernels, defined on the boundary of a higher-dimensional version of chord-arc domains in the plane. Dealing with such problems requires techniques from harmonic analysis, geometric measure theory, and global analysis. This is joint work with Marius Mitrea. (Received August 25, 2014)

1104-35-120 **Ronghua Pan** and **Kun Zhao*** (kzhao@tulane.edu). *Motion of non-isentropic compressible Euler equations with damping and error of isentropic approximation.*

The motion of three-dimensional non-isentropic compressible gas flows through porous media can be modeled by the full compressible Euler equations with frictional damping, which is a 5 by 5 system of hyperbolic balance laws. Mathematically, the non-isentropic model carries certain features, which are totally absent in its isentropic companion, such as the existence of contact discontinuities. Mathematical analysis of the non-isentropic model is more challenging than the isentropic one, due to the degeneracy caused by the coupling of the spatial derivatives of the entropy function in the pressure field. In this talk, recent development on the global well-posedness and large-time behavior of the model with general initial data in the regime of small smooth functions will be reported. Furthermore, the error of "isentropic approximation" will be discussed. (Received August 26, 2014)

1104-35-133 **Jim Isenberg*** (isenberg@uoregon.edu), Dept of Math, Institute for Theoretical Science, University of Oregon, Eugene, OR 97403. *Asymptotic Behavior of Non Round Neckpinches in Ricci Flow.*

Neckpinch singularities are a prevalent feature of Ricci flow, and recent work has given us a good picture of their asymptotic behavior, so long as the geometries are rotationally symmetric. We discuss this asymptotic behavior, both for degenerate and non-degenerate neckpinches. It has been conjectured that neckpinch singularities which develop in non-rotationally symmetric Ricci flows do asymptotically approach roundness, and consequently have very similar asymptotic behavior to those which are rotationally symmetric. We discuss very recent work which supports this conjecture. (Received August 27, 2014)

1104-35-152 **M. Ignatova*** (ignatova@math.princeton.edu), **I. Kukavica**, **I. Lasiecka** and **A. Tuffaha**. *On well-posedness and small data global existence for a damped free boundary fluid-structure model.*

We address a fluid–structure system which consists of the incompressible Navier–Stokes equations and a damped linear wave equation defined on two dynamic domains. The equations are coupled through transmission boundary conditions and additional boundary stabilization effects imposed on the free moving interface separating the two domains. We first discuss the local in time existence and uniqueness of solutions. Given sufficiently small initial data, we prove the global in time existence of solutions. This is a joint work with I. Kukavica, I. Lasiecka, and A. Tuffaha. (Received August 29, 2014)

1104-35-175 **Zaher Hani***, School of Mathematics, Georgia Institute of Technology, Atlanta, GA , and **Laurent Thomann**. *Long-time behavior of the nonlinear Schroedinger equation confined by domain or potential.*

We will consider the cubic nonlinear Schroedinger equation that is either geometrically or externally confined. By geometric confinement, we mean posing the equation on a compact or partially compact domain. By external confinement, we add a confining harmonic potential in all or some directions. We will focus on a recent joint work with Laurent Thomann that builds on an earlier work of the speaker with Benoit Pausader, Nikolay Tzvetkov, and Nicola Visciglia. (Received August 31, 2014)

1104-35-179 **Tiago Henrique Picon*** (picon@ffclrp.usp.br), Josue Marques Martins, 3965, Sao Carlos, Sao Paulo 13569050, Brazil. *Pseudodifferential operators and localizable Sobolev-Hardy spaces.*

In this lecture we present the continuity of pseudodifferential operators on local Hardy spaces $h^p(\mathbb{R}^n)$ with negative symbols in the Hormander class and applications. This is a joint work with G.Hoepfner and R. Kapp. (Received August 31, 2014)

1104-35-184 **Roger M Temam***, Department of Mathematics, Rawles Hall, Indiana University, 831 E 3rd Street, Bloomington, IN 47405. *Existence and Uniqueness of Solutions for Linear and Nonlinear Inviscid Shallow Water Equations.*

Motivated by the equations of the large scale oceans and atmosphere (primitive equations), we discuss the issue of existence and uniqueness of solutions for the linearized shallow water equations in space dimension two in a rectangle. We also study the nonlinear shallow water equations in some subcritical and supercritical situations. The choice of the suitable boundary conditions and the fact that the domain (rectangle) is not smooth, are two essential issues in this study. In particular we show how suitable boundary conditions make the initial and boundary problem mildly dissipative and well-posed. (Received August 31, 2014)

1104-35-195 **Seckin Demirbas*** (demirba2@illinois.edu), 703 W. High St., Apt. 2, Urbana, IL 61801. *Gibbs' measure and almost sure global well-posedness for one dimensional periodic fractional Schrödinger equation.*

In this talk we will present recent local and global well-posedness results on the one dimensional periodic fractional Schrödinger equation. We will also talk about construction of Gibbs' measures on certain Sobolev spaces and how we can prove almost sure global well-posedness using this construction. (Received September 01, 2014)

1104-35-199 **Pedro Tavares Paes Lopes*** (dritao@yahoo.com), Sao Carlos, Brazil. *Gelfand-Shilov regularity of SG elliptic boundary value problems.*

We study the regularity in Gelfand-Shilov spaces of elliptic boundary value problems on the half space and on the complement of a bounded set. We restrict our study to operators whose coefficients satisfy estimates of the following type $\left|\partial^{\beta} a(x)\right| \leq C \langle x\rangle^{m_2-|\beta|}$.

Recently M. Capiello et al. used pseudo-differential operators to study similar differential equations on $\mathbb{R}^n$, obtaining exponential decay of solutions of traveling waves equations.

In our work, we apply their methods to study the regularity of elliptic boundary value problems that satisfy an analogous of the Lopatinski-Shapiro condition - as described by A. K. Erkip and C. Parenti. In order to do that, we characterize first the restrictions of Gelfand-Shilov functions on the half-space, then we study behavior of the class of pseudo-differential operators defined by the above authors on the half plane, the so-called transmission property. The results we obtain are analogous to the results in $\mathbb{R}^n$. (Received September 01, 2014)

1104-35-205 **Michele Coti Zelati*** (micotize@umd.edu) and **Ciprian Gal** (cgal@fiu.edu). *Stability results and fractal dimension estimates for three-dimensional fluid flows.*

We compare the longtime dynamics of the three-dimensional Navier-Stokes-Voigt (NSV) model with that of the Navier-Stokes equations (NSE). As a certain regularization parameter vanishes, we prove a stability result for the weak attractor of the NSE and obtain necessary and sufficient conditions for such attractor to be strong. Moreover, we deduce an estimate on the fractal dimension of the NSV-attractors, uniform with respect to the regularization parameter, which therefore gives some insights on the finite-dimensional behavior of the NSE. (Received September 01, 2014)

1104-35-207 **John A Helms*** (john.helms@gmail.com), Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 931063080, and **Thomas Sideris**, Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 931063080. *Global solutions to 2-D quasilinear wave equations.* Preliminary report.

This work is in joint collaboration with Professor Thomas Sideris (UCSB). We consider small-data solutions to equations of the form

$$\begin{cases} \Box u(t,x) = Q(\partial u, \partial^2 u), & (t,x) \in \mathbb{R}_+ \times \mathbb{R}^2, \\ u(0,x) = \epsilon f(x), \quad \partial_t u(0,x) = \epsilon g(x), \end{cases}$$

where $\Box = \partial_t^2 - \Delta$ and the nonlinearity Q is allowed to depend on ∂u and $\partial^2 u$ at the quadratic level and higher. We also assume that Q is linear in $\partial^2 u$ and that Q satisfies a null condition, which is due to Christodoulou and Klainerman. Alinhac proved global existence of small-data solutions with smooth, compactly supported data (f, g) by using a "Ghost weight" in his main energy estimate. Our proof extends Alinhac's result by allowing for

a weaker hypothesis on the initial data: (f, g) are only required to have a certain amount of weighted Sobolev regularity with no restrictions on the support. Our proof also eliminates the use of the Lorentz boosts $x_i\partial_t + t\partial_i$ $(i = 1, 2)$ from the existence argument. If time permits, I will also discuss some difficulties present in this problem and some possible follow-up projects. (Received September 01, 2014)

1104-35-209 **Rafael Granero-Belinchon*** (rgranero@math.ucdavis.edu), Department of Mathematics, University of California, Davis, One Shields Avenue, Davis, CA 95616. *Global existence and finite time blow-up for the Muskat problem.*

The Muskat problem studies the dynamics of a free boundary of a fluid through porous media. Such free boundary problems for incompressible fluids have been intensively studied in the recent years. A particularly interesting topic is the global existence vs. finite time blow-up of the solution. Most of the known results use the contour equation for the interface. This approach requires tools from harmonic analysis and singular integral operators.

In this talk we will review some of the existing results concerning the 2D case (i.e. the interface is one-dimensional). Finally, we will present a new approach (an Arbitrary Lagrangian Eulerian method) to analyze this problem. We will also present our results obtained by using the ALE method. (Received September 01, 2014)

1104-35-215 **Oliver Buhler**, **Jalal Shatah**, **Samuel Walsh** and **Chongchun Zeng*** (zengch@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30047. *Wind-driven water waves.* Preliminary report.

In this talk, we start with the mathematical theory of wind-generated water waves in the framework of the interface problem between two incompressible inviscid fluids under the influence of gravity. This entails the careful study of the stability of the shear flow solutions to the interface problem of the two-phase Euler equation. Based on a rigorous derivation of the linearized equations about shear flow solutions, we obtained rigorously the linear instability criterion of Miles due to the presence of the critical layer in the steady shear flows. Our analysis is valid even in the presence of surface tension and a vortex sheet (discontinuity in the tangential velocity across the air–sea interface). We are thus able to give a unified equation including the Kelvin–Helmholtz and quasi-laminar models of wave generation put forward by Miles. (Received September 01, 2014)

1104-35-227 **YUNCHENG YOU*** (you@mail.usf.edu), 4202 East Fowler Avenue, CMC 114, Tampa, FL 33620. *Random dynamics and averaging for nonautonomous stochastic wave equations.*

The asymptotic behavior of solutions to a non-autonomous stochastic wave equation with nonlinear damping and multiplicative white noise on an unbounded domain is presented in this talk. By showing the pullback asymptotic compactness of the generated dynamical system in certain parameter region, the existence of a random attractor is proved. Moreover, for the stochastic wave equation with rapidly oscillating external force it is proved that the Hausdorff distance between the random attractor $\mathcal{A}_\epsilon$ of the original equation and the random attractor $\mathcal{A}_0$ of the averaged equation converges to zero. (Received September 02, 2014)

1104-35-230 **Michael J Goldberg*** (goldbeml@ucmail.uc.edu), Department of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221-0025, and **William Green** (green@rose-hulman.edu), Department of Mathematics, Rose-Hulman Institute of Technology, TerreHaute, IN 47803. *Dispersive Estimates for Schrödinger Operators with a Threshold Eigenvalue.*

We prove dispersive estimates for the Schrödinger evolution $e^{itH}P_{ac}(H)$ in $\mathbb{R}^n$, $n \geq 5$, where $H = -\Delta + V(x)$ has an eigenvalue at zero. As a map from $L^1(\mathbb{R}^n)$ to $L^\infty(\mathbb{R}^n)$ there is a rank one term decaying at the rate $|t|^{2-\frac{n}{2}}$ and a finite rank operator with time decay $|t|^{1-\frac{n}{2}}$. The asymptotic expansion continues into more heavily weighted spaces; we show in particular that the remainder term after these finite rank pieces exists as a map from $\langle x\rangle^{-2}L^1$ to $\langle x\rangle^2 L^\infty$.

The initial finite rank terms both vanish if the eigenspace of H satisfies certain cancellation conditions, or equivalently if each eigenfunction satisfies the bound $|\psi(x)| \leq C(1+|x|)^{-n}$. The extra cancellation also removes all need for weights when describing the behavior of the remaining evolution. Under those conditions we recover the same dispersive bound, mapping $L^1(\mathbb{R}^n)$ to $L^\infty(\mathbb{R}^n)$ with norm $|t|^{-\frac{n}{2}}$, as when zero is a regular point of the spectrum. (Received September 02, 2014)

1104-35-236 **Ricardo J. Alonso**, **Irene M. Gamba**, **Nataša Pavlović** and **Maja Tasković*** (mtaskovic@math.utexas.edu), The University of Texas at Austin, Mathematics Dept, RLM 8.100, 2515 Speedway Stop C1200, Austin, TX 78712-1202. *On summability of moments for the Boltzmann equation without Grad's cutoff.*

We consider the spatially homogeneous Boltzmann equation without the Grad's cutoff assumption in the case of variable hard potentials, and study the behavior of its exponential moments of order $s \in (0, 2)$. We provide a new proof of the generation of exponential moments of order up to the rate of potentials (γ). To examine the behavior of exponential moments of order beyond γ, we introduce Mittag-Leffler moments - a generalization of the exponential moments. The propagation of Mittag-Leffler moments of order $s \in (\gamma, 1]$ is proved under the full non-cutoff assumption. The propagation of Mittag-Leffler moments of order $s \in (1, 2)$ is proved under a modified non-cutoff assumption.

This is joint work with Ricardo J. Alonso, Irene M. Gamba, and Nataša Pavlović. (Received September 02, 2014)

1104-35-237 **Deniz Bilman*** (dbilma2@uic.edu), Department of Mathematics, 322 Science and Engineering Offices (M/C 249), 851 S Morgan St, Chicago, IL 60607, and **Irina Nenciu**. *On the evolution of scattering data under perturbations of the Toda lattice.*

We present the results of an analytical and numerical study of the long-time behavior for certain Fermi-Pasta-Ulam (FPU) lattices viewed as perturbations of the completely integrable Toda lattice. Our main tools are the direct and inverse scattering transforms for doubly-infinite Jacobi matrices, which are well-known to linearize the Toda follow. We focus in particular on the evolution of the associated scattering data under the perturbed vs. the unperturbed equations. (Received September 02, 2014)

1104-35-245 **Mihaela Ifrim** and **Daniel Tataru*** (tataru@math.berkeley.edu). *The lifespan of two dimensional water waves.*

The aim of this talk is to describe recent work on long term dynamics for two dimensional water waves in various settings. This talk tied together with the talk of my collaborator, Mihaela Ifrim. (Received September 02, 2014)

1104-35-246 **Jason Metcalfe*** (metcalfe@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Decay of electromagnetic waves on black hole backgrounds.* Preliminary report.

This is a joint work with D. Tataru and M. Tohaneanu. We prove pointwise decay estimates for solutions to Maxwell's equation on black hole backgrounds. This is related to the authors' previous work on Price's law for linear wave equations on the same backgrounds. (Received September 02, 2014)

1104-35-247 **Jason C. Murphy*** (murphy@math.berkeley.edu). *Nonlinear Schrödinger equations at non-conserved critical regularity.*

We consider a class of defocusing nonlinear Schrödinger equations for which the power of the nonlinearity is neither mass-critical nor energy-critical. Following a concentration-compactness approach, we will show that any solution that remains bounded in the critical Sobolev must be global and scatter. (Received September 02, 2014)

1104-35-256 **Mihaela Ifrim*** (ifrim@berkeley.edu) and **Daniel Tataru** (tataru@berkeley.edu). *Tow dimensional water waves in holomorphic coordinates.*

Together with Daniel Tataru, we develop a *quasilinear modified energy method* which we use for the water wave equations written in holomorphic coordinates (Nalimov'74). This method yields an easier route to long time solutions and can be viewed as a quasilinear adaptation of Shatah's normal form method. In the same context, we also introduce the *method of testing by wave packets*, which is a more efficient way to obtain asymptotic equations in problems which exhibit modified scattering asymptotics. (Received September 02, 2014)

1104-35-268 **Benjamin Harrop-Griffiths*** (benhg@math.berkeley.edu), **Mihaela Ifrim** (ifrim@math.berkeley.edu) and **Daniel Tataru** (tataru@math.berkeley.edu). *The lifespan of small data solutions to the KP-I.*

We show that for small, localized initial data there exists a global solution to the KP-I equation in a Galilean-invariant space using the method of testing against wave packets. (Received September 02, 2014)

1104-35-269 **Matthew D Blair*** (blair@math.unm.edu). *On Strichartz and localized energy estimates for dispersive equations in domains.*

We consider Strichartz estimates for wave and Schrödinger equations, which are a family of space time integrability estimates that rely on the dispersive effects of the solution map. While such estimates are reasonably well understood in Euclidean space, less is known about their validity in domains, where the imposition of boundary conditions affect the flow of energy. We discuss recent progress in establishing scale invariant Strichartz estimates in domains with a strictly concave boundary, highlighting their connection with a family of localized energy estimates. (Received September 02, 2014)

1104-35-277 **Andrew Lawrie** and **Sung-Jin Oh*** (sjoh@math.berkeley.edu), UC Berkeley, Dept of Math, 970 Evans Hall, Berkeley, CA 94720, and **Sohrab Shahshahani**. *Wave maps from the hyperbolic plane.*

In this talk, we consider equivariant wave maps from the hyperbolic plane into two model rotationally symmetric targets, namely the two sphere ($\mathbb{S}^2$) and the hyperbolic plane itself ($\mathbb{H}^2$). Due to the non-Euclidean geometry of the domain, this problem exhibits markedly different phenomena compared to its Euclidean counterpart. For instance, there exist numerous stationary solutions to not only $\mathbb{S}^2$ but also $\mathbb{H}^2$, which has a negative constant curvature. Moreover, when the target is $\mathbb{S}^2$, the spectrum of the linearized operator about certain stationary solutions possesses a *gap eigenvalue*, i.e., a simple eigenvalue in the gap $(0, 1/4)$ between 0 and the essential spectrum. (Received September 02, 2014)

1104-35-305 **Gregorio Chinni*** (chinni@ime.usp.br), IME USP, Rua do Matão 1010, Butantã, São Paulo, SP , Brazil. *Perturbation of Globally Gevrey Hypoelliptic Operators.*

Let $P(x, D)$ be a sum of squares analytic operator defined on the N-dimensional torus $\mathbb{T}^N$ satisfying the Hörmander condition. It follows from a celebrated result of Hörmander [Acta Math. **119**, 1967, 147–171] that $P(x, D)$ is locally subelliptic and hypoelliptic. By an easy global argument it then follows that there is an $\epsilon > 0$ such that every solution to $P(x, D) = f \in H^s(\mathbb{T}^N$ belongs to $H^{s+\epsilon}(\mathbb{T}^N)$. The question we are dealing with is the following pertubation property: assume that $P(x, D)$ as above is also globally Gevrey hypoelliptic of order $s \geq 1$. Is it true that $P(x, D) + \Psi(x, D)$ is also globally Gevrey hypoelliptic of order $s \geq 1$, where $\Psi(x, D)$ is an analytic pseudodifferential operator on $\mathbb{T}^N$ of order $< \epsilon$? In order words, can we assert that the subellipticity of $P(x, D)$ is related with the order of perturbation that preserves the global Gevrey hypoelliptic of order $s \geq 1$? We have the precise answer in the following cases: 1) P belongs to the class discussed in [Cordaro, P. and Himonas, A., Math.Res.Letters **1**, 1994, 501–510.] 2) $P = P(D)$ is not necessarily in Hörmander class but has constant coeficients and is hypoelliptic as an operator in $\mathbb{R}^N$. (Received September 03, 2014)

1104-35-308 **Javier Gomez-Serrano*** (jg27@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544. *Computer-assisted proofs in incompressible fluids.*

In this talk we will present some results in problems related to fluid mechanics such as the Muskat problem or the α-patches problem that make use of the computer as a tool to prove rigorous theorems.

Joint work with Angel Castro, Diego Cordoba, Rafael Granero-Belinchon and Alberto Martin Zamora. (Received September 03, 2014)

1104-35-314 **Timur Akhunov*** (takhunov@ur.rochester.edu), Hylan building office 820, University of Rochester, Rochester, NY 14607, and **Cristian Rios**. *Hypoellipticity beyond Hormander's bracket criterion.* Preliminary report.

Elliptic differential equations are a natural generalization of the Laplace equation, one of the most intensely studied differential equations. These equations arise in modeling a wide variety of natural phenomena, with fluid motion and population dynamics being some of the examples. A key question in the analysis of such equations is the possibility of singularities and shocks. One of the mathematical formulations of such phenomena, going back to the influential work of Leon Schwartz, is the question of hypoellipticity. Namely, do smooth input always lead to smooth solutions for a given equation? Or are rough distributional solutions, that may even fail to be functions, possible? Even for linear equations, where the superposition principle holds, this question is highly nontrivial for degenerate elliptic equations. Little is known beyond the famous "bracket condition" of Lars Hormander. We hope that you will get interested in some new progress in this exciting field. (Received September 03, 2014)

1104-35-316 **Hongjie Dong***, 182 George Street, Providence, RI 02912. *Some new results on partial Schauder estimates.*

Under various conditions, we establish Schauder estimates for both divergence and non-divergence form second-order elliptic and parabolic equations involving Hölder semi-norms not with respect to all, but only with respect to some of the independent variables. (Received September 03, 2014)

1104-35-339 **Weiwei Hu**, **Igor Kukavica*** (kukavica@usc.edu), **Fei Wang** and **Mohammed Ziane**. *On global existence for the 2D Boussinesq system.*

We consider the regularity for the 2D Boussinesq equations which consist of the Navier-Stokes equations driven by a density, which is in turn advected by the velocity. We discuss global existence results for data belonging to Sobolev spaces. (Received September 03, 2014)

1104-35-340 **Alexey Cheskidov***, Department of Mathematcs, UIC, Chicago, IL 6007. *Regularity of turbulent flows: Kolmogorov's dissipation range and intermittency.*

We will discuss regularity properties of solutions to the 3D Navier-Stokes equations and their connection to turbulence. In particular, we show that solutions are regular provided the intermittency dimension is larger than 3/2. We will also discuss some recent ill-posedness results, even in spaces where small initial data results are available. (Received September 03, 2014)

42 ► Fourier analysis

1104-42-36 **David Cruz-Uribe** and **José María Martell*** (chema.martell@icmat.es), Instituto de Ciencias Matemáticas, CSIC-UAM-UC3M-UCM, C/ Nicolas Cabrera, 13-15, 28049 Madrid, Spain, and **Cristian Rios**. *The Kato square root problem for degenerate elliptic operators revisited.*

Let L_w be a divergence form degenerate elliptic operator with degeneracy controlled by a Muckenhoupt A_2 weight w. C. Rios and D. Cruz-Uribe solved the Kato problem for L_w obtaining that these operators satisfy the $L^2(w)$-estimates

$$\|L_w^{1/2} f\|_{L^2(w)} \approx \|\nabla f\|_{L^2(w)}.$$

In this talk we will present some recent results showing that, for some restricted class of A_2 weights, we can obtain the unweighted Kato problem for degenerate elliptic operators, that is,

$$\|L_w^{1/2} f\|_{L^2(dx)} \approx \|\nabla f\|_{L^2(dx)}.$$

These estimates are proved by developing the $L^p(w)$-theory for the operators associated with L_w and by establishing "weighted" estimates (with respect to the underlying measure $dw(x) = w(x)\,dx$) for these operators. (Received July 28, 2014)

1104-42-84 **Dorina Mitrea*** (mitread@missouri.edu), University of Missouri, Department of Mathematics, 202 Math. Sci. Bldg., Columbia, MO 65211. *Characterizing Lyapunov domains via Riesz transforms on Hölder spaces.* Preliminary report.

We show that under mild geometric measure theoretic assumptions on a domain, the condition that the domain is Lyapunov is equivalent with having the Riesz transforms continuous on the corresponding Hölder space of its boundary. (Received August 22, 2014)

1104-42-159 **Emilio Marmolejo-Olea***, Department of Mathematics University of, Columbia, Missouri, Columbia, MO 65203, and **Dorina Mitrea**, **Irina Mitrea** and **Marius Mitrea**, Deparment of Mathematics, University of Missouri. *Integral Representation Formulas and Radiation Conditions for Clifford valued functions.* Preliminary report.

We present radiation conditions and Integral representation formulas for solutions of the Helmholtz operator in an exterior domain for functions with values in a Clifford algebra. As particular cases this includes time-harmonic Maxwell systems satisfying the Silver-Müller condition. (Received August 29, 2014)

43 ► Abstract harmonic analysis

1104-43-146 **Ryan Alvarado*** (rjamt9@mail.missouri.edu) and **Marius Mitrea**. *Hardy Spaces and the Geometry of Sets.*

The primary focus of this talk is on how the geometric make-up of a given ambient can directly influence the amount of analysis that the underlying space can support. As an illustration of the interplay between these two

branches of mathematics we will survey some recently obtained results pertaining to the theory of Hardy spaces (H^p spaces) in the setting of d-dimensional Ahlfors-regular quasi-metric spaces. In particular, we will provide examples of several environments which highlight how the nature of these H^p spaces is intimately linked with the geometry of the ambient. These examples include fractal sets such as the four-corner planar Cantor set. As an application of this theory we will present a new, general criterion guaranteeing boundedness in H^p of linear operators. The presented work is in collaboration with M. Mitrea. (Received August 28, 2014)

47 ► Operator theory

1104-47-284 **Ilker Arslan*** (ilkerarslan@sabanciuniv.edu), camlik mah. Fatih cad. emre sok. no:1/9, cekmekoy, 34782 istanbul, Turkey, and **Plamen Borissov Djakov**. *Characterization of the Smoothness of the One Dimensional Dirac Opearators Subject to General Boundary Conditions.*

We consider the one dimensional Dirac operators with periodic potentials which have discrete spectrums. Playing with the boundary conditions makes changes to the spectral values associated with different boundary conditions. It is known that the rate of the decay of the spectral gaps depends on the smoothness of the potential. More specifically, we already know the result that this relation holds with the triple (periodic, antiperiodic and Dirichlet) boundary conditions. I am planning to talk about this relation and some conditions on how much we can change this triple to get the same results. (Received September 03, 2014)

52 ► Convex and discrete geometry

1104-52-42 **Jesus A. De Loera*** (deloera@math.ucdavis.edu), Dept. of Mathematics, Univ. of California, Davis, CA 95616. *Integral versions of Helly's theorem and Applications.*

The famous Doignon-Bell-Scarf theorem is a Helly-type result about the existence of integer solutions on systems linear inequalities. The purpose of this paper is to present the following "weighted" generalization: Given an integer k, we prove that there exists a constant $c(k, n)$, depending only on the dimension n and k, such that if a polyhedron $x : Ax = b$ contains exactly k integer solutions, then there exists a subset of the rows of cardinality no more than $c(k, n)$, defining a polyhedron that contains exactly the same k integer solutions. We work on both upper and lower bounds for this constant. All new results joint work with I. Aliev, Q. Louveaux, R. Bassett (Received August 05, 2014)

1104-52-43 **Winfried Bruns*** (wbruns@uos.de), Universität Osnabrück, FB Mathematik/Informatik, 49069 Osnabrück, Germany. *Recent extensions of Normaliz.*

Normaliz is a computer program for the computation of Hilbert bases of the monoids of lattice points in rational cones, their Hilbert series and related data. In the last year several algorithmic improvements have been implemented, for example in the parallelization of Fourier-Motzkin elimination and pyramid decomposition, in the computation of lattice points in rational polytopes and in the treatment of large simplicial cones. More importantly, the functionality has been extended by the computation of lattice points polyhedra in general and Hilbert series of "semi-open" monoids. (Received August 06, 2014)

1104-52-54 **Martin Henk*** (henk@math.tu-berlin.de). *Cone-volume measure of convex bodies.*

We show that the cone-volume measure of a convex body with centroid at the origin satisfies the subspace concentration condition. This implies, among others, a conjectured best possible inequality for the U-functional of a convex body. For both results we provide stronger versions in the sense of stability inequalities.

(This is joint work with Károly J. Böröczky) (Received August 15, 2014)

1104-52-85 **Andreas Paffenholz*** (paffenholz@mathematik.tu-darmstadt.de), TU Darmstadt, FB Mathematik, Dolivostr. 15, 64293 Darmstadt, Germany. *Finiteness of the polyhedral $\mathbb{Q}$-codegree spectrum.*

The codegree of a lattice polytope P is the smallest integer k such that the k-th dilate of P has an interior lattice point. This is an important and widely studied number-theoretic invariant of a lattice polytope. The rational $\mathbb{Q}$-codegree can be seen as a polyhedral analogue more accessible to geometric methods. In this talk we explain the relevant notions and basic results. In particular, high $\mathbb{Q}$-codegree has strong structural implications on the lattice polytope.

Initially, the definition of the $\mathbb{Q}$-codegree was motivated by an algebraic invariant, the unnormalized spectral value, using the correspondence between lattice polytopes and polarized toric varieties. The spectrum conjecture of Fujita asks whether the set of values the unnormalized spectral value of a smooth polarized variety can assume above any positive threshold is finite. In the main part of the talk we show how the polyhedral methods introduced above can be used to settle this conjecture in the toric case.

Part of this is joint work with Sandra Di Rocco, Christian Haase, and Benjamin Nill. (Received August 22, 2014)

1104-52-86 **Mateusz J Michalek*** (wajcha2@poczta.onet.pl), Zapolskiej 42 m 83, 30126 Krakow, Poland. *Numerical properties of lattice polytopes.*

In our talk we address properties of numerical invariants of a lattice polytope P and its dilations. These include μ_{idp} - the smallest number such that nP is normal for $n \geq \mu_{idp}$ and μ_{Hilb}, the highest degree of the Hilbert basis element of the cone over P.

There are well-known inequalities among such invariants, e.g. $\mu_{idp} \leq \dim P - 1$. In our talk, we would like to present results with number theoretic flavor. For example, there exists a polytope P with $\mu_{Hilb} = n$ and $\mu_{idp} = 2$ if and only if n is a prime number.

We present a construction, through lattice segmental fibrations due to Beck, Delgado and Gubeladze, that allows to present polytopes with very special numerical properties. In particular, we answer several open questions concerning μ_{idp} of very ample polytopes and their gap vectors. These results are from a joint work with Michał Lasoń. (Received August 22, 2014)

1104-52-93 **Guangxian Zhu*** (gz342@nyu.edu), Department of Mathematics, Polytechnic School of Engineering, New York University, Brooklyn, NY 11201. *The logarithmic Minkowski problem for polytopes.*

The logarithmic Minkowski problem of convex bodies in the Euclidean space asks for necessary and sufficient conditions for a finite Borel measure on the unit sphere so that it is the cone-volume measure of a convex body. The problem was solved recently by Boroczky, Lutwak, Yang and Zhang for symmetric convex bodies. Here, we solve the problem for polytopes whose outer unit normals are in general position. We prove that a discrete measure on the unit sphere is the cone-volume measure of a polytope if and only if the support of the measure is not concentrated in a closed hemisphere and is in general position. (Received August 23, 2014)

1104-52-143 **Steven D Hoehner*** (sdh60@case.edu), 10900 Euclid Ave, Yost Hall, 201, Cleveland, OH 44107, and **Carsten Schuett** and **Elisabeth Werner**. *The Surface Area Defect of the Euclidean Ball and a Polytope.*

There is a constant c such that for every $n \in \mathbb{N}$, there is an N_n such that for every $N \geq N_n$ there is a polytope P in $\mathbb{R}^n$ with N vertices such that

$$\mathrm{vol}_{n-1}\left(\partial(B_2^n \Delta P)\right) \leq c\, \frac{\mathrm{vol}_{n-1}\left(\partial B_2^n\right)}{N^{\frac{2}{n-1}}},$$

where for two convex bodies K and L, $\mathrm{vol}_{n-1}\left(\partial(K\Delta L)\right)$ is the surface area of the symmetric difference of K and L. (Received August 28, 2014)

1104-52-185 **Deping Ye*** (deping.ye@mun.ca), Department of Mathematics and Statistics, Memorial University of Newfoundland, St. John's, NL A1C 5S7, Canada. *On Orlicz Affine Isoperimetric Inequalities.*

Affine isoperimetric inequalities and its L_p extensions are powerful tools in convex geometry, and receive extensive consideration. These inequalities, such as, Santaló inequality, are arguably more useful than the classical isoperimetric inequality.

In this talk, I will discuss some Orlicz affine isoperimetric inequalities, which are nontrivial and nonhomogeneous extensions of its L_p counterparts. (Received August 31, 2014)

1104-52-188 **Greg Kuperberg*** (greg@math.ucdavis.edu). *From the Mahler conjecture to the isotropic constant conjecture?* Preliminary report.

To be clear, I don't know how to prove the isotropic constant conjecture or anything close to it. Instead, I will review various small partial results related to the Mahler conjecture and the isotropic constant conjecture. In particular I am interested in other possible uses of the shapes K^+, K^-, and $K^\diamond$ that arose in my proof of the Bourgain-Milman theorem. (Received September 01, 2014)

1104-52-190 **Andrea Colesanti*** (colesant@math.unifi.it), Viale Morgagni 67/a, I50134 Firenze, Italy. *Monotonicity and concavity of integral functionals defined on n-dimensional convex bodies.*

We consider an integral functional F of the form

$$F(K) = \int_{\mathbb{S}^{n-1}} f(u) dS_i(K; u),$$

where: K is a convex body in the n-dimensional Euclidean space $\mathbb{R}^n$, $\mathbb{S}^{n-1}$ is the unit sphere, f is a continuous function on $\mathbb{S}^{n-1}$ and, for $i \in \{1, \dots, n\}$, $S_i(K; \cdot)$ is the i-th area measure of K. Our scope is to find conditions on f such that F is either monotone with respect to set inclusion, or it verifies a Brunn-Minkowski type inequality. (Received September 01, 2014)

1104-52-193 **Florian Besau*** (florian.besau@tuwien.ac.at) and **Elisabeth Werner**. *The Spherical Convex Floating Body.*

We introduce the spherical convex floating body for a convex body on the Euclidean unit sphere. The asymptotic behavior of the volume difference of a spherical convex body and its floating body is investigated. This gives rise to a new spherical area measure, the floating measure. Remarkably, this floating measure turns out to be a spherical analogue to the classical affine surface area from affine differential geometry. We show that the floating measure is an upper-semicontinuous valuation and establish an isoperimetric inequality. (Received September 01, 2014)

1104-52-202 **Umut Caglar*** (uxc8@case.edu) and **Elisabeth M. Werner** (emw2@case.edu). *Mixed f-divergence and inequalities for log concave functions.*

Mixed f-divergences, a concept from information theory and statistics, measure the difference between multiple pairs of distributions. We introduce them for log concave functions and establish some of their properties. Among them are affine invariant vector entropy inequalities, like new Alexandrov-Fenchel type inequalities and an affine isoperimetric inequality for the vector form of the Kullback Leibler divergence for log concave functions.

Special cases of f-divergences are mixed L_λ-affine surface areas for log concave functions. For those, we establish various affine isoperimetric inequalities as well as a vector Blaschke Santaló type inequality. (Received September 01, 2014)

1104-52-216 **Galyna V Livshyts*** (glivshyt@kent.edu), 233, Summit street, Kent, OH 44242. *On the version of the Gaussian Brunn-Minkowski inequality.*

The classical Brunn-Minkowski inequality in one of the forms states that for any measurable sets $A, B \subset \mathbb{R}^n$ and for any $\lambda \in [0, 1]$,

$$|\lambda A + (1-\lambda)B|^{\frac{1}{n}} \geq \lambda |A|^{\frac{1}{n}} + (1-\lambda)|B|^{\frac{1}{n}},$$

where $|\cdot|$ stands for the standard Lebesgue measure. R. Gardner and A. Zvavitch conjectured that for the standard Gaussian measure γ_2 the same inequality holds under some natural assumptions on the sets A and B. Some progress have been made by T. Tkocza and P. Nayar but it remains unclear whether the inequality

$$\gamma_2(\lambda A + (1-\lambda)B)^{\frac{1}{n}} \geq \lambda \gamma_2(A)^{\frac{1}{n}} + (1-\lambda)\gamma_2(B)^{\frac{1}{n}}$$

is true or false when both A and B are origin-symmetric. We discuss some results in this direction. (Received September 01, 2014)

1104-52-229 **Elizabeth Meckes*** (ese3@case.edu), Dept. of Mathematics, 231 Yost Hall, Case Western Reserve University, Cleveland, OH 44106, and **Mark Meckes**. *On the equivalence of modes of convergence for log-concave measures.*

An important theme in recent work in asymptotic geometric analysis is that many classical implications between different types of geometric or functional inequalities can be reversed in the presence of convexity assumptions. I will discuss recent work with M. Meckes in which we explore the extent to which different notions of distance between probability measures are comparable for log-concave distributions. Our results imply that weak convergence of isotropic log-concave distributions is equivalent to convergence in total variation, and is further equivalent to convergence in relative entropy when the limit measure is Gaussian. (Received September 02, 2014)

1104-52-244 **M. Alfonseca-Cubero***, maria.alfonseca@ndsu.edu, and **M. Cordier** and **D. Ryabogin**. *Rotations of projections of convex bodies.* Preliminary report.

Let K and L be two convex bodies containing the origin. If for each hyperplane passing through the origin, the projection of K can be rotated around the origin to fit inside the projection of L, can K be rotated to fit into L?

We will present counterexamples and additional conditions so that the result is true. (Received September 02, 2014)

1104-52-257 **Susanna Dann**, **Grigoris Paouris** and **Peter Pivovarov*** (pivovarovp@missouri.edu). *Functional analogues of Busemann-type inequalities.* Preliminary report.

Busemann's intersection inequality concerns central hyperplane sections of a convex body $K \subset \mathbb{R}^n$ and can be stated as

$$\int_{S^{n-1}} |K \cap \theta^{\perp}|^n d\sigma(\theta) \leq \frac{\omega_{n-1}^n}{\omega_n^{n-1}} |K|^{n-1};$$

equality holds only for origin-symmetric ellipsoids. Here $|\cdot|$ denotes Lebesgue measure, ω_n is the volume of the Euclidean ball B_2^n, S^{n-1} is the sphere, equipped with the Haar probability measure σ. I will discuss functional forms of the latter inequality and its various generalizations. Examples include the analogue for k-dimensional sections $|K \cap E|$, where E is an element of the Grassmannian manifold $G_{n,k}$ of k-dimensional linear subspaces of $\mathbb{R}^n$, due to Busemann-Straus and Grinberg, as well as the related affine versions due to Schneider. (Received September 02, 2014)

1104-52-260 **Dmitry Ryabogin*** (ryabogin@math.kent.edu), OH. *On uniqueness questions of convex bodies in R^3 and R^4.* Preliminary report.

We will discuss several uniqueness questions about projections and sections of convex bodies. (Received September 02, 2014)

1104-52-261 **Vladyslav Yaskin*** (yaskin@ualberta.ca) and **Ning Zhang**. *Non-central sections of convex bodies.* Preliminary report.

In recent years a lot of attention has been attracted to the following open problem, suggested by Barker and Larman. Let K and L be convex bodies in $\mathbb{R}^n$ ($n \geq 2$) that contain a Euclidean ball B in their interiors. If $\mathrm{vol}_{n-1}(K \cap H) = \mathrm{vol}_{n-1}(L \cap H)$ for every hyperplane H tangent to B, does it follow that $K = L$? I will talk about some modifications of this problem. (Received September 02, 2014)

1104-52-272 **Velleda Baldoni**, **Nicole Berline**, **Jesús A. De Loera**, **Matthias Köppe*** (mkoeppe@math.ucdavis.edu) and **Michèle Vergne**. *Real multi-parameter Ehrhart theory: Highest degree terms.*

We study sums $S(P(b), h)$ of polynomials h over the lattice points in multi-parameter polytopes $P(b) = \{\, Ax \leq b \,\}$, where A is rational and $b \in \mathbb{R}^N$ is a *real* parameter vector. On every chamber, $S(P(b), h)$ is a generalized quasi-polynomial function of b, called the (weighted, real, multi-parameter) Ehrhart quasi-polynomial. It is a polynomial in variables b_i whose coefficients are periodic functions of the *real* parameters b_i. We give an algorithm for computing them in a certain closed form ("rational step-polynomials").

This extends to the case of intermediate sums, which interpolate between integrals and discrete sums. Similar to Barvinok (2006), we show that certain linear combinations of the intermediate Ehrhart quasi-polynomials give an approximation of the Ehrhart quasi-polynomial. This gives an algorithm for computing the coefficients of the terms of the highest k degrees in variables b_i. In various interesting settings for varying dimension but fixed k, it runs in polynomial time.

The results are proved on the level of multi-parameter generating functions. We study their bidegree structure and approximation. (Received September 02, 2014)

1104-52-276 **David Alonso-Gutiérrez**, **Alexander E. Litvak** and **Nicole Tomczak-Jaegermann*** (nicole.tomczak@ualberta.ca), , Canada. *On the isotropic constant of random polytopes.* Preliminary report.

Let $X_1, \ldots, X_N$ be independent random vectors uniformly distributed on an isotropic convex body $K \subset \mathbb{R}^n$, and let K_N be the symmetric convex hull of X_i's. We show that with high probability isotropic constant L_{K_N} satisies $L_{K_N} \leq C\sqrt{\log(2N/n)}$, where C is an absolute constant. This result closes the gap in known estimates in the range $Cn \leq N \leq n^{1+\delta}$. Some further extentions of our estimates are also considered. (Received September 03, 2014)

1104-52-281 **Mokshay Madiman*** (madiman@udel.edu) and **Liyao Wang**. *Optimal concentration of information for log-concave distributions.* Preliminary report.

A sharp uniform bound is obtained for the variance of the information content within the class of log-concave distributions. In particular, this yields the optimal strengthening of the equipartition property for such distributions recently proved by Bobkov and the first-named author. Some applications are outlined. (Received September 03, 2014)

1104-52-317 **Matthias Beck**, Department of Mathematics, San Francisco State University, San Francisco, CA 94132, **Pallavi Jayawant**, Department of Mathematics, Bates College, Lewiston, ME 04240, and **Tyrrell B McAllister*** (tmcallis@uwyo.edu), Department of Mathematics, University of Wyoming, Laramie, WY 82071. *Lattice-point generating functions for free sums of polytopes.*

Let $\mathcal{P}$ and $\mathcal{Q}$ be polytopes in $\mathbb{Q}^n$ whose affine spans intersect at a single rational point in $\mathcal{P} \cap \mathcal{Q}$, and let $\mathcal{P} \oplus \mathcal{Q} = \mathrm{conv}(\mathcal{P} \cup \mathcal{Q})$. We give formulas for the generating function

$$\sigma_{\mathrm{cone}(\mathcal{P}\oplus\mathcal{Q})}(z_1, \ldots, z_n, z_{n+1}) = \sum_{(m_1,\ldots,m_n)\in t(\mathcal{P}\oplus\mathcal{Q})\cap\mathbb{Z}^n} z_1^{m_1} \cdots z_n^{m_n} z_{n+1}^t$$

of lattice points in all integer dilates of $\mathcal{P} \oplus \mathcal{Q}$ in terms of $\sigma_{\mathrm{cone}\,\mathcal{P}}$ and $\sigma_{\mathrm{cone}\,\mathcal{Q}}$, under various conditions on $\mathcal{P}$ and $\mathcal{Q}$. This work is motivated by (and recovers) a product formula of B. Braun for the Ehrhart series of $\mathcal{P} \oplus \mathcal{Q}$ in the case where $\mathcal{P}$ and $\mathcal{Q}$ are lattice polytopes containing the origin, one of which is reflexive. In particular, we find necessary and sufficient conditions for Braun's formula and its multivariate analogue. (Received September 03, 2014)

1104-52-338 **Karoly Bezdek** and **Alexander E. Litvak*** (aelitvak@gmail.com), Dept. of Math. and Stat. Sciences, University of Alberta, Edmonton, Alberta T6G2G1, Canada. *Covering and packing convex bodies by cylinders.* Preliminary report.

In connection with a Bang's problem, we provide a lower bound for the sum of the base volumes of cylinders covering a d-dimensional convex body in terms of the relevant basic measures of the given convex body. We discuss related estimates for packing. (Received September 03, 2014)

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1104-53-9 **Kazuyuki Enomoto*** (enomoto_kazuyuki@rs.tus.ac.jp), Oshamambe, Hokkaido 049-3514, Japan. *The total absolute torsion of open curves in E^3.*

The total absolute torsion of smooth curves in E^3 is defined as the total integral of the absolute value of the torsion. This notion is extended to piecewise smooth curves. We study the infimum of the total absolute torsion in a certain set of curves, where the endpoints, the osculating planes at the endpoints and the length are all prescribed. We show how the infimum is calculated from the boundary data. (Received April 05, 2014)

1104-53-12 **Lovejoy S Das*** (ldas@kent.edu), 330 University Dr. NE, New Philadelphia, OH 44663. *Second Order Parallel Tensors on LP-Sasakian Manifolds with a Coefficient alpha.*

Abstract: In 1926, Levy [5] had proved that a second order symmetric parallel nonsingular tensor on a space of constant curvature is a constant multiple of the metric tensor. Sharma [6] has proved that a second order parallel tensor in a Kachler space of constant holomorphic sectional curvature is a linear combination with constant coefficient of the Kachlerian metric and the fundamental 2-form. In this paper, we have shown that a second order symmetric parallel tensor on Lorentrian Para Saskian manifold (briefly LP-Sasakian) with a coefficient alpha (non zero Scalar function) is a constant multiple of the associated metric tensor and we have also proved that there is no non zero skew symmetric second order parallel tensor on a LP-Saskian manifold. (Received April 19, 2014)

1104-53-14 **Bogdan D. Suceavă***, 800 N State College Blvd, 154 McCarthy Hall, Fullerton, CA 92834-6850. *Curvature estimates based on various classes of algebraic inequalities.*

In the last two decades, inspired by B.-Y. Chen's study of his δ-invariants, there have been important advances in the study of new curvature invariants. First, by using an idea described by Cvetkovski, we obtain an estimate of the Gauss-Kronecker curvature of a three-dimensional smooth hypersurface in the four dimensional Euclidean space in function of its mean curvature and its scalar curvature. Then we discuss the geometric meaning of the amalgamatic curvature and we show how a new class of geometric objects is obtained: the absolutely umbilical hypersurfaces. (Received May 28, 2014)

1104-53-15 **Ramesh Sharma*** (rsharma@newhaven.edu), 300 Boston Post Rd., West Haven, CT 06516. *Characterizations of almost contact Lagrangian submanifolds of nearly Kaehler unit 6-sphere.* Preliminary report.

First, we show that a global unit vector field on a Lagrangian submanifold M of the nearly Kaehler 6-sphere, induces an almost contact metric structure on M. Then, we provide characterizations of M, under conditions when the induced structure is (i) contact metric, and (ii) normal almost contact metric. In particular, we show

that this structure is Sasakian if and only if a specifically designed $(1,1)$-tensor field on M vanishes. (Received May 28, 2014)

1104-53-35 **Peng Wu*** (wupenguin@math.cornell.edu). *A Weitzenböck formula for generalized quasi-Einstein manifolds.*

In this talk we will first provide an alternative proof of Derdziński's Weitzenböck formula for Einstein four-manifolds using Berger curvature decomposition. Using a similar argument, we will derive a Weitzenböck formula for four-dimensional generalized quasi-Einstein manifolds. We will also discuss applications of the Weitzenböck formula. (Received July 16, 2014)

1104-53-60 **Gang Liu*** (gangliu@berkeley.edu), 970 evans Hall, Berkeley, CA 94720. *On the volume growth of Kahler manifolds with nonnegative bisectional curvature.*

Let M be a complete Kahler manifold with nonnegative bisectional curvature. Assume the universal cover does not split and M admits a nonconstant holomorphic function with polynomial growth, we prove M is of maximal volume growth. This confirms a conjecture of Lei Ni. The proof is based on Gromov-Hausdorff convergence and the three circle theorem. (Received August 18, 2014)

1104-53-65 **Longzhi Lin*** (lzlin@ucsc.edu), Mathematics Department, University of California, Santa Cruz, 1156 High Street, Santa Cruz, CA 95064, and **Robert Haslhofer**, Courant Institute of Mathematical Sciences, New York University. *Star-shaped mean curvature flow.*

Recently Haslhofer and Kleiner used Andrew's α-noncollapsing result to give a new treatment of the theory of mean convex mean curvature flows, which was established earlier by White and Huisken-Sinestrari in a series of works. In this talk we will discuss the analogous local curvature and convexity estimates for star-shaped mean curvature flows and the consequences. This is joint work with Robert Haslhofer. (Received August 19, 2014)

1104-53-72 **Michael Bradford Williams** (mwilliams@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095, and **Haotian Wu*** (hwu@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Dynamical stability of algebraic Ricci solitons.*

We consider dynamical stability for a modified Ricci flow equation whose stationary solutions include Einstein and Ricci soliton metrics. We focus on homogeneous metrics on non-compact manifolds. Following the program of Guenther, Isenberg, and Knopf, we define a class of weighted little Hölder spaces with certain interpolation properties that allow the use of maximal regularity theory and the application of a stability theorem of Simonett. With this, we derive two stability theorems, one for a class of Einstein metrics and one for a class of non-Einstein Ricci solitons. Using linear stability results of Jablonski, Petersen, and Williams, we obtain dynamical stability for many specific Einstein and Ricci soliton metrics on simply connected solvable Lie groups. (Received August 19, 2014)

1104-53-98 **Jason H Cantarella***, UGA Math Department, Boyd GSRC, Athens, GA 30602, and **Clayton Shonkwiler**. *New Algorithms for Sampling Closed Equilateral Random Walks in $\mathbb{R}^3$ based on Symplectic Geometry.* Preliminary report.

An equilateral random walk in $\mathbb{R}^3$ is formed by sampling steps uniformly on S^2 and summing these steps to form a space polygon. The polygon is closed $\iff$ the vector sum of the steps is $\vec{0}$.

This means that closed equilateral random walks in $\mathbb{R}^3$ are sampled from the volume measure on the $2n-3$ dimensional submanifold of $(S^2)^n$ defined by the closure condition $\sum \vec{e_i} = \vec{0}$. If we take the quotient of this space under the (diagonal) action of $SO(3)$, we get a $2n-6$ dimensional manifold of "closed random walks up to rotation".

It has been known since the 90's that this smaller manifold has a toric symplectic structure. In this talk, we use the toric symplectic structure to create new algorithms for sampling from this manifold. These algorithms are of interest in the numerical simulation and probabilistic analysis of closed "ring" polymers in solution. (Received August 25, 2014)

1104-53-113 **Jeffrey S Case*** (jscase@math.princeton.edu). *A notion of the weighted σ_k-curvature for manifolds with density.*

We propose a natural definition of the weighted σ_k-curvature for a manifold with density; i.e. a triple $(M^n, g, e^{-\phi}\mathrm{dvol})$. This definition is intended to capture the key properties of the σ_k-curvatures in conformal geometry with the role of pointwise conformal changes of the metric replaced by pointwise changes of the measure. We describe some algebraic and analytic properties of the weighted σ_k-curvatures. These results are

all analogues of their conformal counterparts, and in the case $k = 1$ recover some of the well-known properties of Perelman's $\mathcal{W}$-functional. (Received August 26, 2014)

1104-53-114 **Tommy Murphy*** (tmurphy@fullerton.edu), Dept. of Mathematics, California State University at Fullerton, 800 N State College Blvd., Fullerton, CA 92831. *Complex Riemannian foliations of Hermitian locally symmetric spaces.*

Given a Riemannian manifold, a natural problem is to classify the Riemannian foliations whose leaves satisfy natural geometric properties with respect to the metric. Our interest in this question lies in classifying the Riemannian foliations of a Kähler manifold with complex leaves. Such foliations are important in twistor theory and nearly Kähler geometry. The main theorem is a complete answer to this question for the first natural family of Kähler manifolds, namely the Hermitian locally symmetric spaces of compact type. General theorems which help us deduce results for Hermitian locally symmetric spaces of non-compact type will also be outlined. This is joint with Paul-Andi Nagy. (Received August 26, 2014)

1104-53-118 **Thomas A Ivey*** (iveyt@cofc.edu). *Stark Hypersurfaces in Complex Projective Space.* Preliminary report.

Harvey and Lawson showed that $M \subset \mathbb{R}^n$ is austere (i.e., its normal bundle is special Lagrangian in $T\mathbb{R}^n \cong \mathbb{C}^n$) iff all odd-degree symmetric polynomials in the eigenvalues of the second fundamental form (in any normal direction) vanish. For $M \subset \mathbb{C}P^n$ the austerity condition (relative to the Stenzel metric on $T\mathbb{C}P^n$) along a normal direction ν involves the eigenvalues of both the second fundamental form in the direction of ν and its restriction to the subspace of the tangent space orthogonal to $J\nu$. This condition simplifies when M is a hypersurface (i.e., of real codimension one), but these remain unclassified, even for $n = 2$.

In this talk I'll discuss a novel class of hypersurfaces in $\mathbb{C}P^n$ which fulfil both the austerity condition relative to the Stenzel metric and the Euclidean austerity condition. Preliminary computations indicate that these exist for arbitrary n, are fibered by totally geodesic $\mathbb{R}P^n$'s, and are determined by solutions of a compatible system of total differential equations. So far, these are the only known examples of austere hypersurfaces in these spaces. (Received August 26, 2014)

1104-53-123 **Weiyong He*** (whe@uorgon.edu), Eugene, OR 97403. *Sasaki-Einstein manifolds.*

We study the geometry of quasi-regular Sasaki-Einstein metrics. With suitable assumption, we study the geometry of holomorphic line bundles (anti-canonical bundle) on the corresponding Fano orbifold. Donaldson-Sun recently proved the partial C^0 estimate for Kahler-Einstein metrics on Fano manifold (a conjecture by G. Tian).

As an extension, we prove a version of such partial C^0 estimate for quasi-regular Sasaki Einstein metrics. A new ingredient is the S^1 equivarient Gromov-Hausdorff limit for quasi-regular Sasaki-Einstein metrics. (Received August 26, 2014)

1104-53-134 **Handan Yildrim*** (handanyildirim@istanbul.edu.tr), Istanbul University Science Faculty, Mathematics Department Vezneciler-Fatih, 34134 Istanbul, Turkey. *ϕ-hyperbolic duals of spacelike hypersurfaces in the lightcone as wave front sets.*

In this talk which is based on a joint work with Shyuichi Izumiya, as an application of the extended Legendrian dualities defined in [1] depending on a parameter $\phi \in [0, \pi/2]$, first one-parameter families of extrinsic differential geometries on spacelike hypersurfaces in the lightcone are introduced briefly with respect to ϕ-hyperbolic duals. Then, by means of Legendrian singularity theory, these duals are investigated as wave front sets, [2].

References

[1] S. Izumiya and H. Yildirim, *Extensions of the mandala of Legendrian dualities for pseudo-spheres in Lorentz-Minkowski space*, Topology and its Applications **159** (2012), 509-518.

[2] S. Izumiya and H. Yildirim, *Slant geometry of spacelike hypersurfaces in the lightcone*, J. Math. Soc. Japan **63(3)** (2011), 715-752.

(Received August 28, 2014)

1104-53-158 **Ailana Fraser*** (afraser@math.ubc.ca), Department of Mathematics, University of British Columbia. *Morse index and uniqueness results for free boundary minimal surfaces.*

I will discuss joint work with R. Schoen on Morse index and uniqueness results for free boundary minimal surfaces in a Euclidean ball. These are proper branched minimal immersions of a surface into the ball which meet the boundary orthogonally. Such surfaces have been extensively studied and they arise as extremals of the area functional for relative cycles in the ball. They also arise as extremals of a certain eigenvalue problem. (Received August 29, 2014)

1104-53-271 **Tom R Needham*** (tneedham@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *A Metric on the Space of Framed Curves.*

A framed curve is an immersed closed curve in Euclidean space endowed with an adapted moving frame. In this talk we will describe a notion of distance between a pair of framed curves that doesn't differentiate between framed curves that have the "same shape". More precisely, we will define a metric on the space of framed curves modulo Euclidean similarity. This is accomplished by showing that this space admits a Riemannian metric that has explicitly computable geodesics. Although the moduli space is infinite-dimensional, these geodesics have a surprisingly nice form. (Received September 02, 2014)

1104-53-273 **Rafe Mazzeo*** (mazzeo@math.stanford.edu), Dept. of Mathematics, Stanford University, Stanford, CA 94305, **Hartmut Weiss**, , Germany, **Jan Swoboda**, , Germany, and **Frederik Witt**, , Germany. *Ends of moduli spaces of Higgs bundles.*

This will be a report on some recent progress on understanding solutions of Hitchin's equations on Riemann surfaces. The main result is a new construction of solutions of these equations which are "near infinity" in the moduli space, and the consequences of this construction for understanding the asymptotics of the Weil-Petersson metric on this moduli space. (Received September 02, 2014)

1104-53-278 **Mihaela Brindusa Vajiac*** (mbvajiac@chapman.edu), Chapman University, Schmid College of Science and Technology, One University Drive, Orange, CA 92886. *Multicomplex Manifolds.*

In this talk we will present a theory of manifolds on multicomplex spaces. These spaces have garnered a lot of interest in the past decade and we will outline the steps for buliding a submanifold theory in this case. (Received September 03, 2014)

1104-53-294 **Joseph H.G. Fu*** (fu@math.uga.edu), Department of Mathematics, Boyd BSRC, University of Georgia, Athens, GA 30602. *The module of Riemannian curvature measures.* Preliminary report.

Alesker has introduced the concept of *valuations on manifolds* M, which are finitely additive set functions expressible in terms of complete integrals of certain scalar invariants of the second fundamental form on suitably regular subsets $A \subset M$. The space of valuations admits a natural multiplication. Closely related is the concept of a *curvature measure*, which may be thought of as a local integral of this type, and the space of all curvature measures is an algebra over the valuations. If M has a Riemannian structure then there is an associated finite-dimensional subalgebra (the *Lipschitz-Killing algebra*) of valuations on M, given essentially by the coefficients of the Weyl tube formula, as well as a larger space of curvature measures on M given by certain canonical expressions in the curvature tensor. The latter is a module over the former. We describe the structure of this module and give applications to the integral geometry of complex space forms. (Received September 03, 2014)

1104-53-303 **Shihshu Walter Wei*** (wwei@ou.edu), Department of Mathematics, The University of Okalahoma, Norman, OK 73072. *Geometric inequalities and the topology of noncompact submanifolds.*

We'll discuss a number of geometric inequalities on manifolds that are influenced by curvature. Their applications in physics and p-harmonic geometry will be studied. Some links of these geometric inequalities to the topology of noncompact stable minimal hypersurfaces in Riemannian manifolds will also be explored. (Received September 03, 2014)

1104-53-321 **Barbara A. Shipman***, bshipman@uta.edu, and **Patrick D. Shipman** and **Stephen P. Shipman**. *Geometry of Lorentz-Conformal Transformations in the Plane.*

While conformal transformations of the plane preserve Laplace's equation, Lorentz-conformal mappings preserve the wave equation. In dimension 1+1, Lorentz-conformal mappings take on a simple form, allowing for lucid analysis of their geometry. Squares are transformed into curvilinear quadrilaterals where three sides determine the fourth by a geometric "rectangle rule" that can be expressed also by functional formulas. Another rectangle rule governs pairs of crossing curves that can be mapped to intersecting coordinate lines. We characterize classes of Lorentz-conformal mappings by their symmetries under subgroups of the dihedral group of order eight. Unfoldings of non-invertible mappings into invertible ones are reflected in a change of the symmetry group and in different "colorings" of the contour plot. The questions are simple; but the answers are not obvious, yet have beautiful geometric, algebraic, and functional descriptions and proofs. (Received September 03, 2014)

1104-53-342 **Jie Qing*** (qing@ucsc.edu), Department of mathematics, University of California, Santa Cruz, CA 95064, **Changping Wang** (cpwang@fjnu.edu.cn), Department of Mathematics, Fuzhou, Fujian , Peoples Rep of China, and **Jingyang Zhong** (jzhong2@ucsc.edu), Department of Mathematics, University of California, Santa Cruz, CA 95064. *Scalar invariants of surfaces in conformal 3-sphere.* Preliminary report.

This is a preliminary report for my joint work with Changping Wang and Jingyang Zhong. We are interested in establishing a fundamental theorem for surfaces in conformal 3-sphere and conformal 3-manifolds in general. To do so we regard 3-sphere is the projectivized positive light cone in Minkowski space-time of 5 dimension and, in the same spirit, as the conformal infinity of hyperbolic 4-space. We construct associated surfaces in Minkowski space-time as well as in hyperbolic 4-space and apply fundamental theorem for surfaces in (pseudo)-Riemannian geometry. We are looking to extend the use of ambient spaces of Fefferman and Graham to study the conformal geometry of submanifolds. With this approach, one may produce scalar invariants for surfaces in conformal manifolds. (Received September 04, 2014)

54 ► General topology

1104-54-70 **Laura Plunkett*** (plunkett@hnu.edu), Holy Names University, Department of Math and Science, 3500 Mountain Blvd., Oakland, CA 94619. *Knots in thick, self avoiding random walks in 3-space.* Preliminary report.

We describe a new algorithm to generate random walks of an arbitrarily large, specified thickness in $\mathbb{R}^3$, and will outline the proof that this method is transitive on the space of all such thick walks. We will then use the data resulting from our implementation of this method to describe the relationship between the presence and nature of knotting and length, thickness and shape of the random walk. Our simulations will show that modest increases in thickness have a substantial effect on the probability of knot formation, with applications to our understanding of synthetic and biological polymers. (Received August 19, 2014)

1104-54-302 **Jonathan Hanselman*** (hanselman@math.utexas.edu), UT Austin Math Dept, 2515 Speedway, Stop C1200, Austin, TX 78712. *Splicing integer framed knot complements.*

We determine when splicing two integer framed knot complements produces an L-space. This extends a result of Hedden and Levine, who showed that splicing 0-framed knot complements never produces an L-space. For arbitrary integer framings the manifold obtained by splicing is an L-space if both knots are L-space knots and the framings fall in appropriate ranges. The proof relies on bordered Heegaard Floer homology. (Received September 03, 2014)

55 ► Algebraic topology

1104-55-91 **Marcy Robertson*** (mrober97@math.ucla.edu). *Morita Theory and Categorification.* Preliminary report.

We discuss applications of homotopical Morita theory in the sense of Schwede-Shipley and Keller to categorification. We give a preliminary result showing how an "almost" Morita theory can lead to the construction of topological orbit categories as defined by the speaker and Julie Bergner. (Received August 23, 2014)

1104-55-144 **Eric Peterson*** (ericp@math.berkeley.edu), 970 Evans Hall #3840, Berkeley, CA 94720. *Determinantal K–theory and a few applications.*

Chromatic homotopy theory is an attempt to divide and conquer algebraic topology by studying a sequence of what were first assumed to be "easier" categories. These categories come with rich new complications of their own, but in trade they are equipped with intriguing and exciting connections to number theory. I'll describe the most basic of their strange features, then I'll describe an ongoing project which addresses a small part of the "chromatic splitting conjecture". (Received August 28, 2014)

1104-55-172 **Daniel Berwick-Evans*** (danbe@stanford.edu). *Perturbative sigma models and elliptic cohomology with complex coefficients.*

I will describe how the geometry of 2—1-dimensional perturbative sigma models can be used to construct elliptic cohomology with complex coefficients and the Witten class of a smooth manifold. Extending the construction to manifolds with the action of a finite group affords an interplay among gauged sigma models, Chern-Simons theory, and twisted equivariant elliptic cohomology. An analogous discussion in dimension 1—1 recovers similar results for twisted equivariant K-theory. (Received August 31, 2014)

1104-55-213 **Michael Hill** (mikehill@virginia.edu) and **Kyle Ormsby*** (ormsbyk@reed.edu).
Connective, effective, and essential covers in motivic homotopy theory. Preliminary report.
Voevodsky introduced the effective filtration of the stable motivic homotopy category and used it to construct the (effective) slice spectral sequence for algebraic K-theory. This spectral sequence can be viewed as a machine for converting Milnor K-theory into algebraic K-theory. Adapting the two-variable Whitehead tower of Levine-Pelaez, we introduce the *essential* filtration of the stable motivic homotopy category. Taking the essential cover of Hermitian K-theory KO produces a spectrum ko whose cohomology is $A//A(1)$. Moreover, it appears that the essential slice spectral sequence for KO interpolates between Milnor-Witt K-theory and Hermitian K-theory. (Received September 01, 2014)

1104-55-241 **Anna Marie Bohmann*** (bohmann@math.northwestern.edu), Department of Mathematics, 2033 Sheridan Road, Evanston, IL 60208, and **Angelica M. Osorno**.
Constructing equivariant spectra.
Equivariant spectra determine cohomology theories that incorporate a group action on spaces. Such spectra are increasingly important in algebraic topology but can be difficult to understand or construct. In recent work, Angelica Osorno and I have created a machine for building such spectra out of purely algebraic data based on symmetric monoidal categories. Our method is philosophically similar to classical work of Segal on building nonequivariant spectra. In this talk I will discuss an extension of our work to the more general world of Waldhausen categories. Our new construction is more flexible and is designed to be suitable for equivariant algebraic K-theory constructions. (Received September 02, 2014)

1104-55-262 **Deborah Vicinsky*** (vicinsky@uoregon.edu). *Categories, graphs, and Goodwillie calculus.*
Given two well-behaved model categories $\mathcal{C}$ and $\mathcal{D}$ and a functor $F : \mathcal{C} \to \mathcal{D}$, the Goodwillie derivatives of F are objects in the category of spectra on $\mathcal{D}$, denoted $\mathcal{S}p(\mathcal{D})$. Let $\mathcal{C}at$ denote the category of small categories with the canonical model structure. I will show that $\mathcal{S}p(\mathcal{C}at)$ is trivial, and hence the Goodwillie derivatives of any functor into Cat are trivial. I will also discuss my efforts to apply this method to a category of graphs. (Received September 02, 2014)

1104-55-287 **David Carchedi*** (davidcarchedi@gmail.com). *Dg-manifolds as derived manifolds.* Preliminary report.
Given two smooth maps of manifolds $f : M \to L$ and $g : N \to L$, if they are not transverse, the fibered product $M \times_L N$ may not exist, or may not have the correct cohomological properties. In the world of derived manifolds, such a fibered product always exists as a smooth object, regardless of transversality. In this talk we will describe joint work of ours with D. Roytenberg on giving an accessible geometric model for derived manifolds using differential graded manifolds. (Received September 03, 2014)

1104-55-326 **Safia Chettih*** (safia@uoregon.edu). *Topology of Configuration Spaces on Graphs.*
The study of configuration spaces has made use of techniques from group theory, Morse theory, and graph theory, among others. I will outline how explicit presentations for homology and cohomology of configurations on graphs, along with their pairings, illuminate combinatorial structures which others have already described, and I will talk about some extensions made possible by incorporating these methods. (Received September 03, 2014)

57 ► Manifolds and cell complexes

1104-57-38 **Zhiqin Lu*** (zlu@uci.edu), Department of Mathematics, University of California, Irvine, Irvine, CA 92697, and **Reza Seyyedali**. *Extremal Metrics On Ruled Manifolds.*
In this talk, I consider a compact Kähler manifold with extremal Kähler metric and a Mumford stable holomorphic bundle over it. I shall show that, if the holomorphic vector field defining the extremal Kähler metric is liftable to the bundle and if the bundle is relatively stable with respect to the action of automorphisms of the manifold, then there exist extremal Kähler metrics on the projectivization of the dual vector bundle. (Received August 04, 2014)

1104-57-48 **Ina Petkova*** (ina@rice.edu) and **Vera Vertesi**. *Combinatorial tangle Floer homology.*
We extend the functoriality in Heegaard Floer homology by defining a Heegaard Floer invariant for tangles which satisfies a nice gluing formula. We will discuss the construction of this combinatorial invariant for tangles in

S^3, D^3, and $I \times S^2$. The special case of S^3 gives back a stabilized version of knot Floer homology. No prior knowledge of Heegaard Floer homology will be assumed for this talk. (Received August 12, 2014)

1104-57-49 **Jennifer Hom**, **Cagri Karakurt** and **Tye Lidman*** (tlid@math.utexas.edu). *Surgery obstructions and Heegaard Floer homology.*

Using Taubes' periodic ends theorem, Auckly gave examples of toroidal and hyperbolic irreducible integer homology spheres which are not surgery on a knot in the three-sphere. We give an obstruction to a homology sphere being surgery on a knot coming from Heegaard Floer homology. This is used to construct infinitely many small Seifert fibered examples. (Received August 12, 2014)

1104-57-110 **Daniel Ruberman*** (ruberman@brandeis.edu), **David Auckly** (dav@math.ksu.edu), **Hee Jung Kim** (heejungorama@gmail.com) and **Paul Melvin** (pmelvin@brynmawr.edu). *Stabilization in 4-dimensional topology.*

C.T.C. Wall (1964) showed that homotopy equivalent simply-connected 4-manifolds become diffeomorphic after (possibly repeated) stabilization by connected sum with $S^2 \times S^2$. In all known examples, one stabilization suffices. We give concrete examples of a similar phenomenon for embedded 2-spheres. Denote by $X_{m,n}$ the connected sum of m copies of $\mathbb{C}\mathrm{P}^2$ and n copies of $\overline{\mathbb{C}\mathrm{P}}^2$.

Theorem. For any even $m \geq 4$ and $n \geq 5m$, the manifold $X_{m,n}$ contains infinitely many smoothly distinct 2-spheres. These spheres become smoothly isotopic after stabilization with $S^2 \times S^2$.

Corollary. For m as above and $n \geq 5m+2$, there are infinitely many non-isotopic diffeomorphisms f_j of $X_{m,n}$ that become isotopic after stabilization $f_j \to f_j \# \mathrm{id}_{S^2 \times S^2}$. (Received August 25, 2014)

1104-57-115 **Maciej Borodzik**, **Matthew Hedden** and **Charles Livingston***, livingst@indiana.edu. *Cuspidal curves in complex projective space.* Preliminary report.

A homogeneous polynomial in three complex variables defines an algebraic curve C in complex projective space. Generically, C is a smooth surface. This talk will consider the case in which C has isolated singularities. Obstructions based on Heegaard Floer theory constrain the possible singularities that can occur in the case that C is topologically a sphere and lead to a partial classification result for curves of topological genus 1. (Received August 26, 2014)

1104-57-117 **Jennifer Schultens*** (jcs@math.ucdavis.edu), Dept of Mathematics, UC Davis, 1 Shields Ave, Davis, CA 95618. *The Kakimizu complex of a surface.* Preliminary report.

The Kakimizu complex was traditionally defined for a knot. P. Przytycki and the author generalized its definition to 3-manifolds. This talk veers in a rather different direction: Defining Kakimizu complexes in the context of surfaces. This talk will provide key definitions and a discussion of how this endeavor, rife with stumbling blocks, provides rich insights that can be translated back into the context of Kakimizu complexes of 3-manifolds. (Received August 26, 2014)

1104-57-128 **Hans U Boden*** (boden@mcmaster.ca), **Emily Dies**, **Anne Isabel Gaudreau**, **Adam Gerlings**, **Eric Harper** and **Andrew J Nicas**. *Alexander invariants of virtual knots.*

Given a virtual knot K, we construct a group VG_K called the virtual knot group, and we use the elementary ideals of VG_K to define invariants of K called the virtual Alexander invariants. For instance, associated to the $k = 0$ ideal is a polynomial $H_K(s,t,q)$ in three variables called the virtual Alexander polynomial, and it is closely related to the generalized Alexander polynomial for virtual knots of Sawollek, Kauffman-Radford, and Silver-Williams. The virtual Alexander polynomial admits a natural normalization and satisfies a skein formula. Given a representation $\varrho\colon VG_K \to GL_n(R)$, one can use a similar approach to define twisted Alexander invariants, and the twisted virtual Alexander polynomial also admits a natural normalization.

This talk will begin with a brief introduction to virtual knot theory and will present the construction of VG_K and its Alexander invariants. We will also show how to use the invariants to give information about the virtual crossing number of K, and time permitting we may discuss current work in progress on virtual knots K admitting Alexander numberings. (Received August 27, 2014)

1104-57-139 **Eric J Rawdon*** (ericrawdon@gmail.com), Department of Mathematics, OSS 201, 2115 Summit Ave, Saint Paul, MN 55105. *What knots lurk inside other knots?*

For a fixed knot configuration, the subknots are the knot types seen in the open subarcs of the configuration. For nice knot configurations (like ones minimized with respect to some knot energy), the subknots are typically simpler knot types than the host knot type. We compare and contrast the set of subknots coming from KnotPlot

configurations, tight knot configurations, and random configurations. This is joint work with Ken Millett and Andrzej Stasiak. (Received August 28, 2014)

1104-57-148 **Kenneth C Millett*** (millett@math.ucsb.edu), Department of Mathematics, UCSB, Santa Barbara, CA 93106. *Knot complexity: an analysis of subknots.*

Employing a thick polygonal realization of a knot, we analyze the associated local knotting fingerprint, presented as a decorated disk matrix, to determine the directed planar graph expressing the local knot type regions of the fingerprint. The complexity of this graph provides new measures of the complexity of the knot. The number of independent knotting pathways, the number of unconstrained knotting pathways, and a specialization of the Cheeger constant for directed graphs such as these will be described. (Received August 29, 2014)

1104-57-168 **Jennifer Hom*** (hom@math.columbia.edu). *An infinite rank summand of topologically slice knots.*

Let T denote the subgroup of the smooth knot concordance group generated by topologically slice knots. Endo showed that T contains an infinite rank subgroup, and Livingston and Manolescu-Owens showed that T contains a summand of rank three. We show that in fact T contains an infinite rank summand. The proof relies on the knot Floer homology package of Ozsvath-Szabo and the concordance invariant epsilon. (Received August 30, 2014)

1104-57-176 **Kenneth L Baker** and **Allison H Moore*** (allison.h.moore@rice.edu), Department of Mathematics, Rice University, Houston, TX 77005. *Montesinos knots, Hopf plumbings, and L-space surgeries.*

Using Hirasawa-Murasugi's classification of fibered Montesinos knots, we determine the fibered Montesinos knots whose open book decompositions support the tight contact structure on the three-sphere. This allows us to classify the Montesinos knots which admit L-space surgeries. (Received August 31, 2014)

1104-57-191 **Jianfeng Lin*** (linjian5477@gmail.com), 3777 Mentone Apt 411, Los Angeles, CA 90034. *Pin(2)-equivariant KO-theory and intersection forms of spin four-manifolds.*

In this talk, I will explain how to apply Pin(2)-equivariant KO-theory on the Seiberg-Witten Floer spectrum to obtain new 3-manifold invariant and get new constrains on the intersection form of a spin 4-manifolds (closed or with boundary). (Received September 01, 2014)

1104-57-198 **Koya Shimokawa*** (kshimoka@rimath.saitama-u.ac.jp), **Kai Ishihara** and **Mariel Vazquez**. *Site-specific recombination modeled as a band surgery.*

We study site-specific recombination using tangle model. By applying recent results on band surgeries on knots and links, we will mathematically characterize pathways and topological mechanisms of site-specific recombination. (Received September 01, 2014)

1104-57-208 **Kyle Larson** and **Jeffrey Meier*** (jlmeier@indiana.edu), Department of Mathematics, Rawles Hall, 831 East Thrid St., Bloomington, IN 47405. *Fibered disks and 2–knots.*

Classical work of Casson-Gordon and Cochran give characterizations of fibered, homotopy-ribbon 1–knots and 2–knots, respectively. We investigate the relationship between these two characterizations by studying fibered, homotopy ribbon disk-knots. The overall approach is to study these objects by analyzing changes to their monodromies in terms of various surgeries on the total space. To that end, we give analogues of the Stallings twist for fibered disk knots and fibered 2–knots.

These techniques allow us to produce infinite families of distinct disk knots that all double to at most two distinct fibered, homotopy-ribbon 2–knots. Conversely, we see that a given fibered, homotopy-ribbon 2–knot has, as symmetric equators, infinitely many distinct fibered, homotopy-ribbon 1–knots. We will illustrate these ideas using the examples arising from spinning fibered 1–knots, and show that the spins of any two fibered 1–knots can be related by a sequence of torus surgeries.

This is joint work with Kyle Larson. (Received September 01, 2014)

1104-57-225 **Prayat Poudel*** (p.poudel@math.miami.edu), 1365 Memorial Drive, Ungar 515, Coral Gables, FL 33146, and **Nikolai Saveliev**. *Instanton Knot Floer Homology via Equivariant Gauge Theory.*

Kronheimer and Mrowka defined the Instanton knot Floer homology $I^\natural(K)$ using connections singular along the link $K^\natural = K \# H$, a connected sum of K with the Hopf link H. They also constructed a spectral sequence converging from $Kh(K)$ to $I^\natural(K)$ which was instrumental in proving that the $Kh(K)$ is an unknot detector.

In our talk, we will approach $I^\natural(K)$ by passing to the double branched cover of $K^\natural$ and work with equivariant rather than singular connections. This approach results in explicit computations of the chain complex for $I^\natural(K)$ for several families of knots with simple double branched covers (such as two-bridge knots, torus knots, Montesinos knots.) (Received September 02, 2014)

1104-57-228 **Mark Norfleet*** (mnorfleet@unr.edu), University of Nevada, Reno, Math and Stat Dept, 1664 N. Virginia Street, Reno, NV 89557. *Concordance Classes of Knots.*

We will discuss different "concordance" equivalence relations. For a ring R, we define a R-concordance group. We will consider some differences between R-concordance group and the (standard) concordance group. Then we will conclude with some questions about the differences between smooth and topological R-concordance. (Received September 03, 2014)

1104-57-234 **Kyle Evans-Lee*** (kevans@math.miami.edu), 5540 sw 78th st, Apt D, Miami, FL 33143. *On the Homotopy type of the Configuration Spaces of Lens Spaces.*

It is known that the configuration space $F_2(M)$ of ordered pairs of distinct points in a manifold M is not a homotopy invariant of M: Longoni and Salvatore showed that there exist homotopy equivalent lens spaces M and N in dimension three for which $F_2(M)$ and $F_2(N)$ are not homotopy equivalent. In this talk, we will report some recent progress on the question whether, for two arbitrary lens spaces M and N, they must be homeomorphic in order for $F_2(M)$ and $F_2(N)$ to be homotopy equivalent. Among the tools we use are the Cheeger–Simons differential characters of $F_2(M)$ (whose calculation is a problem of independent interest in low-dimensional topology) as well as the R-torsion of spaces $F_2(M)$ and the Massey products of their universal covers. (Received September 02, 2014)

1104-57-238 **Dev P. Sinha***, dps@uoregon.edu, and **Ryan Budney**, **James Conant** and **Robin Koytcheff**. *The embedding calculus and finite-type invariants.*

We outline the steps needed to show that the Goodwillie-Weiss tower gives rise to finite-type invariants. This includes establishing a group structure, as π_0 is a priori a set-valued functor, and analyzing the effect of clasper surgery on the evaluation map of a knot. Time permitting, we indicate how generalized Hopf invariants applied in this setting could give rise to Goussarov-Polyak-Viro formulae. (Received September 02, 2014)

1104-57-239 **Christopher W Scaduto*** (scaduto@math.ucla.edu), University of California, Department of Mathematics, 520 Portola Plaza, Los Angeles, CA 90095-1555. *From odd Khovanov homology to instantons.*

We construct a spectral sequence from the odd Khovanov homology of a link to a version of instanton homology of its branched double cover. We discuss the features of this spectral sequence that set it apart from its motivating analogue, done by Ozsváth and Szabó, in Heegaard Floer homology: gradings and signs. (Received September 02, 2014)

1104-57-242 **Peter S Ozsvath*** (petero@math.princeton.edu), **Andras Stispicz** and **Zoltan Szabo**. *Concordance homomorphisms from knot Floer homology.* Preliminary report.

I will describe infinitely many linearly independent homomorphisms from the smooth concordance group to the integers, and explain some topological applications of these objects. This is joint work with Andras Stipsicz and Zoltan Szabo. (Received September 02, 2014)

1104-57-243 **M Kate Kearney*** (kearney@gonzaga.edu), Gonzaga University Mathematics Department, 502 E. Boone Ave. MSC 2615, Spokane, WA 99258. *Stable Concordance Genus.*

The concordance genus of a knot is the least three–genus of a knot concordant to the knot. The concordance genus is bounded below by the four–genus (or slice genus), and bounded above by the three–genus. This makes the concordance genus a valuable tool to describe the difference between these invariants. In simple cases the concordance genus is not difficult to calculate, since there are a variety of algebraic tools that give bounds for the concordance genus. Unfortunately, as the crossing number increases, it becomes increasingly difficult to find concordances. The stable concordance genus, which we will discuss in this talk, describes the behavior of the concordance genus of a given knot under connect sum. We will briefly define the invariant, give some examples of calculations, and discuss applications to the study of concordance. In particular, we will observe a realization result for the stable concordance genus in relation to the stable four—genus. (Received September 02, 2014)

1104-57-252 **Candice R Price*** (candice.price@usma.edu) and **Isabel K Darcy**. *Application of a Skein Relation to Difference Topology Experiments.* Preliminary report.

Difference topology is a technique used to study any protein that can stably bind to DNA. This technique is used to determine the confirmation of the DNA bound by the protein. Motivated by difference topology experiments, this talk utilizes a skein relation to model the local action of topoisomerase and site specific recombinase. This skein relation relates three knots, K_+, K_-, K_I and one link, K_D where K_+ as an oriented knot with a distinguished positive crossing; K_-, a knot obtained by changing the distinguished positive crossing of K_+ to a negative crossing; K_I, a knot obtained by the non-oriented resolution of the distinguished crossing of $K_\pm$; and, K_D is a link obtained by the orientation preserving resolution of the distinguished crossing. (Received September 02, 2014)

1104-57-254 **Andrew Donald*** (adonald@math.msu.edu). *Embedding 3-manifolds smoothly in S^4.*

We discuss the question of when a closed 3-manifold can be smoothly embedded in the 4-sphere. An obstruction to embedding can be derived from Donaldson's theorem on the intersection forms of definite 4-manifolds and this can be used to classify the connected sums of lens spaces which smoothly embed. Seifert manifolds with non-orientable base surfaces or odd first Betti number are amenable to similar methods. (Received September 02, 2014)

1104-57-264 **Kristen Hendricks***, hendricks@math.ucla.edu. *A spectral sequence for the Floer cohomology of symplectomorphisms of trivial polarization class.*

If M is an exact symplectic manifold with stably trivial tangent bundle, then a symplectomorphism of M induces a map from M to the infinite symplectic group via the induced map on the tangent bundle. We show that if this map is nulhomotopic (and other common technical requirements are satisfied), Seidel and Smith's localization theory for Floer cohomology implies the existence of a spectral sequence from the Floer cohomology of the square of the symplectomorphism to the Floer cohomology of the symplectomorphism itself, and a corresponding rank inequality. (Received September 02, 2014)

1104-57-265 **Tynan B Kelly*** (tbkelly@brandeis.edu). *Twisted linking numbers.*

The twisted Blanchfield pairing is defined on the homology of the complement of a knot with coefficients twisted by a representation. A version of this on the chain level is the twisted linking number. We will discuss recent progress related to these, in particular the geometric interpretation of twisted linking numbers. (Received September 02, 2014)

1104-57-270 **Claus Ernst*** (claus.ernst@wku.edu), Department of Mathematics, Western Kentucky University, 1906 College Heights Blvd, Bowling Green, KY 42101. *Nullification of torus knots and links.*

It is known that a knot/link can be nullified, i.e., can be made into the trivial knot/link, by smoothing some crossings in a projection diagram of the knot/link. The minimum number of such crossings to be smoothed in order to nullify the knot/link is called the nullification number. In this talk I investigate the nullification numbers of a particular knot family, namely the family of torus knots and links (Received September 02, 2014)

1104-57-291 **Christopher M. Herald*** (herald@unr.edu), Department of Mathematics and Statistics, University of Nevada, Reno, Reno, NV 89557-0084, and **Matthew Hedden** and **Paul Kirk**. *A Lagrangian-Floer theory in the pillowcase arising from traceless representations of knot groups.* Preliminary report.

This talk will describe joint work with Matt Hedden and Paul Kirk. We define an elementary relatively $\mathbb{Z}/4$ graded Lagrangian-Floer chain complex for a particular class of 1-manifolds in the pillowcase. Given an appropriate 2-tangle decomposition of a knot, the traceless $SU(2)$ character varieties of the tangles give rise to Lagrangian submanifolds in the pillowcase of traceless representations for the splitting surface. The Lagrangian-Floer chain complex is then generated by intersections that correspond to the generators of Kronheimer and Mrowka's singular instanton chain complex for the knot. We provide evidence to support an Atiyah-Floer conjecture relating these two Floer homology theories. (Received September 03, 2014)

1104-57-309 **Corrin Clarkson*** (cjclarks@indiana.edu), Department of Mathematics, Indiana University, Rawles Hall 425, 831 East 3rd St, Bloomington, IN 47405. *Three manifold mutations and Heegaard Floer homology.*

Given a self-diffeomorphism h of a closed, orientable surface S and an embedding f of S into a three-manifold M, we construct a mutant manifold N by cutting M along f(S) and regluing by h. We will consider whether there are any gluings such that for any embedding, the manifold and its mutant have isomorphic Heegaard Floer

homology. In particular, we will demonstrate that if the gluing is not isotopic to the identity, then there exists an embedding of S into a three-manifold M such that the rank of the non-torsion summands of the Heegaard Floer homology of M differs from that of its mutant. (Received September 03, 2014)

1104-57-318 **Yuanan Diao**, **Claus Ernst**, **Eric Rawdon** and **U Ziegler***, Department of Computer Science, 1906 College Heights Blvd, Bowling Green, KY 42101. *The effect of confinement conditions on topological and geometric properties of random polygons.*

A polymer in confinement is represented by an N-segment, unit-length, free-jointed, closed polygon in spherical confinement. Our algorithm generates segments sequentially and each segment is added based on mathematically derived cumulative conditional probability density functions. This talk discusses the outcomes of a study which investigates the dependence of the knot spectrum and geometric properties of these polygons on the length of the polygons (with fixed confinement size) and on the confining radii (with fixed polygon length). (Received September 03, 2014)

1104-57-323 **Ryan Blair**, **Marion Campisi*** (mcampisi@stanford.edu), **Jesse Johnson**, **Scott Taylor** and **Maggy Tomova**. *Exceptional and cosmetic surgeries on knots.*

We show that the bridge distance of a knot determines a lower bound on the genus of essential surfaces and Heegaard surfaces in the manifolds that result from non-trivial Dehn surgeries on the knot. In particular, knots with high bridge distance do not admit non-trivial non-hyperbolic surgeries or non-trivial cosmetic surgeries. We further show that if a knot has bridge distance at least 3 then its bridge number is bounded above by a function of Seifert genus, or indeed by the genus of (almost) any essential surface or Heegaard surface in the surgered manifold. (Received September 03, 2014)

58 ► Global analysis, analysis on manifolds

1104-58-29 **John Lott*** (lott@berkeley.edu) and **Bruce Kleiner**. *Ricci flow through singularities.*

Perelman's Ricci flow-with-surgery involves a surgery parameter δ, which describes the scale at which surgery is performed. We show that there is a subsequential limit as δ goes to zero, thereby partially answering a question of Perelman. The limiting object is called a singular Ricci flow. Such objects can considered to be flows through singularities, and studied in their own right. We prove some geometric and analytical properties of such singular Ricci flows. (Received July 04, 2014)

1104-58-41 **Jedrzej Z. Sniatycki*** (sniatyck@ucalgary.ca), Department of Mathematics and Statistics, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada, and **Guenter Schwarz**. *Regularity of constraints and reduction in the Minkowski space Yang-Mills-Dirac theory.*

We consider an extended phase space P for Yang-Mills and Dirac fields in the Minkowski space consisting of Cauchy in appropriate Sobolev spaces, which admits existence and uniqueness theorems for the evolution equations. We show that the Lie algebra gs(P) of infinitesimal gauge symmetries of P is a Hilbert-Lie algebra carrying a Beppo Levi topology. The connected group GS(P) of gauge symmetries of P with Lie algebra gs(P) is a Hilbert-Lie group acting properly on P. We construct a closed subgroup $GS(P)_0$ of GS(P) acting on P with a momentum map J_0, such that the constraint equations of the theory are given by J_0=0. We show that the set of solutions of the Yang-Mills-Dirac equations is a smooth submanifold of a dense subspace of P. It is a principal fibre bundle over the reduced phase space with structure group $GS(P)_0$. (Received August 04, 2014)

1104-58-47 **Pengfei Guan** and **Lei Ni***, 9500 Gilman Driver, La Jolla, CA 92093. *Entropy and Gauss curvature flow.*

Gauss curvature flow as initiated by Firey to model the tumbling of the stone. For dimension two the limiting shape was determined by the work of B. Andrews. Here we obtain a new C^2-estimate which implies the convergence to a soliton for the normalized flow in high dimension. The key is to obtain a lower estimate on the Gauss curvature, which in turn depends on a lower estimate of the support function. The lower bound on the support function is obtained via the estimates on the entropy. (Received August 11, 2014)

1104-58-69 **Nelia Charalambous*** (nelia@ucy.ac.cy), Department of Mathematics and Statistics, University of Cyprus, 1678 Nicosia, Cyprus, and **Zhiqin Lu**, Department of Mathematics, University of California at Irvine. *The Weyl Criterion for the Spectrum.*

We prove a generalization of Weyl's criterion for the spectrum of a self-adjoint and nonnegative operator on a Hilbert space. We then apply this generalized criterion to study the L^2 spectrum of the Laplacian on k-forms

over an open manifold. Using our new criterion we first expand the set of manifolds over which the essential spectrum of the Laplacian on functions is the nonnegative real line. Then we show that the spectrum of the Laplacian on 1-forms always contains the spectrum of the Laplacian on functions. We also compute the essential spectrum of complete shrinking Ricci solitons and weighted manifolds in more general cases. Finally, we apply our criterion to study the spectrum of the Laplacian on k-forms under a continuous deformation of the metric. This work is joint with Zhiqin Lu. (Received August 19, 2014)

1104-58-126 **Abdelhamid Meziani*** (meziani@fiu.edu), Department of Mathematics and Statistics, 11200 SW 8th Street, Miami, FL 33199. *Pseudoconvex Mizohata Structures on Compact Manifolds.*

We discuss the rigidity of pseudoconvex Mizohata structures on compact manifolds with abelian fundamental groups. Any simply connected $(n+1)$-dimensional compact manifold with a pseudoconvex Mizohata structure is equivalent the standard Mizohata structure on the sphere $\mathbb{S}^{n+1}$. If an $(n+1)$-dimensional connected compact manifold with a nontrivial abelian fundamental group carries a pseudoconvex Mizohata structure, then it is equivalent to a structure on $\mathbb{S}^1 \times \mathbb{S}^n$. (Received August 27, 2014)

60 ► Probability theory and stochastic processes

1104-60-32 **Sergey Lototsky*** (lototsky@usc.edu), Department of Mathematics, USC, 3620 S Vermont Ave. KAP 106, Los Angeles, CA 90089. *Parameter estimation in second-order continuous time Gaussian autoregressions.*

For the one-dimensional Ornstein-Uhlenbeck process, asymptotic behavior of the maximum likelihood estimator (MLE) of the drift depends on the sign of the unknown parameter, and there are three different distributions possible in the limit. The objective of the talk is to discuss a similar problem when the corresponding deterministic equation is second-order in time and there are two parameters to estimate. In this case, the asymptotic behavior of the MLE depends on the roots of the corresponding characteristic equation. All in all, there are nine cases to consider, and some of the results are rather unexpected. (Received July 08, 2014)

1104-60-39 **Edward C Waymire*** (waymire@math.oregonstate.edu), Department of Mathematics, Kidder Hall, Oregon State University, Corvallis, OR 97331, and **Thilanka Appuhamillage**, **Vrushali Bokil**, **Jorge Ramirea** and **Enrique Thomann**. *Interfacial Dispersion and Continuity of Local Time.* Preliminary report.

Results are provided that highlight the effect of interfacial discontinuities in the diffusion coefficient on the behavior of local times and occupation times. The main goal is to obtain a characterization of large scale parameters by an analysis at the fine scale of stochastic particle motions. In particular it is shown that the continuity of a natural modification of local time is the individual (stochastic) particle scale equivalent to continuity of flux at the scale of the (macroscopic) particle concentrations. Interfacial effects on occupation time of the associated stochastic particles are obtained as a consequence. This is based on published work in collaboration with T. Appuhamillage, V. Bokil, E. Thomann, and B. Wood at Oregon State University in the case of piecewise constant coefficients, and work in preparation with Jorge Ramirez, Nacional University of Colombia, and Enrique Thomann for the case of piecewise smooth coefficients. (Received August 04, 2014)

1104-60-88 **Mark M. Meerschaert** (mcubed@stt.msu.edu), **Renè L. Schilling** (rene.schilling@tu-dresden.de) and **Alla Sikorskii*** (sikorska@stt.msu.edu), 619 Red Cedar Road, Department of Statistics and Probability, Michigan State University, East Lansing, MI 48824. *Stochastic solutions for fractional wave equations.*

A fractional wave equation replaces the second time derivative by a Caputo derivative of order between one and two. In this paper, we show that the fractional wave equation governs a stochastic model for wave propagation, with deterministic time replaced by the inverse of a stable subordinator whose index is one half the order of the fractional time derivative. (Received September 02, 2014)

1104-60-95 **Wojbor A Woyczynski*** (waw@case.edu), Case Western Reserve University, Cleveland, OH 44106. *Asymptotics and critical behavior for nonlinear and nonlocal evolution equations driven by jump Markov (Levy) processes.*

A review of recent results on the behavior of solutions of nonlinear and nonlocal evolution equations driven by jump Markov (Levy) processes. Critical nonlinearities and shock creation and dissolution for fractional conservation laws and Hamilton-Jacobi type equations will be discussed. Joint work with B. Gunaratnam, G. Karch and P. Biler (Received August 24, 2014)

1104-60-122 **Nicos Georgiou** and **Firas Rassoul-Agha*** (firas@math.utah.edu), 155 S 1400 E, Salt Lake City, UT 84109, and **Timo Seppalainen**. *The growth model: Busemann functions, shape, geodesics, and other stories.*

We consider the directed last-passage percolation model on the planar integer lattice with nearest-neighbor steps and general i.i.d. weights on the vertices, outside the class of exactly solvable models. Stationary cocycles are constructed for this percolation model from queueing fixed points. These cocycles define solutions to variational formulas that characterize limit shapes and yield new results for Busemann functions, geodesics and the competition interface. (Received August 26, 2014)

1104-60-212 **Subhankar Ghosh**, **Umit Islak** (islak@usc.edu) and **Gokhan Yildirim*** (gyildiri@usc.edu), USC Dornsife Department of Mathematics, 3620 S. Vermont Ave., KAP 104, Los Angeles, CA 90089. *Some Remarks on Concentration Inequalities via Size Biased Couplings.*

We prove concentration of measure type inequalities for random vectors $\mathbf{W} = (W_1, \ldots, W_k)$ with nonnegative coordinates by making use of size biased couplings. The results generalize the previous univariate cases via size biasing, and are demonstrated with applications on local dependence and counting patterns. (Received September 01, 2014)

1104-60-222 **Konstantin Tikhomirov*** (ktikhomi@ualberta.ca), 632 Central Academic Building, Edmonton, Alberta T6G2G1, Canada. *The limit of the smallest singular value of random matrices with i.i.d. entries.* Preliminary report.

For a two-dimensional array $\{a_{ij}\}$ $(1 \leq i, j < \infty)$ of i.i.d. real valued random variables with zero mean and unit variance, we prove the following: Let $(N_m)_{m=1}^{\infty}$ be an integer sequence satisfying $m/N_m \longrightarrow z$ for some $z \in (0, 1)$. Further, for each $m \in \mathbb{N}$ and for the $N_m \times m$ random matrix $A_m = (a_{ij})$ $(1 \leq i \leq N_m, 1 \leq j \leq m)$, let $s_{\min}(A_m)$ denote its smallest non-trivial singular value. Then the sequence $\left(\frac{s_{\min}(A_m)}{\sqrt{N_m}}\right)_{m=1}^{\infty}$ converges to $1 - \sqrt{z}$ almost surely. This result generalizes a well known theorem of Bai and Yin which was proved under the additional assumption of a bounded fourth moment of the entries. (Received September 02, 2014)

1104-60-258 **Fei Lu*** (flu@lbl.gov), Mathematics group, Lawrence Berkeley National Lab, Berkeley, CA 94720, and **Alexandre J Chorin** (chorin@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, Berkeley, CA 94720. *Parameter estimation for a partially observed Ornstein-Uhlenbeck process with degenerate noise.*

We consider the joint estimation of the drift and diffusion coefficients of a two-dimensional Ornstein-Uhlenbeck process with degenerate noise, when the observation is a discrete sampling of the integrated component at times $k\Delta, k = 1, \ldots, n$. Estimators are constructed from the autocorrelation function of the observed process. Unlike the widely used methods based on approximation of the likelihood or the transition density, we do not require Δ to be small. For a fixed Δ, we prove that the estimators are consistent and asymptotically jointly normal. In numerical simulations, the proposed method works well even when Δ is large. (Received September 03, 2014)

1104-60-266 **Umit Islak*** (islak@usc.edu), 1267 Fifield Pl Falcon Heights, St Paul, MN 55108, and **Christian Houdre**. *On limit laws for the lengths of longest common subsequences.*

The longest common subsequence (LCS) problem has attracted a lot of interest in the last decades due to their applications in the computer science, computational biology and several other fields. The first purpose of this talk is to show that the length of the LCS of certain random permutations converge to the Tracy-Widom distribution after proper centering and scaling. Secondly, I will present discussions on some ongoing work on a generalization of the LCS problem via score functions. (Joint work with Christian Houdré.) (Received September 02, 2014)

1104-60-289 **Alperen Y Ozdemir***, University of Southern California, Kaprielian Hall 415, Los Angeles, CA 90007, and **Umit Islak**. *Weakly Increasing Subsequences of Random Words.*

Letting $X_1, X_2, \ldots, X_n$ be independent, uniformly distributed random variables over $\{1, 2, \ldots, m\}$, the length of the longest weakly increasing subsequence of $\mathbf{X} = (X_1, \ldots, X_n)$ is defined as the largest k so that there exists $1 \leq i_1 < \ldots < i_k \leq n$ with $X_{i_1} \leq X_{i_2} \leq \cdots \leq X_{i_k}$. In this work, we study the asymptotics of the mean and the variance of the number of weakly increasing subsequences of a fixed length, and also prove that they satisfy a central limit theorem. Connections to increasing subsequences in random permutations and other related problems are also discussed. (Joint work with Ümit Işlak.) (Received September 03, 2014)

1104-60-298 **Wei-Kuo Chen**, **Nikos Dafnis** and **Grigoris Paouris*** (grigorios.paouris@gmail.com), Department of Mathematics, Texas A&M University, TX 77843-3368. *Improved Holder and reverse Holder inequalities for Gaussian random vectors.*

We propose algebraic criteria that yield sharp Hölder type of inequalities for the product of functions of Gaussian random vectors with arbitrary covariance structure. While our lower inequality appears to be new, we prove that the upper inequality gives an equivalent formulation for the geometric Brascamp-Lieb inequality for Gaussian measures. As an application, we retrieve the Gaussian hypercontractivity as well as its reverse and we present a generalization of the sharp Young and reverse Young inequalities. From the latter, we recover several known inequalities in literature including the Prékopa-Leindler and Barthe inequalities. (Received September 03, 2014)

62 ► Statistics

1104-62-5 **Rowena Angeles Monfero*** (rowenama74@yahoo.com), Far Eastern University, N. Reyes St., Sampaloc, 1008 Manila, Philippines, and **Priscilla Altares**. *Applied Mathematics with Information Technology: Alignment of Exit Competencies with Current Job Competencies.* Preliminary report.

This study focused on the alignment of the exit competencies of the BSAMIT(Bachelor of Science in Applied Mathematics with Information Technology) graduates with their current job competencies. One of the research goals was to determine the knowledge and skills that the graduates of BSAMIT demonstrated in their workplace. Results indicated that majority of the graduates from 2005-2010 were employed in their field of specialization which is Mathematics and Information Technology. Some of the skills learned in College which were needed in their jobs were communication skills, interpersonal skills, analytical and problem solving skills were given emphasis. Most of their competencies were derived from their undergraduate course BSAMIT, and from their previous and current jobs.The exit competencies derived from the BSAMIT program were critical and analytical skills followed by problem solving skills and knowledge in Information Technology skills. The least needed competencies were the teaching skills and entrepreneurial skills. The skills and competencies needed for their present job were mathematical (critical. analytical and problem solving) skills and IT skills(basic programming languages and basic processes), communication (English proficiency) and human relations. (Received March 09, 2014)

1104-62-46 **Alexander Aue*** (aaue@ucdavis.edu), **Rex Cheung**, **Thomas Lee** and **Ming Zhong**. *Simultaneous break point detection and variable selection in quantile (auto)regression models.*

This talk discusses new model fitting techniques for quantiles of an observed data sequence, including methods for data segmentation and variable selection. The main contribution is in providing a means to perform these two tasks simultaneously. This is achieved by matching the data with the best-fitting piecewise quantile regression model, where the fit is determined by a penalization derived from the minimum description length principle. The resulting optimization problem is solved with the use of genetic algorithms. The proposed, fully automatic procedures are, unlike traditional break point procedures, not based on repeated hypothesis tests, and do not require, unlike most variable selection procedures, the specification of a tuning parameter. Theoretical large-sample properties are derived. Empirical comparisons with existing break point and variable selection methods for quantiles indicate that the new procedures work well in practice. (Received August 10, 2014)

1104-62-83 **Jing Xi*** (jxi2@ncsu.edu), 3151 SAS Hall, Raleigh, NC 27695, and **Seth Sullivant** (smsulli2@ncsu.edu), 3151 SAS Hall, Raleigh, NC 27695. *Sequential Importance Sampling for Two-dimensional Ising Models.*

In recent years, sequential importance sampling (SIS) has been well developed for sampling contingency tables with linear constraints. In this talk, we apply SIS procedure to 2-dimensional Ising models, which give observations of 0-1 tables and include both linear and quadratic constraints. We show how to compute bounds for specific cells by solving linear programming (LP) problems over cut polytopes to reduce rejections. The computational results, which includes both simulations and real data analysis, suggest that our method performs very well for sparse tables and when the 1's are spread out: the computational times are short, the acceptance rates are high, and in most cases our conclusions are theoretically reasonable. (Received August 22, 2014)

1104-62-132 **Ruth E Davidson*** (redavid2@illinois.edu), **Joseph Rusinko** and **Jing Xi**. *Modeling the distribution of distance data in Euclidean space.*

One way to gain insight into the behavior of a phylogenetic tree reconstruction method is by understanding how the mathematical properties of the inputs and outputs for the method influence its behavior. The inputs and

outputs of distance-based methods are points in a Euclidean space, and their geometric properties therefore can be studied towards this end. While many of the geometric properties of the outputs of phylogenetic distance-based methods are known, the space of all likely inputs is less well-understood in the geometric setting. Past analyses of this sort either assumed a uniform distribution of input points in the Euclidean space or a distribution based on simulations from a model tree. These simplifying assumptions account poorly in practice for the actual inputs used in phylogenetic reconstruction, which are usually computed from aligned sequences using a statistical model of sequence evolution. In this paper we present a model for the distribution of distance data in three dimensions designed to mimic the behavior of biological data. We propose this model as a tool for testing simulations and theoretical results using distance-based methods. (Received August 27, 2014)

1104-62-170 **Piotr Zwiernik*** (piotr.zwiernik@gmail.com), University of California Berkeley, Department of Statistics, Berkeley, CA 94720-3860. *Maximum Likelihood Estimation for Linear Gaussian Covariance Models.*

We study parameter estimation in linear Gaussian covariance models, which are p-dimensional Gaussian models with linear constraints on the covariance matrix. Maximum likelihood estimation for this class of models leads to a non-convex optimization problem which typically has many local optima. We prove that the log-likelihood function is concave over a large region of the cone of positive definite matrices. Using recent results on the asymptotic distribution of extreme eigenvalues of the Wishart distribution, we provide sufficient conditions for any hill climbing method to converge to the global optimum. The proofs of these results utilize large-sample asymptotic theory under the scheme $n/p \to \gamma > 1$. Remarkably, our numerical simulations indicate that our results remain valid for $\min\{n, p\}$ as small as 2. An important consequence of this analysis is that for sample sizes $n \simeq 14p$, maximum likelihood estimation for linear Gaussian covariance models behaves as if it were a convex optimization problem.

Joint work: Caroline Uhler, Donald Richards (Received August 31, 2014)

1104-62-177 **Caroline Uhler*** (caroline.uhler@ist.ac.at), IST Austria, Am Campus 1, 3400 Klosterneuburg, Austria, and **Donald Richards** (richards@stat.psu.edu), Penn State University, Department of Statistics, 323 Thomas Building, University Park, PA 16802. *Generalized Fréchet bounds and correlation inequalities for multidimensional contingency tables.* Preliminary report.

We consider the lattice, L, of all subsets of a multidimensional contingency table and we establish the properties of supermodularity and subadditivity for certain functions on L, such as marginal cell counts. We derive higher-order supermodularity properties of these functions and deduce as special cases some generalized Fréchet bounds that have appeared in the literature. Further, we construct on the lattice L some probability measures which are multivariate totally positive of order 2, and we derive FKG correlation inequalities on L. (Received August 31, 2014)

1104-62-197 **Yajun Mei*** (ymei@isye.gatech.edu), 765 Fesrt Drive, Atlanta, GA 30332-0205. *Monitoring Large-Scale Data Streams via Shrinkage.* Preliminary report.

In the modern information age one often monitors large-scale data streams with the aim of offering the potential for early detection a "trigger" event, e.g., quality control, (bio)surveillance, health care, security and environmental science. In this talk, we investigate the problem of online monitoring large-scale independent data streams where an undesired event may occur at some unknown time and may affect only a few number of data streams. In order to develop scalable global monitoring schemes, we propose to monitor each univariate local data stream by a classical sequential change-point detection method, and then combine all local detection schemes together to produce an efficient global scheme via shrinkage transformations. Besides numerical simulations, the asymptotic properties of the false alarm rate of the proposed schemes are also derived under the modern setting when the number of data streams goes to infinity. (Received September 01, 2014)

1104-62-200 **Alexandra Piryatinska*** (alpiryat@sfsu.edu), 1600 Holloway Ave, San Francisco, CA 94132, and **Boris Darkhovsky** (darbor2004@mail.ru), 9 Pr. 60-letiya Oktyabrya, Moskow, 117312, Russia. *Novel Methodology for Segmentation of Time Series Generated by Arbitrary Mechanism.*

The segmentation problem of time series generated by different mechanisms (stochastic, deterministic and mixed) into homogeneous segments is considered. We call a segment homogeneous if it was generated by a single mechanism. A novel approach to this problem is proposed. This approach is based on the authors' concept of the ϵ-complexity of continuous functions and the non-parametric change-point detection methodology. In this talk we show that for a function satisfying a Hölder condition the ϵ-complexity can be characterized by a pair of

real numbers called here ϵ-complexity coefficients. These coefficients are used as diagnostic sequences to detect changes in the generating mechanism. The proposed methodology is model-free and does not depend on the data generating mechanism. The results of simulations, and applications to real EEG and stock market data, demonstrate efficiency of the proposed methodology. (Received September 01, 2014)

1104-62-220 **Dennis Leung***, dmhleung@uw.edu, and **Hisayuki Hara** and **Mathias Drton**. *Identifiability of acyclic directed Gaussian graphical models with one latent variable.*

Acyclic directed graphical models capture dependence structures that arise from causal relations between random variables of interest. We consider the problem of parameter identifiability in the Gaussian setting, in which we seek graphical conditions that guaranteed that all model parameters can be recovered from the covariance matrix of the observed variables. Specializing to the case of precisely one latent/unobserved variable, we will discuss the results of algebraic computations for graphs up to 7 nodes and describe a new sufficient criterion for finite identifiability. A necessary condition will also be introduced, which has not been found in the literature before. Finally, we will discuss a result on how knowledge about identifiability of a subgraph can be extended to identifiability of an original graph. (Received September 02, 2014)

1104-62-249 **Sonja Petrovic*** (sonja.petrovic@iit.edu), **Dane Wilburne**, **Despina Stasi**, **Michael Pelsmajer** and **Vishesh Karwa**. *A family of statistical models for k-core decompositions of graphs.*

In the network (random graphs) literature, network analyses are often concerned- either directly or indirectly- with the degrees of the nodes in the network. Familiar statistical frameworks, such as the beta or p1 models, associate probabilities to networks in terms of their degree distributions. However, this approach may fail to capture certain vital connectivity information about the network. Often, it matters not just to how many other nodes a particular node in the network is connected, but also to which other nodes it is connected. Degree-centric analyses are not well-suited to model such situations. This talk introduces a model family for one such connectivity structure and is motivated by examples of social networks. (Received September 02, 2014)

1104-62-255 **Serkan Hosten*** (serkan@sfsu.edu), San Francisco State University, Mathematics Department, 1600 Holloway Avenue, San Francisco, CA 94132. *Boundary stratification of tensors with nonnegative rank two.* Preliminary report.

We study the boundary of the semi-algebraic set of real tensors with nonnegative rank two and describe the "faces" of this set in the interior of the probability simplex. We also elaborate on the implications of this stratification for maximum likelihood estimation and the EM algorithm. (Received September 02, 2014)

1104-62-327 **Elizabeth Gross*** (elizabeth.gross@sjsu.edu) and **Jose Israel Rodriguez**. *Maximum likelihood degree in the presence of data zeros.*

Given a statistical model, the maximum likelihood degree is the number of complex solutions to the likelihood equations for generic data, or equivalently, the degree of the likelihood locus. In this talk, we consider discrete algebraic statistical models and explore the solutions to the likelihood equations when the data are no longer generic, but instead contain zeros. In this case, with the help of numerical algebraic geometry, we see that the solutions partition into two clusters, solutions to the likelihood equations for sampling zeros and solutions that lie on the coordinate hyperplanes. Using this fact, we show how the problem of finding critical points to the likelihood function can be partitioned into smaller and computationally easier problems involving sampling and model zeros. (Received September 03, 2014)

1104-62-328 **Sebastien Bubeck*** (sebubeck@microsoft.com), Building 99, Microsoft campus, Redmond, WA 98052. *Estimation in high-dimensional random geometric graph.*

We consider a random graph model where connections depend on unknown d-dimensional labels (or feature vectors) for the vertices. Upon the observation of a realization from this model we are interested in estimating the unknown dimension d of the feature vectors. We propose a new statistic, based on "signed triangles", which can successfully estimate dimensions as large as n^2 (where n is the number of vertices), while a simple count of triangles would only work up to dimension of order n. We also show that n^2 is optimal, using a new bound on the total variation distance between Wishart matrices and the Gaussian Orthogonal Ensemble.

Joint work with Jian Ding, Ronen Eldan, and Miklos Racz. (Received September 03, 2014)

65 ► Numerical analysis

1104-65-79 **J Ding*** (jiudin@gmail.com), Department of Mathematics, 118 College Dr., Box 5045, Hattiesburg, MS 39406. *Least squares approximations of Stationary Densities of Dynamical Systems.*

We present a mathematical analysis for high order least squares methods based on splines for the computation of stationary densities of deterministic dynamical systems, via the approximation of the underlying Frobenius-Perron operator by the projection principle. We establish some stability and consistence inequalities in terms of different norms, based on which the convergence and error estimates could be obtained. (Received August 20, 2014)

1104-65-154 **Gideon Simpson*** (simpson@math.drexel.edu), Department of Mathematics, Korman Center - Room 206, 33rd and Market Streets, Philadelphia, PA 19104. *Algorithms for Nonlinear Bound States in Hamiltonian PDE.*

Nonlinear bound states, including solitons, are found in many dispersive Hamiltonian PDE, including the Nonlinear Schrdinger equation and the Nonlinear Wave equation. Numerically computing these solutions requires care, as they solve a nonlinear elliptic equation which also has the zero function as a solution; nothing prevents Newton's method from converging to the trivial solution. A number of algorithms have been developed to tackle this problem, including Petviashvilli's method, Spectral Renormalization, and the Imaginary time method. In this talk, I will present results analyzing the application of Petviashvilli's method to the Dirichlet problem, on a domain in $\mathbb{R}^n$ with sufficiently smooth boundary. This work also lends itself to the computation of excited state solutions of the associated problem on $\mathbb{R}^n$. (Received August 29, 2014)

1104-65-295 **Dhagash Mehta*** (dmehta@nd.edu), 152B Hurley Hall, Dept of App and comp Math and Stat, University of Notre Dame, Notre Dame, IN 46556. *Exploring Potential Energy Landscapes of different models arising from science and technology using Computational Algebraic Geometry.*

Finding the stationary points of a potential energy function arising from scientific and engineering phenomena is an important problem. In this talk, I will explain how computational algebraic geometry methods can be of great help here with a mention of various examples. (Received September 03, 2014)

1104-65-297 **Jonathan Hauenstein*** (hauenstein@nd.edu), 146 Hayes-Healy, Notre Dame, IN 46556, and **Tianran Chen**, **Alan Liddell**, **Dhagash Mehta** and **David Wales**. *Newton homotopies and applications.*

A Newton homotopy is a homotopy in which only the constant terms vary. Although the homotopies are simply constructed, they can be used in many applications with certifiable path tracking computations. This talk will explore some of these applications, including moving robots and solving PDEs, as well as mention results about the path tracking cost of Newton homotopies. (Received September 03, 2014)

70 ► Mechanics of particles and systems

1104-70-129 **D. B. Mehta**, **J. D. Hauenstein**, **M. E. Niemerg*** (matthew.niemerg@berkeley.edu), **N. J. Simm** and **D. E. Stariolo**. *Energy Landscape of the Finite-Size Mean-field 2-Spin Spherical Model and Topology Trivialization.*

Motivated by the recently observed phenomenon of topology trivialization of the potential energy landscapes (PELs) of several statistical mechanics models, we perform a numerical study for the finite size 2-spin spherical model using the numerical polynomial homotopy continuation method which guarantees to find all the stationary points of this model. We not only compute the average number of stationary points while changing the topology of the PEL, but also the variance, and histograms of these stationary points, and analyse the trend of the complex stationary points. We then connect the topology trivialization to two different branches of Mathematics, namely, algebraic geometry and Catastrophe theory, and argue that topology trivialization phenomenon is a fertile ground for sowing the seeds of the fruitful interdisciplinary research. (Received August 27, 2014)

76 ► Fluid mechanics

1104-76-178 **Xiaoming Wang*** (wxm@math.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32306. *The rate of heat transport in the vertical direction.*

We discuss the scaling of the long time averaged rate of heat transport in the vertical direction, quantified as the Nusselt number, within the Rayleigh-Benard model for convection. The dynamics is governed by the well-known Boussinesq system for fluid convection. How the Nusselt number scales in terms of the parameters of the system, i.e., the Rayleigh and Prandtl numbers, is an outstanding open problem in classical physics. Both the case of finite Prandtl number, and the case of infinite Prandtl number will be discussed. Classical no-slip boundary condition as well as geophysically important free-slip boundary conditions will be investigated. Numerical methods that are able to asymptotically preserve the Nusselt number will be presented as well. (Received August 31, 2014)

1104-76-201 **Jeongwhan Choi*** (jchoi@korea.ac.kr), Sungbukgu Anamdong 5-1, Dept of Math. Korea University, Seoul, 136-701, South Korea, **Shu-Ming Sun** (sun@math.vt.edu), Department of Mathematics, Virginia Polytech, Blacksburg, VA 24061, and **Sung-Im Whang** (siwhang@korea.ac.kr), Dept. of Math., Ajou University, Suwon, South Korea. *Surface waves on water over a bump with critical surface tension.*

We consider steady forced surface waves propagating on a two dimensional incompressible and inviscid fluid with a small bump placed on a rigid flat bottom. When the surface tension coefficient on the free surface is not zero and is near a critcal number, so called Bond number, KdV equation fails and the following a Kawahara equation with forcing is derived,

$\eta_t + \lambda\eta_x - (3/2)\eta\eta_x + (\tau/2)\eta_{xxx} - (1/90)\eta_{xxxxx} = b_x(x)$.

Here, λ, τ are free constant parameters for the speed of the water at far upstream and the surface tension of the surface respectively and $b(x)$ is a function for a small bump at the flat rigid bottom. We study above Kawahara equation with forcing theoritically and numerically. Existence theorems are proved and new numerical solutions have been found. The numerical stability of steady solutions are also studied. (Received September 01, 2014)

1104-76-282 **Ravi A Shankar*** (rshankar@mail.csuchico.edu). *Computing wave breaking times of the inviscid Burgers equation using finite difference methods.*

The inviscid Burgers equation is solved numerically in application to water wave breaking. As an alternative to complicated numerical methods based on the locating the first intersection of the characteristic lines, a simple finite difference scheme is used to compute the time when the wave energy first starts to dissipate. A flux limiter is used to minimize spurious diffusion. To compensate for numerical error introduced by integrating near the steep wave front, a local averaging method is used to smooth the energy curve. The numerical results give good agreement with analytical breaking times. (Received September 03, 2014)

1104-76-288 **Jeff Mortensen** (jm@unr.edu), Department of Mathematics and Statistics, University of Nevada, Reno, NV 89557, and **Aleksey S Telyakovskiy*** (alekseyt@unr.edu), Department of Mathematics and Statistics, University of Nevada, Reno, NV 89557. *Analytical analysis of nonlinear differential equations from hydrology.* Preliminary report.

Nonlinear diffusion equations describe flows in unconfined groundwater reservoirs. Often in such settings diffusivity is a power-law function of the hydraulic head, which is the dependent quantity. Common examples of such nonlinear equations are the Boussinesq equation and the porous medium equation. We are interested in the construction of approximate solutions in closed-form. Such approximate solutions are easy to use and they can replicate the key properties of the true solution. (Received September 03, 2014)

1104-76-311 **Aseel Farhat*** (afarhat@indiana.edu), **Evelyn Lunasin** and **Edriss Titi**. *A New Abridged Continuous Data Assimilation Algorithm for the 2D NSE and the 3D α-Models of Turbulence.*

We introduce an abridged continuous data assimilation algorithm for the 2D Navier-Stokes equations and 3D subgrid scale α-models of turbulence. The novelty of this improved algorithm is on the reduction on the components of the observational data that needs to be measured and inserted into the model equation, in the form of a feedback control term, to recover the unknown reference solution. We show that for the 2D Navier-Stokes equations the approximate solutions constructed using observations in only one component of the velocity field converge in time to the reference solution. In the case of the 3D α-models, we show that the approximate solutions constructed using only observations any two components, without any measurements on the third component, of the velocity field converge in time to the reference solution. (Received September 03, 2014)

81 ► Quantum theory

1104-81-37 **Michael George Dombroski*** (dombroskistm11@verizon.net). *Real Integer Physics.* Preliminary report.

In this paper we empirically investigate the Boson Matrix $\mathbf{H}:=\begin{pmatrix} 0 & 1 & 0 \\ -1 & 0 & -1 \\ 0 & 1 & 0 \end{pmatrix}$ as a basis for Real Integer Physics.

Real Poisson Bracket analogs yield the result (SI)**H**, where (SI) is a **Scalar Integer** that factors out of the **H** matrix.

Real Least Action analogs yield similar results with **H**.

We *hypothesize* **H *Matrix* = Planck's Constant *Matrix*** (PC*M*) = **Higgs Boson *Matrix*** (HB*M*).

Website—**dombroskiSTM.org** (Received August 08, 2014)

82 ► Statistical mechanics, structure of matter

1104-82-251 **Stefan M Giovan**, University of Texas at Dallas, Department of Molecular and Cell Biology, 800 West Campbell Rd., FO31, Richardson, TX 75080, **Andreas Hanke**, University of Texas at Brownsville, Department of Physics and Astronomy, 80 Fort Brown, Brownsville, TX 78520, and **Stephen D Levene*** (sdlevene@utdallas.edu), University of Texas at Dallas, Departments of Bioengineering, 800 West Campbell Rd, EC31, Richardson, TX 75080. *DNA looping and knotting in the wormlike limit: normal modes and the harmonic approximation.*

The free-energy cost of forming DNA knots and loops involves a delicate and length-scale-dependent balance of enthalpic and entropic contributions. Although obtaining the enthalpy due to geometrical and/or topological constraints from computational models is generally trivial, computing the entropic term, $T\Delta S$ is a challenging problem in statistical mechanics. For sufficiently small systems it is possible to obtain the entropy by using normal-mode analysis, which reduces the problem to a system of harmonic oscillators. This technique not only gives an exact result for the free energy but also yields the full spectrum of eigenmodes, which in turn may yield insight into the dynamic behavior of the system. We will explore the applicability of this approximation for small DNA loops and circular DNAs along with extensions to systems that cannot rigorously be considered harmonic. (Received September 02, 2014)

1104-82-263 **Christine Soteros*** (soteros@math.usask.ca). *Lattice Polygon Models of Polymer and Biopolymer Entanglements.* Preliminary report.

We have been using self-avoiding lattice polygons to investigate entanglement measures such as knotting probabilities and knot-transition probabilities for models of polymers and biopolymers. One goal of these studies is to characterize how a given entanglement measure changes with polygon size and how it is affected by other system properties such as geometrical confinement and/or solvent quality. A better understanding and characterization of these effects is expected to lead to an improved understanding of, for example, DNA confined to a viral capsid and/or DNA-enzyme interactions. Recent progress has been made both theoretically and numerically with respect to the effect of confinement on knot probabilities and the effect of salt concentration on knot-transition probabilities. I will review overall progress and highlight some recent results. (Received September 02, 2014)

1104-82-267 **Andrew Rechnitzer*** (andrewr@math.ubc.ca). *Further adventures in Hopfs.* Preliminary report.

I will examine the geometry of random embeddings of Hopf links into R^3. In previous work we observed that each component of the link expells the other and so there is very few points of contact between them. In this work we seek to understand the local geometry around these points of contact.

This is work together with Buks van Rensburg and Greg Buck. (Received September 02, 2014)

92 ► Biology and other natural sciences

1104-92-100 **Wilma K. Olson*** (wilma.olson@rutgers.edu), Wright-Rieman Laboratories, 610 Taylor Road, Piscataway, NJ 08854, and **Juan Wei**, **Luke Czapla**, **Michael A. Grosner** and **David Swigon**. *DNA topology confers sequence specificity to non-specific architectural proteins.*

Topological constraints placed on short fragments of DNA change the disorder found in chain molecules randomly decorated by nonspecific, architectural proteins into tightly organized three-dimensional structures. The bacterial protein HU builds up, counter to expectations, in greater quantities and at particular sites along simulated DNA minicircles and loops. The many ways in which the protein induces nearly the same closed circular configuration point to the statistical advantage of its nonspecificity. The rotational settings imposed on DNA by the repressor proteins, by contrast, introduce sequential specificity in HU placement, with the nonspecific protein accumulating at particular loci on the constrained duplex. Thus, an architectural protein with no discernable DNA sequence-recognizing features becomes site-specific and potentially assumes a functional role upon loop formation. The locations of HU on the closed DNA reflect long-range mechanical correlations. The protein responds to DNA shape and deformability rather than unique features of the constituent base pairs. The structures of the simulated loops suggest that HU architecture may influence repressor-operator interactions in the context of the bacterial nucleoid. (Received August 25, 2014)

1104-92-105 **Tamar Schlick***, 251 Mercer St., New York, NY 10012, and **Namhee Kim**, **Mai Zahran** and **Shereef Elmetwaly**. *Folding RNA by a Hierarchical Graph Sampling Approach.*

A current challenge in structure prediction of ribonucleic acids (RNA) is the description of global tertiary (3D) topology or helical arrangements compatible with a given RNA secondary (2D) structure. We present a hierarchical Monte Carlo sampling approach to describe RNA helical geometries by a coarse-grained sampling of 3D graphs guided by knowledge-based potentials derived from bend, twist, and radii of gyration measures based on known structures. Sampling RNA graphs accelerates the global search for candidate RNA topologies, and the scoring potentials help select good candidates using a clustering approach. The combination of coarse-grained modeling, junction prediction, and efficient sampling leads to significant improvements over current approaches for characterizing 3D global helical arrangements in large RNAs from a given 2D structure. The remaining step of translating candidate graphs to atomic models can be approached with our ideas of graph partitioning and build-up procedures already utilized for RNA design. (Received August 25, 2014)

1104-92-130 **Nataša Jonoska*** (jonoska@mail.usf.edu), Department of Mathematics and Statistics, USF, 4202 E. Fowler Av. CMC 342, Tampa, FL 33620, and **Masahico Saito** (saito@usf.edu), Tampa, FL 33620. *DNA Recombination Through Spatial Graphs.*

Certain species of ciliates undergo massive DNA rearrangements during their development. taking these species as model organisms, we study DNA recombination, in particular, rearrangements guided by RNA templates. We use spacial rigid vertex graphs, possibly with end points. Single gene rearrangements can be described by double occurrence words (unsigned Gauss codes), also used in knot theory. Assembled DNA segments are modeled by certain types of paths in graphs called Hamiltonian polygonal paths, while the homologous recombination is modeled by vertex smoothings. We discuss properties of such graphs motivated by DNA assembly, such as the minimum number of polygonal paths, genus ranges, and rearrangement pathways. In particular we analyze these properties for recently sequenced thousands of scrambled genes in ciliate *Oxytricha*. (Received August 27, 2014)

1104-92-160 **Eleni Panagiotou*** (panagiotou@math.ucsb.edu), Department of Mathematics, University of California Santa Barbara, Santa Barbara, CA 93106-3080, **Martin Kroeger** (mk@mat.ethz.ch), Department of Materials, ETH Zurich, Zurich, Switzerland, and **Kenneth Millett** (millett@math.ucsb.edu), Department of Mathematics, University of California Santa Barbara, Santa Barbara, CA 93106-3080. *Writhe and mutual entanglement combine to give the entanglement length.*

We propose a new method to estimate N_e, the entanglement length, that incorporates both local and global topological characteristics of chains in a melt under equilibrium conditions. This estimate uses the writhe of the chains, the writhe of the primitive paths and the number of kinks in the chains in a melt. An advantage of this new method is that it works for both linear and ring chains, works under all periodic boundary conditions, does not require knowing the contour length of the primitive paths and it does not rely on a smooth set of data. We apply this method to linear finitely extendable non-linear elastic chains and we observe that our estimates are consistent with those from other studies. (Received August 29, 2014)

1104-92-166 **De Witt Sumners*** (sumners@math.fsu.edu), Department of Mathematics, Florida State University, Tallahassee, FL 32306. *Topological friction strongly affects viral DNA ejection.*

Bacteriophages initiate infection by releasing their double-stranded DNA into the cytosol of their bacterial host. However, what controls and sets the timescales of DNA ejection? We will discuss evidence from stochastic simulations which shows that the topology (knotting) and organization of DNA packed inside the capsid plays a key role in determining these properties.

The results to be discussed are contained in the following paper:

D. Marenduzzo, C. Micheletti, E. Orlandini, D.W. Sumners. Topological Friction Strongly Affects Viral DNA Ejection, Proc. National Academy of Sciences USA 110 (2013), 20081-20086. (Received August 30, 2014)

1104-92-231 **MASSA SHOURA*** (marcela@utdallas.edu), 800 W. Campbell Rd., Mail station: ECSS 3.9, Biomedical Engineering Department, RICHARDSON, TX 75080, and **Stephen Levene** (sdlevene@utdallas.edu), 800 W. Campbell Rd., Mail station: ECSS 3.9, Biomedical Engineering Department, RICHARDSON, TX 75080. *Beyond Crystal Structure- Picture Perfect: The mechanics of DNA shape and flexibility in site-specific recombination.* Preliminary report.

Many methods have been used to directly observe DNA looping or knotting in vitro, such as scanning-probe and electron microscopy. However, the number of techniques available for quantifying DNA looping in solution is limited. Characterization of the rates at which proteins bind to, and bend, DNA provides insights into the reaction intermediates; hence it is a natural way to probe the mechanism of these interactions. Our approach characterizes the rate-determining steps for inter- and intramolecular synapsis in a Cre site-specific recombination reaction to answer the following questions: does Cre induce a bend in its DNA substrate, and can the Cre-loxP system report on DNA flexibility? This methodology, which can be extended to future in-vivo studies, uses time-dependent FRET in conjunction with numerical modeling of the recombination pathway to monitor target-site synapsis and the Cre-recombination products. In this talk, I will show that the quotient of apparent equilibrium constants for the intramolecular and equivalent intermolecular Cre reaction yields several parameters that determine the free energy of the looped intermediate including DNA helical repeat, DNA bending and torsional flexibilities, and most significantly, the geometry of the nucleoprotein complex. (Received September 02, 2014)

1104-92-293 **Rossitza N. Irobalieva**, **Jonathan M. Fogg**, **Daniel J. Catanese, Jr.**, **Thana Sutthibutpong**, **Steven J. Ludtke**, **Sarah A. Harris**, **Michael F. Schmid**, **Wah Chiu** and **Lynn Zechiedrich*** (elz@bcm.edu), One Baylor Plaza, Mail-stop: BCM-280, Baylor College of Medicine, Houston, TX 77030. *Structural diversity of positively and negatively supercoiled DNA revealed by electron cryo-tomography.*

DNA supercoiling affects all aspects of DNA metabolism (Fogg et al. 2012 Q Rev Biophys 45:257). In most organisms DNA is maintained in a negatively supercoiled (underwound) state. Positively supercoiled (overwound) DNA is generated during DNA replication and transcription, and, if not promptly removed, inhibits these processes. DNA topological regulation is critical and is the target of drugs against cancer and bacterial infections. Together with two more authors that did not fit on the form, graduate students, Muyuan Chen and Anna K. Barker, both of Baylor College of Medicine, we determined the 3D structure of DNA with specific levels of supercoiling. DNA supercoiling facilitated a wide variety of conformations and there were profound differences between positively and negatively supercoiled DNA and exposed DNA bases that varied with the direction and degree of supercoiling. These findings demonstrate that DNA uses supercoiling to change its structure in ways that significantly influence interactions with proteins, other segments of DNA or RNA, as well as the drugs that target DNA metabolic processes. Supported by NIH grant RO1A1054830, a Human Frontier Science Program grant, and an award from the John S. Dunn Foundation. (Received September 03, 2014)

1104-92-329 **Michele M Klingbeil*** (klingbeil@microbio.umass.edu), 639 North Pleasant Street, Amherst, MA 01003, and **Yuanan Diao** and **Javier Arsuaga**. *Multidisciplinary approaches to study the topological complexity in kinetoplast DNA.* Preliminary report.

Trypanosomes are unicellular parasitic protozoa that cause fatal diseases in humans and livestock. A distinctive feature of these organisms is their mitochondrial DNA known as kinetoplast DNA (kDNA), which is essential for parasite survival. kDNA is the most structurally complex DNA in nature composed of a few dozen maxicircles and thousands of minicircles that are topologically linked into a chainmail-like network. Network replication proceeds through a unique minicircle unlinking and relinking mechanism that requires a plethora of non-redundant activities such as primases, polymerases, and helicases. The network structure persists with changes in linking number. Formation of the network structure is still a puzzle in spite of numerous biochemical and molecular

studies. Currently, there are no methods to study kDNA network formation in vivo. Mathematical modeling has defined minicircle volume confinement as the main contributing factor for network formation but cannot account for the in vivo linking number. To refine the model, we are using RNAi to silence essential kDNA associated proteins to produce network collapse. The topology of resulting networks (reduced stable structures before collapse) will help determine the critical and saturation densities for network formation. (Received September 03, 2014)

94 ► Information and communication, circuits

1104-94-232 **Tom Leinster** and **Mark Meckes*** (mark.meckes@case.edu), 10900 Euclid Ave., Cleveland, OH 44106. *A general framework for entropies.* Preliminary report.

I will introduce a family of functionals which generalize and unify various types of entropy which appear in a number of different fields (information theory, metric geometry, theoretical ecology, probability, and combinatorics), and discuss the corresponding entropy-maximization problem. (Received September 02, 2014)

1104-94-337 **Michael E O'Sullivan*** (mosullivan@mail.sdsu.edu), Department of Mathematics and Statistics, San Diego State University, San Diego, CA 92182. *Remarks on non-Shannon information inequalities.* Preliminary report.

Let $X_1, \ldots, X_n$ be discrete random variables and, for a nonempty $A \subseteq \{1, \ldots, n\}$, let X_A be the random vector indexed by A. The vector of entropies $H(X_A)$ indexed by A satisfies inequalities discovered by Shannon as well as numerous non-Shannon inequalites discovered by Zhang and Yeung, Dougherty et al, Matus, and others. I will discuss these inequalities and Matus's technique of adhesion of polymatroids, after a linear transformation related to Yeung's information diagrams. (Received September 03, 2014)

00 ► General

1105-00-42 **Chris D. Lynd*** (clynd@bloomu.edu) and **Devyn A. Lesher**. *Convergence Results for the Class of Periodic Left Nested Radicals.*

In our paper, we utilize techniques from the field of difference equations to prove several theorems about the end-behavior of periodic left nested radicals. We will present the results of three theorems about the convergence of left nested radicals and one theorem about sequences of left nested radicals that converge asymptotically to a periodic sequence. We conclude the presentation by constructing a sequence of left nested radicals whose limiting sequence repeats the digits in the phone number 867-5309. (Received August 23, 2014)

1105-00-43 **Devyn A. Lesher*** (dal64360@huskies.bloomu.edu) and **Chris D. Lyd**. *Difference Equations and the Class of Periodic Left Nested Radicals.*

Since the time of the ancient Greeks, mathematicians have been fascinated with nested radicals. We will provide a variety of examples of left and right nested radicals as we present a brief history of this topic and illustrate its connection to difference equations. We also provide the formal definition of a left and a right nested radical as we present the first of several new results about the class of periodic left nested radicals. (Received August 23, 2014)

1105-00-93 **Laura Taalman*** (laurataalman@gmail.com). *Five ways to 3D-print a knot.*

In this talk we will outline various methods of creating files suitable for 3D-printing knot models using OpenSCAD, Blender, KnotPlot, Mathematica, and TopMod. Physical 3D-printed knot models and a live 3D-printing demonstration will accompany this talk. (Received September 09, 2014)

03 ► Mathematical logic and foundations

1105-03-194 **Henry A Gore*** (hgore@gordonstate.edu). *The Ordered Mostowski Model.*

The full universe built from denumerably many atoms can be obtained as a generic extension of the ordered Mostowski model of set theory with atoms. While the Axiom of Choice fails in the ordered Mostowski model, the Axiom of Choice holds in this generic extension of the ordered Mostowski model. (Received September 19, 2014)

05 ► Combinatorics

1105-05-14 **George E Andrews*** (gea1@psu.edu), 306 McAllister Bldg., Mathematics Department, Pennsylvania State University, University Park, PA 16802. *Partitions with fixed difference between largest and smallest parts.*

This is joint work with Matthias Beck and Neville Robbins. Let p(n,t) denote the number of partitions of n in which the difference between largest and smallest parts is t. We shown that when t>1 the related generating function is an explicitly given rational function. We then generalize this to p(n,t1,t2,...,tk) which denotes the number of partitions of n in which there is a subsequence of parts s0,s1,s2,...,sk (where s0 is the smallest part and sk is the largest part) such that s1-s0=t1, s2-s1=t2, s3-s2=t3, ... Again the related generating function is an explicitly given rational function. (Received May 26, 2014)

1105-05-40 **Steven Schluchter*** (sschluch@gmu.edu), Department of Mathematical Sciences, George Mason University, 4400 University Drive: MS 3F2, Fairfax, VA 20032. *Applications Of Ordinary Voltage Graph Theory To Graph Embeddability, Part One.*

Consider a cellular embedding of a graph G in S. A free action of a group A on G that extends to a cellular automorphism of S is called a pseudofree action of A on S. It is a consequence of ordinary voltage graph theory that any such embedding can be encoded using an ordinary voltage graph. Let p be a prime greater than 5. We will show that the Generalized Petersen Graph of the form $GP(2p, 2)$ has no cellular embedding in the torus such that a group acts pseudofreely on the the corresponding cellular decomposition of the torus. We will also show

that each $GP(2p, 2)$ does embed in the Klein bottle in this way, and that the automorphism group of $GP(2p, 2)$ does act pseudofreely on the torus given a different sort of embedded graph. (Received August 18, 2014)

1105-05-48 **Heather C. Smith*** (smithhc5@mailbox.sc.edu), **László Székely** (laszlo@mailbox.sc.edu) and **Hua Wang** (hwang@georgiasouthern.edu). *Eccentricity in Trees.*

The eccentricity of a vertex, $ecc(v) = \max_{u \in T} d_T(v, u)$, was one of the first, distance-based, tree invariants studied [Jordan, *J. Reine Angew. Math.*, **70**(1869), 185-190]. The total eccentricity of a tree, $Ecc(T)$, is the sum of eccentricities of its vertices. We determine extremal values and characterize extremal tree structures for the ratios $Ecc(T)/ecc(u)$, $Ecc(T)/ecc(v)$, $ecc(u)/ecc(v)$, and $ecc(u)/ecc(w)$ where u, w are leaves of T and v is in the center of T. Analogous problems have been resolved for other tree invariants including distance [Barefoot, Entringer, Székely, *Discrete Appl. Math.*, **80**(1997), 37-56] and number of subtrees [Székely, Wang, *Electron. J. Combin.*, **20**(1)(2013), P67]. In addition, we determine the tree structures that minimize and maximize total eccentricity among trees with a given degree sequence. (Received August 25, 2014)

1105-05-68 **David Galvin*** (dgalvin1@nd.edu), Notre Dame, IN 46556. *The independent set sequence of trees.* Preliminary report.

The independent set (or stable set) sequence of a graph is the sequence whose kth term is the number of independent sets of size k in the graph. Alavi, Malde, Schwenk and Erdős studied this sequence in 1987, and showed that it can exhibit any pattern of rises and falls. They raised the question, however, of whether the independent set sequence of a tree, or more generally a forest, is always unimodal — that is, has a single peak. This intriguing question is still fairly much open; I'll survey some results around it. Some of this is joint work with Justin Hilyard. (Received September 03, 2014)

1105-05-77 **Justin Allman*** (allmanjm@wfu.edu) and **Richard Rimanyi**. *Positivity for the K-theoretic Pieri rule on Grassmannians via iterated residues.* Preliminary report.

Stable Grothendieck polynomials are important objects in the study of the K-theory of Grassmannians. They exhibit many remarkable properties which have been studied in the context of algebraic geometry and tableaux combinatorics. We introduce a new tool similar to generating sequences, called the iterated residue technique, to establish a new proof that the Pieri rule for stable Grothendieck polynomials exhibits alternating signs. (Received September 04, 2014)

1105-05-87 **János Pach** (pach@renyi.hu), École Polytechnique Fédérale de, Lausanne, Station 8, CH-1015 Lausanne, Switzerland, **László A. Székely*** (szekely@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208, **Csaba D. Tóth** (cdtoth@eecs.tufts.edu), California State University Northridge, Department of Mathematics, Northridge, CA 91330-8313, and **Géza Tóth** (geza@renyi.hu), Rényi Institute, Hungarian Academy of Sciences, Budapest, Hungary. *A note on k-planar crossing numbers.* Preliminary report.

The k-planar crossing number $cr_k(G)$ of a graph G is $\min_{G_1 \cup G_2 \cup \cdots \cup G_k = G}\{cr(G_1) + cr(G_2) + \ldots + cr(G_k)\}$, where cr is the planar crossing number. We give near tight upper bounds for $cr_k(G)$ in terms of a constant multiple of $cr(G)$. (Received September 08, 2014)

1105-05-89 **A.V. Kostochka**, **X. Li**, **W. Ruksasakchai**, **M. Santana*** (santana@illinois.edu), **T. Wang** and **G. Yu**. *The strong chromatic index of subcubic planar graphs.*

A *strong edge-coloring* of a graph G is a proper edge-coloring with the additional property that each color class forms an induced matching in G. The *strong chromatic index* of G is the minimum k for which G has a strong edge-coloring using k colors. Erdős and Nešetřil conjectured that every graph with maximum degree Δ has strong chromatic index at most $\frac{5}{4}\Delta^2$, if Δ is even, and at most $\frac{5}{4}\Delta^2 - \frac{1}{2}\Delta + \frac{1}{4}$, if Δ is odd. If true, both cases are best possible. In 1990, Faudree, Gyárfás, Schelp, and Tuza revised this conjecture for planar graphs with maximum degree at most 3, stating that such graphs should have strong chromatic index at most 9. We verify this conjecture, which is best possible, and extend it to loopless multigraphs (Received September 08, 2014)

1105-05-90 **A. V. Kostochka** and **B. M. Reiniger*** (reinige1@illinois.edu). *The minimum number of edges in a 4-critical graph that is bipartite plus 3 edges.*

Rödl and Tuza proved that sufficiently large $(k+1)$-critical graphs cannot be made bipartite by deleting fewer than $\binom{k}{2}$ edges, and that this is sharp. Chen, Erdős, Gyárfás, and Schelp constructed infinitely many 4-critical graphs obtained from bipartite graphs by adding a matching of size 3 (and called them $(B+3)$-graphs). They conjectured that every n-vertex $(B+3)$-graph has much more than $5n/3$ edges, presented $(B+3)$-graphs with

$2n-3$ edges, and suggested that perhaps $2n$ is the asymptotically best lower bound. We prove that indeed every $(B+3)$-graph has at least $2n-3$ edges. Our proof uses a potential function and the connection between orientations and colorings of graphs. (Received September 08, 2014)

1105-05-98 **Wayne Goddard** (goddard@g.clemson.edu), School of Computing, Clemson University, Clemson, SC 29634, **Kirsti Wash** (kirsti.wash@trincoll.edu), Department of Mathematics, Trinity College, Hartford, CT 06106, and **Honghai Xu*** (honghax@g.clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634. *WORM Colorings of Graphs.*

Given a coloring of the vertices of a graph, we say subgraph H is monochromatic if every vertex of H is assigned the same color, and rainbow if no pair of vertices of H are assigned the same color. Given a graph G and a forbidden graph F, we define an F-WORM coloring of G as a coloring of the vertices of G without a rainbow or monochromatic subgraph isomorphic to F. We explore such colorings especially as regards to the existence, complexity, and optimization within certain graph classes. Our focus is on the case that F is a path, cycle, or complete graph. (Received September 09, 2014)

1105-05-100 **Chris Rodger*** (rodgec1@auburn.edu), Department of Math and Statistics, 221 Parker Hall, Auburn University, AL 36849-5310. *Amalgamations of Graphs and Hypergraphs.*

In this talk, recent uses of amalgamations of graphs will be described, starting with their applications to graphs, then seeing more recent use of the approach for hypergraphs. The results obtained provide both factorizations of (hyper)graphs and embeddings of edge-colored hyper(graphs). The results follow from joint work with Amin Bahmanian and Aras Erzurumluoglu. (Received September 09, 2014)

1105-05-116 **Ronald J. Gould*** (rg@mathcs.emory.edu), Dept. Math and CS, Emory University, Atlanta, GA 30322. *Placing Vertices on Hamiltonian Cycles.*

Over the last few years a number of new results involving the controlled placement of vertices on a hamiltonian cycle have appeared. In this talk I will present a number of these results and in particular, results for a general set of vertices and also for an ordered set of vertices. Further, we also consider the following conjecture of Enomoto:

If G is a graph of order n with $\delta(G) \geq n/2+1$, then for any integer $2 \leq k \leq n/2$ and any vertices x and y, there is a hamiltonian cycle C of G such that $dist_C(x,y) = k$. (Received September 12, 2014)

1105-05-128 **Lucas Kramer** and **Ryan R. Martin*** (rymartin@iastate.edu), Department of Mathematics, Iowa State University, 396 Carver Hall, Ames, IA 50011, and **Michael Young**. *Recent progress on diamond-free families.*

In the Boolean lattice, a diamond is a subposet of four distinct subsets A, B, C, D such that $A \subset B, C$ and $D \subset B, C$. One of the most well-studied problems in extremal poset theory is determining the size of the largest diamond-free family in the n-dimensional Boolean lattice. We will discuss some recent progress on this problem. (Received September 14, 2014)

1105-05-133 **Kagan Kursungoz*** (kursungoz@sabanciuniv.edu), Sabanci Univ. MDBF, Orta Mh. Universite Cd. No 27, Orhanli Tuzla, 34956 Istanbul, Turkey. *A One-Parameter Generalization of Dilcher's Identity.*

We will examine Dilcher's identity in the context of k-marked Durfee symbols (due to Andrews), after the necessary background on Durfee symbols of integer partitions. Then we will give a one-parameter generalization of the said identity, and sketch the proof as time allows. (Received September 15, 2014)

1105-05-136 **Taylor Short*** (shorttm2@email.sc.edu), **Craig Larson** and **Bethany Turner**. *Towards Vizing's Independence Number Conjecture.* Preliminary report.

The *chromatic index* χ' of a graph is the minimum number of colors needed to properly color its edges. A graph G with maximum degree Δ is *edge critical* if $\chi`(G-e) = \Delta$ for every edge e. The *independence number* α of a graph is the cardinality of a largest set of vertices which are pairwise non-adjacent. For edge critical graphs with n vertices, Vizing conjectured that $\alpha(G) \leq n/2$. For these graphs, Woodall has shown that $\alpha(G) \leq 3n/5$ and better results exist for specific values of Δ. We discuss a new approach using the Independence Decomposition Theorem: namely that any graph can be decomposed into unique subgraphs having certain nice properties. (Received September 15, 2014)

1105-05-143 **Joshua Cooper*** (cooper@math.sc.edu) and **David Collins**. *Deducing vertex weights from empirical occupation times.*

Let G be a vertex-weighted digraph with marked "start" and "end" vertices. Suppose that a random walker begins at the start vertex, steps to neighbors of vertices with probability proportional to their weights, and stops upon reaching the end vertex. Can one deduce the weights from the paths that many such walkers take? An iterative numerical solution to this reconstruction problem is analyzed for when the empirical mean occupation times of the walkers is given. We show that a choice of weights that gives rise to a given list of proposed expected occupation times exists precisely when one of several equivalent conditions are satisfied, and give a quadratically convergent algorithm to compute it. (Received September 15, 2014)

1105-05-146 **Oliver Pechenik** (pecheni2@illinois.edu) and **Dominic Searles*** (searles2@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801. *Root-system combinatorics and the Belkale-Kumar product on cohomology.*

In 2006, P. Belkale and S. Kumar introduced a new deformation of the cup product on cohomology of generalized flag varieties. We present a new rule, due to the second author, for the Belkale-Kumar product for flag varieties of type A (after the puzzle rule of A. Knutson - K. Purbhoo). Our rule uses the combinatorial model of root-theoretic Young diagrams. Inspired by recent work of S. Evens - W. Graham, we also give a new proof that the Belkale-Kumar product is well-defined in general type, utilizing root-system combinatorics of K. Purbhoo based on tangent space methods. (Received September 16, 2014)

1105-05-147 **Anant Godbole*** (godbolea@etsu.edu). *Eulerian and Universal Cycles for Set Partitions.* Preliminary report.

We study universal cycles of the set $P_{n,k}$ of k-partitions of the set $[n]$ and prove that the transition digraph associated with $P_{n,k}$ is Eulerian. But this does not imply that universal cycles (or U-cycles) exist, since vertices represent equivalence classes of partitions! We use this result to prove, however, that U-cycles of $P_{n,k}$ exist for all $n \geq 3$ when $k = 2$ and for odd n when $k = n-1$. We also (re)prove that U-cycles do not exist for n even when $k = n-1$ or when $S(n-2, k-2)$ is odd $(3 \leq k < n-1)$. The second half of the talk will focus on showing that there exist universal cycles of partitions of $[n]$ into k subsets of distinct sizes when k is sufficiently smaller than n, and therefore that there exist U-packings of partitions of $P_{n,k}$. An analogous result for coverings completes the investigation. This is joint work with Zach Higgins, Elizabeth Kelley, and Bertilla Sieben. (Received September 16, 2014)

1105-05-169 **Rachel M Landers*** (rachel.landers@tamuc.edu), 2600 South Neal Street, Commerce, TX 75428, and **Hasan Coskun** (hasan.coskun@tamuc.edu), 2600 South Neal Street, Commerce, TX 75428. *A new combinatorial interpretation of qt-binomial coefficients.*

We present a new combinatorial interpretation for the qt-binomial coefficients. We also investigate the application of our interpretation to other sequences of multiple combinatorial numbers. (Received September 17, 2014)

1105-05-170 **Jessica McDonald*** (mcdonald@auburn.edu). *A list analog of Vizing's Theorem for simple graphs with triangles but no other odd cycles.*

We prove that if G is a simple graph with no odd cycles of length 5 or longer, then G is $(\Delta + 1)$-list-edge-colourable, where Δ is the maximum degree of G. Our method involves manipulating F. Galvin's proof that the list-edge-colouring conjecture holds for bipartite graphs. (Received September 18, 2014)

1105-05-171 **Arran C Hamm*** (hamma@winthrop.edu) and **Jeff Kahn** (jkahn@math.rutgers.edu). *On Erdős-Ko-Rado for Random Hypergraphs.*

Denote by $\mathcal{H}_k(n,p)$ the random k-graph in which each k-subset of $\{1 \dots n\}$ is present with probability p, independent of other choices. More or less answering a question of Balogh, Bohman and Mubayi, we show: there is a fixed $\varepsilon > 0$ such that if $n = 2k+1$ and $p > 1-\varepsilon$, then w.h.p. (that is, with probability tending to 1 as $k \to \infty$), $\mathcal{H}_k(n,p)$ has the "Erdős-Ko-Rado property." (Received September 18, 2014)

1105-05-180 **Edward Richmond*** (edward.richmond@okstate.edu) and **William Slofstra**. *Fiber bundle structures on Schubert varieties.*

We give a combinatorial characterization of when fiber-bundle structures on Schubert varieties are induced from the natural projection maps between the flag varieties. Applications of such fiber-bundle structures include a new proof of Peterson's theorem that rationally smooth Schubert varieties are smooth and a proof of the Billey-Crites conjecture that a Schubert variety in affine type A is smooth if and only if the corresponding affine permutation avoids the patterns 4231 and 3412. (Received September 19, 2014)

1105-05-181 **Craig Larson*** (clarson@vcu.edu), Department of Mathematics, 4106 Grace E. Harris Hall, 1015 Floyd Avenue, Richmond, VA 23284, and **Nico Van Cleemput** (nico.vancleemput@gmail.com), Departmentment of Mathematics, European Centre of Excellence NTIS, Univerzitni 8, 306 14 Plzen, Czech Rep. *Automated Property-relations Conjectures for Graph Theory.*

We will describe preliminary results and the use of a new open source program for making properties-relations conjectures about graphs.

Our primary example will be the generation of conjectures for necessary and sufficient conditions for the existence of a hamilton cycle in a graph.

A new feature of the program is the ability to add existing theory and a guarantee that the produced conjectures are not implied by this theory. (Received September 19, 2014)

1105-05-199 **Vivek Dhand*** (vivek.dhand@gmail.com). *Boxed plane partitions: combinatorial unimodality and enumeration of matchings of $L(3,n)$.*

The lattice of boxed plane partitions $L(a,b,c)$ is unimodal, but no purely combinatorial proof of this fact is known. An application of Stanley's fundamental lemma for P-partitions reduces the problem to rectangular standard Young tableaux with s descents, and Early used this method to deal with the case where $a = 2$. We extend this result to $a = 3$ and $s = 2$. In particular, we obtain a new positive summation formula for the q-analogue of the higher-dimensional Narayana number $N_2(3,n)$. In another direction, Kuperberg has shown that $L(a,b,c)$ and related objects correspond naturally to matchings of certain planar hexagonal systems. We present a recursive procedure for generating matchings of $L(3,n)$, whose enumeration involves cyclically symmetric transpose complement plane partitions (CSTCPPs) and vertically symmetric alternating sign matrices (VSASMs). (Received September 19, 2014)

1105-05-222 **Kalyn R. Lamey**, **Daniel S. Silver** and **Susan G. Williams*** (swilliam@southalabama.edu). *Graphs, medial links and growth of spanning trees.*

Let G be a countable, locally finite graph with a free action by $\mathbb{Z}^d$ for some positive integer d. We describe a space of *conservative* vertex colorings of G that is a module over the ring of Laurent polynomials in d variables. This gives rise to polynomial invariants $\Delta_k(x_1,\dots,x_d)$.

When G is a plane graph with free $\mathbb{Z}$-action, Δ_0 determines the number of components of the associated medial link. In general, the Mahler measure of Δ_0 is the growth rate of spanning trees of G. This quantity, sometimes called the *thermodynamic limit* of G, has previously been calculated by purely analytic methods methods using partition functions.

MSC2010: 05C10, 37B10, 57M25, 82B20 (Received September 21, 2014)

1105-05-243 **Mahir Bilen Can*** (mcan@tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118, and **Michael Joyce** and **Benjamin Wyser**. *Maximal chains in weak orders on Borel orbits of some symmetric spaces.*

The $\mathcal{W}$-set of an element of a weak order poset is useful in the cohomological study of the closures of spherical subgroups in generalized flag varieties. We explicitly describe in a purely combinatorial manner the $\mathcal{W}$-sets of the weak order posets of three different sets of involutions in the symmetric group, namely, the set of all involutions, the set of all fixed point free involutions, and the set of all involutions with signed fixed points (or "clans"). These distinguished sets of involutions parameterize Borel orbits in the classical symmetric spaces associated to the general linear group. In particular, we give a complete characterization of the maximal chains of an arbitrary lower order ideal in any of these three posets. (Received September 22, 2014)

1105-05-250 **Clifford Smyth*** (cdsmyth@uncg.edu), Department of Mathematics and Statistics, 116 Petty Building, University of North Carolina at Greensboro, Greensboro, NC 27402. *Revolutionaries and Spies.* Preliminary report.

Introduced by Jozsef Beck, "Revolutionaries and Spies" is game played on a graph G between a team of r revolutionaries and a team of s spies. The game has an additional parameter, m, the threshold meeting size of the revolutionaries. First, the r revolutionaries each select a location in $V(G)$. Then the s spies do the same. Any vertex may be occupied by multiple revolutionaries and multiple spies. Each revolutionary then moves from its current vertex, say v, to a vertex in $\{v\} \cup N(v)$. Then the spies do the same. The two teams continue to alternate moves in this fashion. The revolutionaries win the game if they get m of their number onto a single vertex v in such a way that no spy can occupy v in their next move. The spies win if they can prevent the revolutionaries from winning.

We'll survey some results and conjectures on this game. (Received September 22, 2014)

1105-05-253 **Blair D. Sullivan*** (blair_sullivan@ncsu.edu), 890 Oval Drive, Box 8206, Department of Computer Science, North Carolina State University, Raleigh, NC 27695. *Random Graphs and Structural Sparsity.*

Do real-world complex networks exhibit structural sparsity that is sufficient to enable efficient graph algorithms? We discuss initial work on answering this central question in the quest to make tools from parameterized complexity usable in the analysis of large graph data.

In this talk, we focus on the property of bounded expansion— roughly, that any subgraph has bounded average degree after contracting disjoint bounded-diameter subgraphs – which formalizes the intuitive notion of "sparsity" well-observed in real-world complex networks. We offer the first characterization of the conditions under which many previously proposed random network models (e.g. Kleinberg's small world graphs, Barabasi-Albert's preferential attachment model, random intersection graphs, and the Molloy-Reed configuration model) produce graph classes of bounded expansion.

As time allows, we will also briefly mention several new algorithmic advances for classes of bounded expansion, and preliminary empirical evaluations of the expansion in real-world data sets. This is joint work with E. Demaine, M. Farrell, T. Goodrich, N. Lemons, F. Reidl, P. Rossmanith, F. Sánchez Villaamil, and S. Sikdar. (Received September 22, 2014)

1105-05-260 **Maria Ramirez-Solano*** (mrs@math.ku.dk), Department of Mathematical Sciences, Universitetsparken 5, DK-2100 Copenhagen, Denmark. *A Non-standard Hierarchical Tiling.*

The Bowers and Stephenson conformally regular pentagonal tiling of the plane enjoys remarkable combinatorial and geometric properties. Since it does not have finite local complexity in any usual sense, it is beyond the standard tiling theory. On the other hand, the tiling can be completely described by its combinatorial data that, rather automatically, has finite local complexity. With the aim to compute its K-theory, we construct the hull and C*-algebra of this tiling solely from its combinatorial data. As the tiling possesses no natural $\mathbb{R}^2$ action by translation, there is no a priori reason to expect that the K-theory of the C*-algebra of the tiling is the same as the K-theory or cohomology of the hull of the tiling, and it would be very interesting if they were different. (Received September 22, 2014)

1105-05-282 **Glenn Hurlbert***, Dept of Math & Applied Math, Richmond, VA 23284-2014, **Liliana Alcon**, La Plata, Argentina, and **Maria Gutierrez**, La Plata, Argentina. *Pebbling in Split Graphs.*

Graph pebbling is a network optimization model for transporting discrete resources that are consumed in transit: the movement of two pebbles across an edge consumes one of the pebbles. The pebbling number of a graph is the fewest number of pebbles t so that, from any initial configuration of t pebbles on its vertices, one can place a pebble on any given target vertex via such pebbling steps. It is known that deciding if a given configuration on a particular graph can reach a specified target is NP-complete, even for diameter two graphs.

For many families of graphs there are formulas or polynomial algorithms for computing pebbling numbers; for example, cubes, trees, cycles, and diameter two graphs. Graphs having minimum pebbling number are called Class 0, and many authors have studied which graphs are Class 0.

In this paper we investigate an important family of diameter three chordal graphs called split graphs. We provide a formula for the pebbling number of a split graph, along with an algorithm for calculating it that runs in $O(n^\beta)$ time, where $\beta = 2\omega/(\omega+1) \cong 1.41$ and $\omega \cong 2.376$ is the exponent of matrix multiplication. Furthermore we determine that all split graphs with minimum degree at least 3 are Class 0. (Received September 22, 2014)

1105-05-303 **Richard Hammack*** (rhammack@vcu.edu). *When can we cancel?*

We are concerned with questions about cancellation of graphs over the direct product. What structural property must a graph C possess so that $A \times C \cong B \times C$ implies $A \cong B$ for any graphs A and B? Lovász provided the answer: C must have an odd cycle.

We investigate a flip side of this question. What structural property must A have so that $A \times C \cong B \times C$ implies $A \cong B$ for any B and C? This is an open question, but we will discuss definite answers under mild restrictions on A. (Received September 23, 2014)

1105-05-308 **Zsófia R. Kereskényiné Balogh** (zsofia.kereskenyinebalogh@univie.ac.at) and **Michael J. Schlosser*** (michael.schlosser@univie.ac.at), Faculty of Mathematics, University of Vienna, Oskar-Morgenstern-Platz 1, 1090 Vienna, Wien, Austria. *Elliptic Stirling numbers of the first and second kind.* Preliminary report.

We give elliptic generalizations of the Stirling numbers of the first and second kind which extend the q-Stirling numbers of Carlitz by two extra independent parameters a, b and a nome p. Our Stirling numbers arise as coefficients connecting powers of elliptic numbers with elliptic shifted factorials, and happen to satisfy nice recursions. They appear to be different from the multivariate elliptic Stirling numbers studied by Hasan Coskun. (Received September 23, 2014)

1105-05-313 **Eva Czabarka*** (czabarka@math.sc.edu). *Joint degree matrices and partition adjacency matrices.* Preliminary report.

The joint degree matrix (JDM) of a graph contains the number of edges between vertices of degree i and degree j in the (i, j)-th position. In formation in the joint degree matrix is sufficient to compute the assortativity of the graph, which is essentially the Pearson correlation coefficient of the degrees of adjacent vertices. The partition adjacency matrix (PAM) is a slight generalization: given a partition $\{P_1, \ldots, P_M\}$ of the vertex set, the (i, j)-th entry gives the number of edges between vertices of the i-th and j-th partition class. We will discuss some results on JDMs, PAMs, and the connectedness of the collection of graphs with the same degree sequence and same JDM/PAM under certain restricted edge swaps, and discuss some open problems related to the topic. (Received September 23, 2014)

1105-05-315 **Gexin Yu*** (gyu@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23185. *A proof of Reed's conjecture on path cover number of 3-regular Graphs.* Preliminary report.

A path cover of a graph is a set of disjoint paths so that every vertex in the graph is contained in one of the paths. The path cover number $p(G)$ of graph G is the cardinality of a path cover with minimum number of paths. Reed conjectured that a 2-connected 3-regular graph has path cover number at most $\lceil n/10 \rceil$. In this paper, we confirm this conjecture. (Received September 23, 2014)

1105-05-318 **Paul N Balister*** (pbalistr@memphis.edu), Department of Math Sciences, University of Memphis, Memphis, TN 38152, and **Bela Bollobas** and **Paul Smith**. *The speed of bootstrap percolation in two dimensions.*

Let $\mathbb{T}_n$ be the n by n discrete torus and assume each vertex of $\mathbb{T}_n$ is initially *infected* with probability p. At each time step, every vertex with at least two infected neighbors becomes infected. It was proved by Holroyd that there s a threshold of $(1 + o(1))\pi^2/18 \log n$ above which the entire torus becomes infected with high probability, and below which the entire torus becomes infected only with very low probability. For p greater than this threshold, we consider the number of steps T_n needed for full infection and show that

$$T_n = \begin{cases} \frac{\log n}{2\log(1/(1-p))} + O\big(e^{\frac{\pi^2+o(1)}{9p}}\big) & \text{for } p \gg \frac{1}{\log\log n}; \\ \Theta\Big(\sqrt{\frac{\log n}{p}}\, e^{\frac{\pi^2+o(1)}{18p}}\Big) & \text{for } p \ll \frac{1}{\log\log n}. \end{cases}$$

(Received September 23, 2014)

1105-05-322 **Ryan L Kaliszewski*** (rlk72@drexel.edu), Department of Mathematics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104, and **Jennifer Morse**. *Combinatorial Fillings and their Correspondence with Reverse Plane Partitions.* Preliminary report.

Inspired by the long-standing open problem to combinatorially characterize the Macdonald symmetric functions, Austin Roberts recently introduced a new combinatorial structure and proved that the Lascoux-Schützenberger charge/tableaux formulation for the $q = 0$ Macdonald polynomials can instead be written using these combinatorial objects with the major index statistic. We have discovered that a variation on these objects newly characterize Schur and Grothendieck polynomials (representatives for cohomology and K-theory classes, respectively), and lends itself to an alternate view on classical combinatorial formulas such as the Littlewood-Richardson rule and the hook-length formula for standard Young tableaux. (Received September 23, 2014)

1105-05-329 **H. A. Kierstead**, **A. V. Kostochka**, **T. Molla** and **E. C. Yeager*** (yeager2@illionis.edu). *Disjoint Cycles and a Question of Dirac.*

In 1963, Corrádi and Hajnal famously proved the following: If a graph has minimum degree at least $2k$, and at least $3k$ vertices, then it contains a set of k vertex-disjoint cycles. The degree bound is sharp, but has been

improved by considering Ore-type conditions. That is, by bounding the minimum degree sum of nonadjacent vertices.

We discuss a relaxation of the minimum degree requirement, and as a consequence answer a 1963 question posed by Dirac: which $(2k-1)$-connected hypergraphs do not have k disjoint cycles?

In discussing the existence of disjoint cycles in a graph, we also use techniques of equitable coloring. Our results, aside from having implications about the existence of disjoint cycles, also prove a small case of an Ore-type analog to the Chen-Lih-Wu conjecture. The Chen-Lih-Wu conjecture can be seen as the equitable-coloring equivalent of Brooks's Theorem. (Received September 23, 2014)

1105-05-335 **Jerrold R Griggs** and **Kevin G Milans*** (milans@math.wvu.edu), West Virginia University, Morgantown, WV, and **David Oxner** and **David Stoner**. *Tilings of Hypercubes.* Preliminary report.

A graph G tiles a graph H if there is a partition of $V(H)$ into parts that induce copies of G. Which graphs G have the property that for n sufficiently large, G tiles the n-dimensional hypercube Q_n? Not much is known. For G to tile a sufficiently large hypercube, it is clearly necessary that G is contained in some hypercube and that $|V(G)|$ is a power of two. When G is acyclic, these conditions are also sufficient. (Received September 23, 2014)

1105-05-337 **Hasan Coskun*** (hasan.coskun@tamuc.edu), 2600 S Neal St, Commerce, TX 75429. *A Combinatorial Formula for Rational Macdonald Functions and Applications.*

We present a combinatorial formula for a class of rational Macdonald functions used in our definition of multiple binomial coefficients, and other sequences of multiple combinatorial numbers. The combinatorial interpretation is then used to establish combinatorial formulas for certain families of multiple qt-numbers constructed in two recent papers by the author. (Received September 23, 2014)

1105-05-345 **Ernie Croot*** (ecroot@math.gatech.edu) and **Albert Bush**. *Few Products, Many h-Fold Sums.*

In this talk I will briefly discuss some recent work showing that if A is a set of n real numbers such that the productset $A.A := \{xy : x, y \in A\}$ has size not much bigger than n, then the h-fold sumset $hA := \{x_1 + \cdots + x_h : x_i \in A\}$ grows rapidly with h. The bounds we obtain on the growth rate here are much stronger than previous results. This is joint work with Albert Bush. (Received September 23, 2014)

1105-05-346 **Carlos M Nicolas*** (cnicolas@ferrum.edu). *Lower and upper bounds on the number of relatively convex subsets of a set of n points in the plane.*

Let $S \subseteq \mathbb{R}^n$. A subset A of S is convex *relative to* S if there exists a convex set C such that $A = S \cap C$. We give lower and upper bounds on the minimum number of relatively convex subsets when S is a set of n points in the plane in general position. (Received September 23, 2014)

11 ► Number theory

1105-11-6 **Ellen Eischen*** (eeischen@email.unc.edu). *p-adic properties of Eisenstein series and applications.*

The properties of certain Eisenstein series are closely tied to the behavior of certain L-functions. In this talk, I will discuss my recent results on some p-adic properties of Eisenstein series and some anticipated applications. (Received April 11, 2014)

1105-11-10 **Michael Lipnowski*** (malipnow@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708. *Non-liftable weight 1 modular forms.*

Remarkable computations of George Schaeffer suggest that there is an abundance of weight 1 modular forms mod p which do not lift to characteristic zero. We will discuss this observation in the context of the Arakelov-Riemann-Roch Theorem, which provides an appropriate analytic framework for studying growth of torsion in coherent cohomology. (Received May 05, 2014)

1105-11-11 **John W Jones***, SoMSS, ASU, Tempe, AZ 85282. *A database of local fields.*

We will discuss the local field database, some of the algorithms used in its construction, and applications. (Received May 11, 2014)

1105-11-23 **James A Sellers*** (sellersj@psu.edu), Department of Mathematics, Penn State University, 104 McAllister Building, University Park, PA 16802. *Congruences for Fishburn Numbers.*

The Fishburn numbers, originally considered by Peter C. Fishburn, have been shown to enumerate a variety of combinatorial objects. These include unlabelled interval orders on n elements, (2+2)-avoiding posets with n elements, upper triangular matrices with nonnegative integer entries and without zero rows or columns such that the sum of all entries equals n, non-neighbor-nesting matches on $[2n]$, a certain set of permutations of $[n]$ which serves as a natural superset of the set of 231-avoiding permutations of $[n]$, and ascent sequences of length n. However, as far as we know, the Fishburn numbers have not been studied from an arithmetic point of view. In this talk, we prove that the Fishburn numbers satisfy infinitely many Ramanujan-like congruences modulo certain primes p (the set of which we will easily describe in the talk). This is joint work with George Andrews. (Received July 18, 2014)

1105-11-27 **Frank Thorne*** (thorne@math.sc.edu). *Two statistical theorems in field counting.*

I will discuss two results applying statistics to number theory, where we obtain Gaussian distribution results for certain counting functions related to field extensions.

The first result is joint with Maosheng Xiong; we obtain a Gaussian distribution for the location of the zeroes of zeta functions of trigonal curves over finite fields. The second result is joint with Robert Lemke Oliver; we obtain an Erdős-Kac result for the number of primes ramifying in S_n number fields of bounded discriminant and degree up to 5. In each case the proof is by the method of moments. (Received July 31, 2014)

1105-11-29 **Hang Xue***, 2990 Broadway MC4406, New York, NY 10025. *Fourier–Jacobi coefficients on the unitary groups.*

We formulate a conjectural formula relating the Fourier–Jacobi period on the unitary groups and the central value of some Rankin–Selberg L-functions. This formula can be viewed as a refinement to the Gan–Gross–Prasad conjecture. We verify this conjectural formula in some cases. (Received August 04, 2014)

1105-11-31 **Jeremy Rouse***, Department of Mathematics, Wake Forest University, Winston-Salem, NC 27109, and **David Zureick-Brown**. *Elliptic curves over $\mathbb{Q}$ and 2-adic images of Galois.*

We give a classification of all possible 2-adic images of Galois representations associated to elliptic curves over $\mathbb{Q}$. To this end, we compute the 'arithmetically maximal' tower of 2-power level modular curves, develop techniques to compute their equations, and classify the rational points on these curves. (Received August 09, 2014)

1105-11-44 **Nathan C. Ryan*** (nathan.ryan@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837, and **Gonzalo Tornaría**, Universidad de la República, 11300 Montevideo, Uruguay. *Formulas for central values of twisted spin L-functions attached to paramodular forms.* Preliminary report.

In the 1980s Böcherer formulated a conjecture relating the central values of the imaginary quadratic twists of the spin L-function attached to a Siegel modular form F to the Fourier coefficients of F. This conjecture has been proved when F is either a Yoshida lift or a Saito-Kurokawa lift. More recently, we formulated an analogous conjecture for paramodular forms F of prime level, even weight and in the plus-space. In this talk, we examine this conjecture and some of its generalizations. (Received August 23, 2014)

1105-11-46 **Jayce R. Getz** (jgetz@math.duke.edu), Department of Mathematics, Duke University, Durham, NC 27708, and **Heekyoung Hahn*** (hahn@math.duke.edu), Department of Mathematics, Duke University, Durham, NC 27708. *A general simple relative trace formula and a relative Weyl law.*

In this talk, we prove a general simple relative trace formula. As an application, we prove a relative analogue of the Weyl law. (Received August 25, 2014)

1105-11-57 **Luis A Medina*** (luis.medina17@upr.edu), University of Puerto Rico, Department of Mathematics, Box 70377, San Juan, PR 00931. *The p-adic valuation of Eulerian numbers: trees and Bernoulli numbers.* Preliminary report.

In this work we explore the p-adic valuation of Eulerian numbers. We construct a tree whose nodes contain information about the p-adic valuation of these numbers. Using this tree, and some classical results for Bernoulli numbers, we compute the exact p divisibility for the Eulerian numbers when the first variable lies in a congruence class and p satisfies some regularity properties. (Received August 28, 2014)

1105-11-72 **Robin French*** (rfrench3@elon.edu) and **Chad Awtrey**. *A new algorithm for Galois groups of quintic polynomials.*

Finding solutions of polynomial equations is a central problem in mathematics. Of particular importance is the ability to solve a polynomial "by radicals"; i.e., using only the coefficients of the polynomial, the four basic arithmetic operations (addition, subtraction, multiplication, division), and roots (square roots, cube roots, etc.). For example, the existence of the quadratic formula shows that all quadratic polynomials are solvable by radicals. In addition, degree three polynomials and degree four polynomials are also solvable by radicals, which was shown in the 16th century. However, the same is not true for all degree five polynomials. Therefore, we are left with the following question: how do we determine which degree five polynomials are solvable by radicals? To answer this question, we study an important object that is associated to every polynomial. This object, named after 19th century mathematician Evariste Galois, is known as the polynomial's Galois group. The characteristics of the Galois group encode arithmetic information regarding its corresponding polynomial, including whether or not the polynomial is solvable by radicals. In this talk, we will discuss a new algorithm for determining the Galois group of a degree five polynomial. (Received September 04, 2014)

1105-11-79 **George E Andrews*** (gea1@psu.edu), 306 McAllister Bldg., Mathematics Department, Pennsylvania State University, University Park, PA 16802. *Partition Identities and Mock Theta Functions.*

This is a report on joint work with Stephen Hill. In 1961, Basil Gordon proved a sweeping generalization of the Rogers-Ramanujan identities. His theorem may be broadly characterized as identifying the generating function for partitions having specified difference conditions on the parts with the quotient of two theta functions. We shall provide a new class of partitions (similar to those studied by Gordon) where the generating function is identified with the quotient of a Hecke-type theta series divided by the Dedekind eta function. The simplest case is related to one of the fifth order mock theta functions of Ramanujan. The partitions in question are similar in kind to those described in: G.E Andrews, Partitions with inital repetitions, Acta Math. Sinica, English Series, 25(2009), 1437-1442, and in G.E Andrews, Partitions with early conditions, In Advances in Combinatorics Waterloo Workshop in Computer Algebra, W80 May. 26-29, 2011. (Received September 05, 2014)

1105-11-83 **T. Alden Gassert*** (thomas.gassert@colorado.edu), Department of Mathematics, University of Colorado Boulder, Campus Box 395, Boulder, CO 80309. *Discriminants of simplest 3^n-tic extensions.*

Let $\ell > 2$ be a positive integer, ζ_ℓ a primitive ℓ-th root of unity, and K a number field containing $\zeta_\ell + \zeta_\ell^{-1}$ but not ζ_ℓ. In a recent paper, Chonoles et. al. study iterated towers of number fields over K generated by the generalized Rikuna polynomial, $r_n(x, t; \ell) \in K(t)[x]$. They note that when $K = \mathbf{Q}$, $t \in \{0, 1\}$, and $\ell = 3$, the only ramified prime in the resulting tower is 3, and they ask under what conditions is the number of ramified primes small. In this talk, we apply a theorem of Guàrdia, Montes, and Nart to derive a formula for the discriminant of $\mathbf{Q}(\theta)$ where θ is a root of $r_n(x, t; 3)$, answering the question of Chonoles et. al. in the case $K = \mathbf{Q}$, $\ell = 3$, and $t \in \mathbf{Z}$. (Received September 06, 2014)

1105-11-85 **Luca Candelori*** (lcandelori@lsu.edu). *An algebro-geometric theory of vector-valued modular forms of half-integral weight attached to Weil representations.*

In this talk we give a geometric theory of vector-valued modular forms attached to Weil representations of rank 1 lattices. More specifically, we construct vector bundles $\mathcal{V}_{m,k}$ over the moduli stack $\mathcal{M}_1$ of elliptic curves, whose sections over the complex numbers give weight $k + 1/2$ vector-valued modular forms attached to rank 1 lattices with quadratic form $x \mapsto mx^2/2$, for $m \in 2\mathbb{Z}_{>0}$. The key idea is to construct vector bundles of Schrödinger representations and line bundles of half-forms over appropriate 'metaplectic stacks', which are μ_2-gerbes over $\mathcal{M}_1$, and then show that their tensor products $\mathcal{V}_{m,k}$ descend to $\mathcal{M}_1$. We then extend the bundles $\mathcal{V}_{m,k}$ to the cusp ∞ and give an algebraic notion of q-expansions of vector-valued modular forms. We define holomorphic vector-valued modular forms and cusp forms and compute algebraic dimension formulas for these spaces over any algebraically closed field of characteristic $\neq 2, 3$, by using the Riemann-Roch theorem for DM stacks. Finally, by specializing the theory to the case $m = 2$, we obtain an algebro-geometric theory of modular forms of half-integral weight, as defined in the complex-analytic case by Shimura. (Received September 07, 2014)

1105-11-94 **Beth Malmskog** (beth.malmskog@gmail.com), Department of Mathematics and Statistics, Villanova University, and **Christopher Rasmussen*** (crasmussen@wesleyan.edu), Department of Mathematics & Computer Science, Wesleyan University. *Picard curves with good reduction away from 3.*

Curves with good reduction over a small set of primes often present both unusual arithmetic and geometry, but are hard to find explicitly in practice. Motivated by earlier work of N. P. Smart, we determine all Picard curves over $\mathbf{Q}$ with good reduction away from 3. We provide a correspondence between such curves and various equivalence classes of binary forms; finding all appropriate forms involves solving an S-unit equation.

We discuss connections between the arithmetic of the Jacobians of these curves and a long-standing question of Ihara on the nature of the canonical outer Galois representation associated to $\mathbf{P}^1_{01\infty}$. (Received September 09, 2014)

1105-11-101 **Lassina Dembélé**, **Nuno Freitas** and **John Voight*** (jvoight@gmail.com), 6188 Kemeny Hall, Hanover, NH 03755. *On computing Hilbert modular forms by type and generalized Fermat curves of degree 19.* Preliminary report.

We exhibit an algorithm to compute spaces of Hilbert modular forms by type. We apply this algorithm, using the method of Frey curves, to characterize integer solutions to the equation $x^{19} + y^{19} = Cz^p$ with p prime. (Received September 09, 2014)

1105-11-102 **Katherine Alexander Anders*** (kanders@uttyler.edu). *Asymptotics of sums of non-standard binary representations.* Preliminary report.

Let $\mathcal{A}$ be a finite subset of $\mathbb{N}$ including 0 and let $f_{\mathcal{A}}(n)$ be the number of ways to write $n = \sum_{i=0}^{\infty} \epsilon_i 2^i$, where $\epsilon_i \in \mathcal{A}$. We consider asymptotics of the summatory function

$$s_{\mathcal{A}}(r) = \sum_{n=2^r}^{2^{r+1}-1} f_{\mathcal{A}}(n)$$

and show that $s_{\mathcal{A}}(r) \approx c(\mathcal{A})|\mathcal{A}|^r$ for some constant $c(\mathcal{A}) \in \mathbb{Q}$. (Received September 10, 2014)

1105-11-110 **Frank Thorne***, 1523 Greene St, Columbia, SC 29208, and **Henri Cohen** and **Simon Rubinstein-Salzedo**. *Discriminant counting identities generalizing the Ohno-Nakagawa relations.*

Let $N_3(D)$ denote the number of cubic fields of discriminant D, and write D^* for $-D/3$ or $-3D$ depending on whether D is divisible by 3 or not.

For $D > 0$, the classical 1931 reflection principle of Scholz established that $N_3(D^*)$ is equal to either $N_3(D)$ or $3N_3(D) + 1$. Much later work of Ohno and Nakagawa established an exact equality, by adding an $N_3(-27D)$ term to $N_3(D^*)$. This result was the consequence of an identity satisfied by Shintani's zeta function associated to the space of binary cubic forms.

In this talk I will sketch a proof of the Ohno-Nakgawa identities which does not appeal to zeta functions or to binary cubic forms, and then I will give a generalization counting appropriate fields of degree ℓ, for any odd prime ℓ. (Received September 11, 2014)

1105-11-114 **Nicolas Bergeron** (bergeron@math.jussieu.fr), Paris 6, **Mehmet Haluk Sengun*** (m.sengun@sheffield.ac.uk), Sheffield, and **Akshay Venkatesh** (akshay@math.stanford.edu), Stanford. *Torsion Homology Growth and Cycle Complexity of Arithmetic Manifolds.*

Torsion in the homology of arithmetic groups has gained a lot of interest from number theorists recently. In this paper, we formulate a conjecture on the topological complexity of cycles on an arithmetic hyperbolic 3-manifold which implies a certain asymptotic growth for the size of the torsion. We prove our conjecture in two very often occurring cases, using heavy number theoretic machinery. (Received September 12, 2014)

1105-11-126 **Dylan Airey** and **Bill Mance*** (mance@unt.edu), General Academics Building 435, 1155 Union Circle, Denton, TX 76203-5017. *The Hausdorff dimension of sets of numbers defined by their Q-Cantor series expansions.*

Following in the footsteps of P. Erdős, A. Rényi, and T. Šalát we compute the Hausdorff dimension of sets of numbers whose digits with respect to their Q-Cantor series expansions satisfy various statistical properties. In particular, we consider difference sets associated with various notions of normality and sets of numbers with a prescribed range of digits. (Received September 14, 2014)

1105-11-127 **Minerva Catral**, **Pari Ford** and **Pamela E Harris*** (pamela.harris@usma.edu), United States Military Academy, Department of Mathematical Sciences, 646 Swift Road, West Point, NY 10996, and **Steven J Miller** and **Dawn Nelson**. *Generalizing Zeckendorf's Theorem: The Kentucky Sequence.*

Zeckendorf's theorem states that every positive integer can be uniquely decomposed as a sum of non-consecutive Fibonacci numbers. We generalize the Zeckendorf condition to generate (s, b)-Generacci sequences which give unique decompositions of positive integers as a sum of (s, b)-Generacci numbers. In fact the $(1, 1)$-Generacci sequence is the Fibonacci sequence. In this talk we focus on the $(1, 2)$-Generacci sequence, which we call the Kentucky sequence. Previous methods to determine the behavior of the number of summands for integers in a given interval do not apply to such a sequence (whose recurrence relation has zero leading coefficient) yet we can prove that this sequence displays Gaussian behavior. As a consequence of our proof we rederive many properties of the Fibonacci polynomials. Furthermore, we show that the distribution of gaps between summands in the $(1, 2)$-Generacci decomposition converges to exponential decay. (Received September 14, 2014)

1105-11-137 **Eva G. Goedhart*** (egoedhart@brynmawr.edu). *New Results on Diophantine Equations.*

In the context of presenting my new results concerning specific Diophantine equations and families of equations, I will survey a variety of current techniques, including Lehmer numbers, linear forms in logarithms, Diophantine approximation, and the modular approach, explaining how each is used in my proofs. (Received September 15, 2014)

1105-11-138 **Nicole Soltz*** (nsoltz@elon.edu) and **Chad Awtrey** (cawtrey@elon.edu). *Counting roots and Galois groups.*

Let $f(x)$ be an irreducible polynomial over a field F with roots a, b, and c (in some algebraic closure), and let $K = F(a)$ be the extension obtained by adjoining one root of f to F. We present two methods for determining the Galois group of $f(x)$. One involves answering the question: is $(a - b)(a - c)(b - c) \in F$? The other involves answering the question: how many roots of f are in K? We end by discussing an application to computing Galois groups of degree 15 polynomials defined over an extension of the p-adic numbers. (Received September 15, 2014)

1105-11-142 **D. Airey*** (dylan.airey@utexas.edu) and **B. Mance** (mance@unt.edu). *Unexpected distribution phenomenon resulting from Cantor series expansions.*

We explore in depth the number theoretic and statistical properties of certain sets of numbers arising from their Cantor series expansions. As a direct consequence of our main theorem we deduce numerous new results as well as strengthen known ones. (Received September 15, 2014)

1105-11-155 **Lee Thomas Troupe*** (ltroupe@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *The number of prime factors of $s(n)$.*

Let $\omega(n)$ denote the number of distinct prime divisors of a natural number n. In 1917, Hardy and Ramanujan famously proved that the normal order of $\omega(n)$ is $\log\log n$; in other words, a typical natural number n has about $\log\log n$ distinct prime factors. Erdős and Kac later generalized Hardy and Ramanujan's result, showing (roughly speaking) that $\omega(n)$ is normally distributed and thereby giving rise to the field of probabilistic number theory. In this talk, we'll discuss the normal order of $\omega(s(n))$, where $s(n)$ is the usual sum-of-proper-divisors function. This new result supports a conjecture of Erdős, Granville, Pomerance, and Spiro; namely, that if a set of natural numbers has asymptotic density zero, then so does its preimage under s. (Received September 16, 2014)

1105-11-157 **David Pollack*** (dpollack@wesleyan.edu) and **Avner Ash**. *Computations with an eigencurve for GL(3).*

Starting with a numerically non-critical (at p) Hecke eigenclass f in the homology of a congruence subgroup Γ of $\mathrm{SL}_3(\mathbb{Z})$ (where p divides the level of Γ) with classical coefficients, we will show how to compute to any desired degree of accuracy a lift of f to a Hecke eigenclass F with coefficients in a module of p-adic distributions. Then we will discuss an ongoing calculation to find to any desired degree of accuracy the germ of the projection to weight space of the eigencurve Z around the point z corresponding to the system of Hecke eigenvalues of F. We do this under the conjecturally mild hypothesis that Z is smooth at z. (Received September 16, 2014)

1105-11-173 **Ivan Horozov***, Department of Mathematics, Washington University in St. Louis, One Brookings Dr, Campus Box 1146, Saint Louis, MO 63130. *Non-commutative Hilbert Modular Symbols.*

The main goal of this paper is to construct non-commutative Hilbert modular symbols. However, we also construct commutative Hilbert modular symbols. Both the commutative and the non-commutative Hilbert modular symbols are generalizations of Manin's classical and non-commutative modular symbols. We prove that many cases of (non-)commutative Hilbert modular symbols are periods in the sense on Kontsevich-Zagier. Hecke operators act naturally on them.

Manin defines the non-commutative modilar symbol in terms of iterated path integrals. In order to define non-commutative Hilbert modular symbols, we use a generalization of iterated path integrals to higher dimensions, which we call iterated integrals on membranes. Manin examines similarities between non-commutative modular symbol and multiple zeta values both in terms of infinite series and in terms of iterated path integrals. Here we examine similarities in the formulas for non-commutative Hilbert modular symbol and multiple Dedekind zeta values, recently defined by the author, both in terms of infinite series and in terms of iterated integrals on membranes. (Received September 18, 2014)

1105-11-201 **Abbey Bourdon*** (abourdon@uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Pete L. Clark** and **James Stankewicz**. *Rational Torsion on CM Elliptic Curves Over Real Number Fields.*

Let E be an elliptic curve with complex multiplication defined over a number field F. In the case where F has prime degree we give a complete determination of the possible torsion subgroups E(F)[tors]. In addition, we find other restrictions on torsion points, especially in the case where F is real. (Received September 19, 2014)

1105-11-202 **Cam McLeman*** (mclemanc@umflint.edu). *Cohen-Lenstra Partitions and Class Groups of Quadratic Imaginary Number Fields.*

We introduce the notion of a Cohen-Lenstra partition of a natural number, and use the Cohen-Lenstra heuristics to interpret results about these partitions in the context of ideal class groups of quadratic imaginary number fields. In particular, our results imply, under these same heuristics, that most finite abelian p-groups do not appear as such a class group. We further conjecture that for p odd, no elementary abelian p-groups of rank at least 3 so appear. (Received September 19, 2014)

1105-11-213 **Florin P. Boca*** (fboca@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, **Alexandru A. Popa**, Simion Stoilow Institute of Mathematics, of the Romanian Academy, P.O.Box 1-764, 014700 Bucharest, Romania, and **Alexandru Zaharescu**, Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801. *Irregularities in the distribution of hyperbolic lattice angles.*

Spacing statistics measure the randomness of uniformly distributed sequences, or more generally increasing sequences of finite sets of real numbers. A familiar example of a uniformly distributed sequence of sets is given by the directions of vectors joining a fixed point in the Euclidean plane, with all (or only visible) points of integer coordinates inside balls of fixed center and increasing radius. However, these directions are not randomly distributed, and even the study of their most popular spacing statistics, limiting gap distribution and pair correlation function, turn out to pose challenges. This talk will discuss recent progress in the study of the spacing statistics for the hyperbolic counterpart of this type of geometric configuration, comparing it with the Euclidean situation. (Received September 22, 2014)

1105-11-227 **Sneha Chaubey*** (chaubey2@illinois.edu), **J Athreya**, **A Malik** and **A Zaharescu**. *Geometric Statistics of Ford Circles.*

We compute the distributions and some moments of certain statistics of geometric quantities associated to Ford circles. Our methods to compute distributions use the equidistribution of periodic orbits of the BCZ map, while our methods to compute moments are based in analytic number theory. (Received September 21, 2014)

1105-11-230 **Byron N. Heersink*** (heersin2@illinois.edu). *The spacing statistics of Farey fractions and the horocycle flow in SL(2,$\mathbb{R}$).*

Recently, Athreya and Cheung constructed a cross section for the horocycle flow on the modular surface X=SL(2,$\mathbb{R}$)/SL(2,$\mathbb{Z}$) having properties related to the spacings in Farey fractions. This talk will discuss how to lift this section to covers SL(2,$\mathbb{R}$)/H of X, with H a finite index subgroup of SL(2,$\mathbb{Z}$). As an application, the existence of the limiting gap distribution of various subsets of Farey fractions will be established. (Received September 21, 2014)

1105-11-235 **John Cullinan*** (cullinan@bard.edu) and **Farshid Hajir**. *Algebraic properties of certain lifts of supersingular polynomials.* Preliminary report.

If p is a prime number, we define the supersingular polynomial $s_p \in \mathbf{F}_p[j]$ by

$$s_p(j) = \prod_{j'}(j - j')$$

where j' runs over all the j-invariants of supersingular elliptic curves in $\overline{\mathbf{F}_p}$. Kaneko and Zagier describe a number of natural lifts of s_p to $\mathbf{Q}[x]$ coming from the theory of elliptic modular forms. These include lifts due to Hasse-Deuring, Deligne, and Atkin as well as one of due to Kaneko and Zagier, denoted $\widetilde{F_k}(j)$. In this talk, we describe the algebraic properties of $\widetilde{F_k}(j)$ and exhibit new cases of the irreducibility and Galois properties of these polynomials, giving further evidence of a conjecture of Mahlburg and Ono. (Received September 21, 2014)

1105-11-239 **Jonah B Leshin***, JLeshin@gc.cuny.edu, and **Melanie Matchett Wood**. *The Malle-Bhargava principle and local conditions on Cohen-Lenstra heuristics.* Preliminary report.

We study the effect of imposing local constraints on Cohen-Lenstra heuristics for unramified extensions of number fields. In particular, we prove, under mild hypotheses, that a principle of Malle and Bhargava implies that the Cohen-Lenstra heuristics are robust to local constraints. We also verify that in the case of unramified quadratic extensions of non-Galois cubic fields, this predicted local invariance is correct. (Received September 22, 2014)

1105-11-256 **Nathan C. Jones*** (ncjones@uic.edu), Dept. of Mathematics, Stat. and Comp. Sci., University of Illinois at Chicago, SEO 322, 851 S Morgan Street, Chicago, IL 60607-7045. *A local-global principle for power maps.*

Let f be a function from the set of integers into itself. We call f a global power map if there exists a non-negative integer k so that $f(x) = x^k$ for every integer x. We call f a local power map at the prime number p if f induces a well-defined group homomorphism on the multiplicative group of integers modulo p. It has been conjectured that, if f is a local power map at infinitely many primes p, then f is a global power map. In this talk, I will discuss a theorem implying that, if f is a local power map at all primes p in a set with positive upper density relative to the set of all primes, then f must be a global power map. (Received September 22, 2014)

1105-11-262 **Ricky E Farr*** (refarr@uncg.edu), Department of Mathematics & Statistics, 116 Petty Building, PO Box 26170, Greensboro, NC 27402-6170, and **Sebastian Pauli** (s_pauli@uncg.edu), Department of Mathematics and Statistics, 116 Petty Building, PO BOX 26170, Greensboro, NC 27402-6170. *On Non-integer Stieltjes Constants and Fractional Differentiation.* Preliminary report.

The generalized Stieltjes constants $\gamma_k(a)$ ($k \in \mathbb{N} \cup 0$) are the coefficients of the Laurent series expansion of the Hurwitz zeta function $\zeta(s, a)$ about the point $s = 1$. Kreminski defined these constants for any $k \geq 0$ using the notion of fractional differentiation. We discuss fractional differentiation and give a definition of these constants that is equivalent to Kreminski's generalization. From this, we will then prove a conjecture set forth by Kreminski. We will also discuss approximation of these constants using Euler-Maclaurin summation. (Received September 22, 2014)

1105-11-265 **Brian Sinclair*** (basincla@uncg.edu). *Enumerating Extensions of p-adic Fields with Given Invariants.*

It is well known that p-adic fields have a finite number of extensions of a given degree. With Ore's conditions and Krasner's mass formula, we can find all of the possible discriminants for such an extension and how many extensions have each discriminant. An algorithm of Pauli and Roblot uses these to enumerate extensions of given degree and discriminant. In this talk, we will look at finding Eisenstein polynomials that generate all totally ramified extensions of a given degree, discriminant, and additional invariants related to the ramification polygon. As we can find all possibilities for these invariants, this forms the core of a new algorithm for enumerating all extensions of given degree that is far faster than current methods and only requires computation in the base field and it's residue class field. (Received September 22, 2014)

1105-11-272 **Joseph A Vandehey*** (vandehey@uga.edu). *When multiplying by 2 is a hard thing to do.* Preliminary report.

If one is handed the base 10 expansion of a number $x \in [0, 1)$ and asked what the nth digit of $2x$ is, this is generally not a difficult problem: one only needs to look at the nth and $n + 1$th digit of x to determine the nth digit of $2x$. For continued fraction expansions, unfortunately, the same question requires knowing all of the

digits from the 1st place to the nth. We will discuss how to understand this problem better, and its implications for how rational multiplication preserves continued fraction normality. (Received September 22, 2014)

1105-11-276 **Amita Malik*** (amalik10@illinois.edu), 1409 W Green Street, Urbana, IL 61801, and **Florin Stan** and **Alexandru Zaharescu**. *Siegel norm and the character values of finite groups.*

In 1969, Cassels showed that under certain conditions, an algebraic integer in an abelian field is a sum of at most two roots of unity. From this, similar results can be deduced for the character values of finite groups. An unpublished theorem of Thompson states any character has length at most one at more than one third of the group elements. We generalise these results for arbitrary length by establishing a connection between the Siegel norm, the length function. In particular, we obtain a dual result to that of Burnside. This is joint work with Florin Stan and Alexandru Zaharescu. (Received September 22, 2014)

1105-11-281 **Maurizio Monge*** (maurizio.monge@im.ufrj.br), Instituto de Matemática da UFRJ, Av. Athos, CT, Bloco C, Ilha do Fundão, Caixa Postal 68530, Rio de Janeiro, RJ 21941-909, Brazil. *Special Eisenstein Polynomials generating Totally Ramified Estensions of a p-adic Field.*

In this seminar, we will present a few algorithms for working with extensions of a p-adic field K. A reduction algorithm will be presented, such algorithm allows to transforms any Eisenstein polynomial into a special polynomial. Each totally ramified extension is generated by at least one special polynomial, and the number of special polynomials generating the extension L/K is at most the number of different conjugate fields of L/K, and in particular it is unique for Galois extensions. Studying the reduction procedure, we obtain a criterion that allows sometimes to guarantee that two polynomials generate non-isomorphic extensions. We will describe an algorithm that allows to contruct the special polynomial generating a totally ramified class field, given a suitable description of the norm group. Finally, we will present a result on the characterization of coefficients of Eisenstein polynomials of degree p^2 with prescribed Galois group, over an unramified p-adic field. (Received September 22, 2014)

1105-11-283 **Chad Awtrey*** (cawtrey@elon.edu), **Nicole Miles**, **Jonathan Milstead**, **Christopher Shill** and **Erin Strosnider**. *Degree 14 2-adic fields.*

Fix a prime number p and a positive integer n. A foundational result in algebraic number theory states that there are only finitely many nonisomorphic extensions of the p-adic numbers of degree n. Researchers have focused on developing methods for computing data about these extensions, such as Galois groups and ramification information. In this talk — which is joint work with undergraduates from the speaker's institution and a graduate student — we illustrate several of the tools we have employed to compute Galois groups of degree 14 extensions of the 2-adic numbers. (Received September 22, 2014)

1105-11-284 **Rafe Jones***, 1 North College St, Northfield, MN 55122. *Arboreal Galois representations.*

Iteration of a rational function $f \in K(x)$ (K a global field) gives rise to a Galois representation in a natural way: the successive pre-images of zero form an infinite rooted tree, upon which the absolute Galois group of K acts as tree automorphisms. These are known as arboreal Galois representations, and I will give an overview of what is known about them, especially the size of their images and properties of Frobenius conjugacy classes. I'll state a conjecture that these representations have only a finite number of orbits on the set of infinite branches of the tree, except in certain very special circumstances, and discuss recent results in this direction. (Received September 22, 2014)

1105-11-286 **Matthew Boylan*** (boylan@math.sc.edu), Mathematics Department, University of South Carolina, 1523 Greene Street, Columbia, SC 29208. *Arithmetic properties of a distinguished subspace of modular forms.* Preliminary report.

Subspaces of modular forms obtained as multiples of fixed powers of the Dedekind eta-function by modular forms on the full modular group with fixed weight arise in the study of arithmetic properties of partition-theoretic functions. I will discuss the image of Hecke operators on these subspaces both in characteristic zero and modulo primes p. As an application, I will give congruences between images of the Shimura map when the subspaces have half-integral weight. (Received September 22, 2014)

1105-11-289 **Michael Filaseta*** (filaseta@math.sc.edu), Mathematics Department, 1523 Greene Street, University of South Carolina, Columbia, SC 29208, **Stavros Garoufalidis** (stavros@math.gatech.edu), School of Mathematics, 686 Cherry Street, Georgia Institute of Technology, Atlanta, GA 30332, and **Joshua Harrington** (joshua.harrington@cedarcrest.edu), Department of Mathematics, Cedar Crest College, Allentown, PA 18104. *Trace fields of hyperbolic 3-manifolds and the factorization of sparse polynomials.* Preliminary report.

Fixing a hyperbolic 3-manifold M, we can describe the trace field of the Dehn fillings of one of its cusps in terms of a factorization problem for a sparse polynomial. In particular, these polynomials can be given explicitly for the trace fields of Dehn fillings of the Whitehead link and for the case of the $(-2, 3, 3 + 2n)$ pretzel knots. This talk will be given by two speakers. Stavros Garoufalidis will speak on the connection between these Dehn fillings and the factorization of sparse polynomials. Michael Filaseta will elaborate on work associated with finding factorization results for the sparse polynomials encountered. (Received September 22, 2014)

1105-11-302 **David Ford**, **Sebastian Pauli*** (s_pauli@uncg.edu) and **Brian Sinclair**. *A Guide to OM algorithms.* Preliminary report.

An OM[1] algorithm is an algorithm that computes the Okutsu invariants of a polynomial Φ over a local field. The Okutsu invariants include, among other data, the ramification index and inertia degree of the irreducible factors of Φ. The data returned by the OM algorithm can be used to obtain a factorization of Φ, to find local and global integral bases, and the decomposition of ideals in global fields. Examples of OM-algorithms are the Montes algorithm and its variations and the Round Four algorithm and its variations

The process of approximating the irreducible factors of Φ in Montes algorithm can be regarded as a process of partitioning the set of its zeros. We present a Montes algorithm following this approach and show how it ties in with of Okutsu and Maclane. [1]By convention OM stands for the regular expression (Ore+Okutsu)(MacLane+ Montes). (Received September 23, 2014)

1105-11-304 **Katherine Thompson*** (kthompson0721@gmail.com). *Local Densities and Quadratic Forms.*

To study a positive definite integral quadratic form Q analytically, one examines its theta series Θ_Q–a modular form with weight, level and character determined by Q. The theory of local densities, developed by Siegel in the 1930s, is then used to understand the Fourier coefficients of Θ_Q. This technique is very powerful and is a crucial ingredient for major modern results on quadratic forms including the Bhargava-Hanke 290-Theorem (2005). This talk will discuss the way one generally applies this tool, as well as mention more recent applications to quadratic forms defined over totally real number fields and Hilbert modular forms. (Received September 23, 2014)

1105-11-320 **David Zureick-Brown*** (dzb@mathcs.emory.edu), 628 West College Ave., Decatur, GA 300303609, and **John Voight**. *The canonical ring of a stacky curve.*

We give a generalization to stacks of the classical theorem of Petri – i.e., we give a presentation for the canonical ring of a stacky curve. This is motivated by the following application: we give an explicit presentation for the ring of modular forms for a Fuchsian group with cofinite area, which depends on the signature of the group. This is joint work with John Voight. (Received September 23, 2014)

1105-11-321 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706. *Probabilistic Galois Theory.*

In recent years, the study of randomness has profitably entered many fields, such as random graphs, random codes, random groups, random curves, and random 3-manifolds. In this talk, I shall review what arithmetic statistics has had to say about Galois groups and then discuss my recent work with Bush, Ellenberg, Hajir, Ross, Wood, and others on how often a given non-abelian group arises as a Galois group in various contexts. (Received September 23, 2014)

1105-11-323 **Jacob Hicks*** (jhicks@math.uga.edu). *Universal Quaternary Quadratic Forms and Geometry of Numbers.*

This work builds on a paper of Mordell that proves representation theorems of diagonal quaternary quadratic forms. Using Geometry of Numbers and lattice arguments, we prove a small multiple theorem for quadratic forms with square discriminant. A previous paper used that result to show universality for all diagonal universal quaternary quadratic forms of square discriminant. In that paper all but one form was proven universal by coming up with changes of variables by hand. For the final form, an algorithm was produced to create and test

changes of variables. This algorithm was extended and improved to allow the consideration of nondiagonal forms and its success resulted in the addition of 96 universality results. (Received September 23, 2014)

1105-11-325 **Tim Huber*** (hubertj@utpa.edu). *Combinatorics of modular generators.* Preliminary report.

Let p be prime and $p \leq 23$. Analytic properties of certain weight one generators for the graded algebra of positive integer weight modular forms on $\Gamma_1(p)$ will be used to formulate congruences for Fourier coefficients of the generators and for allied combinatorial generating functions. (Received September 23, 2014)

1105-11-326 **David Zureick-Brown*** (dzb@mathcs.emory.edu), 628 West College Ave., Decatur, GA 30030, and **Anton Geraschenko**. *Gauss composition and integral arithmetic invariant theory.*

Motivated by the problem of representing integers via quadratic forms, Gauss discovered a "composition law" on binary quadratic forms. Gauss's law, while explicit, was a mathematical behemoth; inspired by a Rubik's cube, Bhargava famously rederived Gauss's composition laws in a more user friendly way.

More recently, Bhargava, Gross and Wang began the study of "arithmetic invariant theory, putting this into a modern cohomological framework. I will discuss each of these topics (starting with the elementary setup of Gauss) and describe a recent generalization of this work with Anton Geraschenko. (Received September 23, 2014)

1105-11-349 **Patrick J Dynes** (pdynes@clemson.edu), 110 Cherry Hill Avenue, Goose Creek, SC 29445, **Brian McDonald*** (bmcdon11@u.rochester.edu), 12947 Wembly Court, Carmel, IN 46033, and **Kimsy Tor**, **Andrew Best**, **Xixi Edelsbrunner**, **Madeleine Weinstein** and **Steven J Miller**. *Benfordness of Zeckendorf Decompositions.*

We report on connections we have established between Zeckendorf decompositions and Benford's law. Zeckendorf showed that every positive integer can be decomposed uniquely into a sum of non-consecutive Fibonacci numbers; this result has been extended to decompositions arising from many other recurrence relations. Additionally, the Fibonacci numbers are known to satisfy Benford's law of digit bias, which means that the density of elements with first digit d is $\log_{10}(1 + \frac{1}{d})$. According to this law, the smaller the digit, the more likely it is to occur as a leading digit.

We prove that for a randomly selected integer between 1 and the nth Fibonacci number, as $n \to \infty$ the leading digits of the Fibonacci summands in its Zeckendorf decomposition are arbitrarily close to Benford almost surely. The proof proceeds by first analyzing random subsets of Fibonacci numbers for Benfordness. The main ingredient there is showing sets of density are preserved under this process. Using this, prove a correspondence between Zeckendorf decompositions and random subsets of Fibonacci numbers. In those sets the Fibonacci numbers are chosen with a probability $p = 1/\varphi^2$ (where φ is the golden mean) if the previous Fibonacci number wasn't chosen, and 0 otherwise. (Received September 23, 2014)

12 ► Field theory and polynomials

1105-12-92 **Sunil K Chebolu*** (schebol@ilstu.edu), Normal, IL 67161, and **Jan Minac**. *Towards a refinement of the Bloch-Kato conjecture.*

The Rost-Voevodsky theorem (Bloch-Kato conjecture) tells us that over a field containing a primitive pth root of unity, the Galois cohomology ring with $\mathbb{F}_p$ coefficients is generated (as an $\mathbb{F}_p$–algebra) by elements in degree one. It is a natural problem to refine the Rost-Voevodsky theorem by finding field extensions of the base field where a given indecomposable classes in the cohomology groups decompose as a sum of products of degree one elements under the inflation map. We provide some answers to this question for cohomology classes in degree two, thus setting the first step towards a refinement of the Bloch-Kato conjecture. (Received September 09, 2014)

1105-12-124 **Danny Neftin*** (neftin@umich.edu), 530 Church Street, Ann Arbor, MI 48109-1043. *The Sylow subgroups of the absolute Galois group of Q.*

Following a question of Serre, the Sylow subgroups of the absolute Galois group of a p-adic field were studied and completely understood by Labute. However, the structure of the p-Sylow subgroups of the absolute Galois group of the field of rational numbers is much more subtle and mysterious. We make progress towards its determination via a surprisingly simple decomposition. Joint work with Lior Bary-Soroker and Moshe Jarden. (Received September 13, 2014)

1105-12-228 **Jan Minac** (minac@uwo.ca), **Andrew Schultz*** (andrew.c.schultz@gmail.com) and **John Swallow** (john.swallow@sewanee.edu). *Galois module structure of p^sth power classes of a field.* Preliminary report.

When a field K contains a primitive pth root of unity, Kummer theory tells us that the $\mathbb{F}_p$-space $K^\times/K^{\times p}$ is a paremeterizing space for elementary p-abelian extensions of K. In previous work, the authors computed the Galois module structure of this set when the Galois group came from an extension K/F whose Galois group is isomorphic to $\mathbb{Z}/p^n\mathbb{Z}$. In this talk we consider the more refined group $K^\times/K^{\times p^s}$ as a Galois module, and we report on some preliminary progress in computing its structure. It appears that there is only one summand which is not free (either under the full ring or one of its natural quotients), and this summand's structure seems to be connected to the cyclotomic character and a certain family of embedding problems along the tower K/F. (Received September 21, 2014)

1105-12-311 **Rachel Davis***, Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907, and **Edray Goins**. *Explicit étale covers of an elliptic curve minus a point.* Preliminary report.

Let E be an elliptic curve defined over an algebraically closed field of characteristic 0, and let $X = E - \mathcal{O}$. Then, $\pi_1^{et}(X)$ is the profinite completion of a free group on two letters. Therefore for any 2-generated finite group G, there should exist a Galois étale cover $Y \to X$ with G as Galois group.

For example, the map multiplication by n has abelian Galois group $(\mathbb{Z}/n\mathbb{Z})^2$. We are especially interested in concrete maps that have non-abelian Galois groups. Professor Donu Arapura gave an explicit example with S_3 as its Galois group. Motivated by this and its applications to Galois representations, we study other examples of 2-generated finite groups. This is joint work with Professor Edray Goins. (Received September 23, 2014)

1105-12-312 **David Harbater**, **Julia Hartmann** and **Daniel Krashen*** (dkrashen@uga.edu). *Higer dimensional local-global principles for torsors under linear algebraic groups.*

In this talk, I'll discuss some recent joint work with David Harbater and Julia Hartmann on finding higher-dimensional versions of local-global principles for linear algebraic groups, and describe some conjectures and open problems. (Received September 23, 2014)

13 ► Commutative rings and algebras

1105-13-106 **Scott C. Batson*** (scbatson@ncsu.edu). *On the Algebraic Structure of Principal Ideal Lattices.* Preliminary report.

Lattices with a special algebraic structure, called ideal lattices, are at the center of many recent developments in lattice-based cryptography. The shortest vector problem (SVP) is the most important underlying hard lattice problem. Algorithms that output a short vector in ideal lattices typically operate in a strict geometric fashion; few algorithms exploit the algebraic structure. Whether or not the SVP in ideal lattices can be solved algebraically remains unknown. We consider ideal lattices that correspond to principal ideals in the cyclotomic quotient ring $\mathbb{Z}[x]/(\Phi_m(x))$ and randomly sample a large number of these principal ideal lattices to infer a relationship between the algebraic structure of an ideal and the geometric structure of its corresponding lattice. We show that a generator of the ideal always corresponds to a solution of the SVP for cyclotomic indices $m = 1, 2, 3, 4, 6$. We also run the LLL lattice reduction algorithm on a particular basis for the sampled lattices and present empirical evidence of a probabilistic correspondence between this short vector output of the LLL and a generator of the ideal. These results demonstrate progress towards solving the SVP in ideal lattices algebraically. (Received September 11, 2014)

14 ► Algebraic geometry

1105-14-56 **Dave Anderson*** (anderson.2804@math.osu.edu), **Mathieu Florence** and **Zinovy Reichstein**. *Rationality of a Lie algebra over its quotient by the adjoint action.*

A semisimple algebraic group G acts on the function field of its Lie algebra $k(\mathfrak{g})$ via the adjoint action, and a basic question is this: can $k(\mathfrak{g})$ be generated by algebraically independent elements over the invariant field $k(\mathfrak{g})^G$? In 2011, Colliot-Thélène, Kunyavskiĭ, Popov, and Reichstein found the answer for all groups not containing a factor of type G_2. We recently settled this last case. I will give a rough overview of the problem, and sketch the solution in the G_2 case concretely. (Received August 28, 2014)

1105-14-71 **Frank Sottile*** (sottile@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77840, and **Praise Adeyemo** (ph.adeyemo@ui.edu.ng), Department of Mathematics, University of Ibadan, Ibadan, Oyo , Nigeria. *Cohomological Consequences of the Pattern Map.* Preliminary report.

Billey and Braden defined maps on flag manifolds of any Lie type that are the geometric counterpart of permutation patterns. A section of their pattern map is an embedding of the flag manifold of a Levi subgroup into the full flag manifold. We give two expressions for the induced map on cohomology. One is in terms of generators and the other is in terms of the Schubert basis. We show that the coefficients in the second expression are naturally Schubert structure constants and therefore positive. Similar results hold for K-theory, generalizing known formulas in type A for cohomology and K-theory. (Received September 04, 2014)

1105-14-135 **Benjamin Gaines*** (bencg@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708-0320. *The G-Hilbert Scheme and the (0,2)-McKay Correspondence.*

We study first order deformations of the smooth resolutions of orbifolds that are of the form $\mathbb{C}^3/\mathbb{Z}_r$, focusing on the cases where the orbifold has an isolated singularity. We prove a lower bound exists on the number of deformations for any crepant resolution of this orbifold. We also show that this lower bound is achieved when the resolution used is the G-Hilbert scheme, and note that this lower bound can be found using methods from string theory. These methods lead us to a new way to construct the G-Hilbert scheme using the singlet count. (Received September 15, 2014)

1105-14-145 **Colin Diemer*** (cdiemer@gmail.com), 1200 Mariposa Ave, E202, Miami, FL 33146. *Mirror symmetry of GIT quotients.*

We will discuss attempts to understand the homological mirror symmetry conjecture at the level of GIT quotients. Recently, Kontsevich has proposed conjectures which involve relating the "Lagrangian skeleton" approach to mirror symmetry to the "grade restriction rules" of Herbst-Hori Page. Even in the toric case homological mirror symmetry is quite subtle from the perspective of Cox quotients, and so new ideas such as these are essential, even in elementary cases. This is based on a joint work with M. Ballard, D. Favero, and M. Kontsevich. (Received September 15, 2014)

1105-14-153 **Katrina Honigs*** (honigska@math.berkeley.edu). *Zeta Functions of Derived Equivalent Varieties.*

In this talk, I will present results demonstrating that derived equivalence between varieties over finite fields that are either abelian or surfaces implies equality of zeta functions. (Received September 16, 2014)

1105-14-156 **Eric R Sharpe*** (ersharpe@vt.edu), Department of Physics MC 0435, 850 West Campus Drive, Blacksburg, VA 24061. *An introduction to heterotic mirror symmetry.*

In this talk we will describe progress towards a generalization of mirror symmetry pertinent for heterotic strings. Whereas ordinary mirror symmetry relates, in its simplest incarnations, pairs of Calabi-Yau manifolds, the heterotic generalization relates pairs of holomorphic vector bundles over (typically distinct) Calabi-Yau's, satisfying certain consistency conditions. We will also outline the corresponding analogue of quantum cohomology, known as quantum sheaf cohomology. (Received September 16, 2014)

1105-14-191 **Nicolas Addington*** (adding@math.duke.edu). *On various rationality conjectures for cubic fourfolds.*

I'll try to clarify the interrelations between several conjectural criteria for rationality of cubic fourfolds: Hassett's (1996), Kuznetsov's (2008), and Galkin and Shinder's (last May). In particular I'll explain that a cubic has an associated K3 surface in the sense of Hassett if and only if its variety of lines is birational to a moduli space of sheaves on a K3 surface, which is slightly weaker than Galkin and Shinder's condition that it be birational to $\mathrm{Hilb}^2(\mathrm{K3})$. Time permitting I may say a bit about Lehn et al.'s hyperkähler 8-fold. (Received September 19, 2014)

1105-14-197 **Justin Sawon*** (sawon@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Debarre's fibration on generalized Kummer varieties, and its dual.*

In this talk we consider four Lagrangian fibrations on holomorphic symplectic manifolds, and their dual fibrations. The non-compact examples are Hitchin systems, specifically, the GL(n) and SL(n) Hitchin systems. The compact examples are the Beauville-Mukai integrable system on the Hilbert scheme of points on a K3 surface, and the Debarre integrable system on the generalized Kummer variety. A degeneration of the Beauville-Mukai system is a

compactification of the GL(n) Hitchin system, whereas the Debarre system behaves similarly to the SL(n) Hitchin system. We use this latter analogy to construct a dual fibration of the Debarre system, by imitating Hausel and Thaddeus's construction of the duality between SL(n) and PGL(n) Hitchin systems, and we conjecture some deeper mirror symmetry relations between the Debarre system and its dual. (Received September 19, 2014)

1105-14-198 **Justin Sawon*** (sawon@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Projective duality and Brauer elements on K3 surfaces.*

The Brauer group of a variety S is the group of torsion elements in $\mathrm{H}^2(S, \mathcal{O}^*)$. These elements arise as obstructions to lifting $\mathrm{PGL}(n)$-bundles to $\mathrm{GL}(n)$-bundles, and can therefore be represented geometrically as $\mathbb{P}^{n-1}$-bundles, known as Brauer-Severi varieties. Brauer elements of K3 surfaces arise naturally in moduli problems, but it is not always clear how to realize these elements geometrically. In this talk we describe some examples coming from projective duality. These include a degree eight K3 surface in $\mathbb{P}^5$, projectively dual to a degree two K3 surface, and a degree eighteen K3 surface in $\mathbb{P}^{10}$ (a linear section of a certain G_2-homogeneous variety), also projectively dual to a degree two K3 surface. In these examples, Brauer elements arise with natural geometric realizations, coming from certain Fano varieties associated to the K3 surfaces. (Received September 19, 2014)

1105-14-204 **Matt Kerr*** (matkerr@math.wustl.edu), 153 Panofsky Lane, Princeton, NJ 08540. *Orbits of real Lie groups in flag varieties.*

We describe results of work with C. Robles and G. Pearlstein on orbit closure relations in Hodge-theoretic classifying spaces $\check{D} = G/P$, and say something about the algebro-geometric motivation that led us to these results. (Received September 20, 2014)

1105-14-205 **Matt Kerr*** (matkerr@math.wustl.edu), 153 Panofsky Lane, Princeton, NJ 08540. *Arithmetic of degenerating VHS.*

We take a look at limits of variations of mixed Hodge structure arising from degenerating families of Calabi-Yau varieties. Our main emphasis will be on examples arising from middle convolutions and from LG models associated to Fano varieties. (Received September 20, 2014)

1105-14-215 **Paolo Aluffi*** (aluffi@math.fsu.edu), Mathematics Department, Florida State University, Tallahassee, FL 32306. *Degrees of projections of rank loci.*

We provide formulas for the degrees of the projections of the locus of square matrices with given rank from linear spaces spanned by a choice of matrix entries. The motivation for these computations stem from applications to 'matrix rigidity'. These degrees appear to match the numbers of Kekulé structures of certain benzenoid hydrocarbons, and arise in many other contexts with no apparent direct connection to the enumerative geometry of rank conditions. (Received September 20, 2014)

1105-14-223 **Ted Spaide*** (tspaide@gmail.com), 4247 Locust St. 925, Philadelphia, PA 19104. *Derived Symplectic Structures on Framed Mapping Spaces.*

I will discuss spaces of maps which are framed on a divisor. I will show that these spaces have shifted symplectic structures under certain conditions. This can be used to provide examples of classical symplectic structures on moduli spaces. (Received September 21, 2014)

1105-14-238 **Andrew Obus***, 141 Cabell Drive, Kerchof Hall, Charlottesville, VA 22903, and **Stefan Wewers** (stefan.wewers@uni-ulm.de). *Toward a generalization of the Oort Conjecture.* Preliminary report.

The (local) Oort conjecture (now a theorem of Obus-Wewers and Pop), states that any cyclic G-action on $k[[t]]$, where k is algebraically closed of characteristic p, lifts to characteristic zero. If G is not necessarily cyclic, but still has characteristic zero, then lifting is not always possible, due to the so-called Bertin obstruction. We conjecture that the Bertin obstruction is the only obstruction in this case. Furthermore, for each given group and ramification filtration to which our conjecture applies, we exhibit a finite computation that, if successful, will verify the conjecture. (Received September 22, 2014)

1105-14-240 **Andrew J Harder*** (aharder@ualberta.ca), 632 CAB, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *K3 fibrations on Calabi-Yau threefolds and Landau-Ginzburg models of Fano threefolds.* Preliminary report.

Calabi-Yau threefolds can be constructed as smoothings of unions of pairs of blown-up Fano threefolds. It is well known that this construction should be related to K3 surface fibrations on the mirror Calabi-Yau threefold. I will describe in several cases how mirror Calabi-Yau threefolds can be constructed from the Landau-Ginzburg models of the Fano threefolds with which we began. (Received September 22, 2014)

1105-14-252 **Swarnava Mukhopadhyay*** (swarnava@umd.edu), University of Maryland, College Park, MD 20742. *Rank-Level duality and Conformal Blocks divisors $\overline{M}_{0,n}$.*

Conformal blocks are vector bundles on moduli space of curves with marked points that arise naturally in rational conformal field theory. They also give rise to a very interesting family of nef divisors and hence relate to questions on nef cone of moduli space of genus zero curves with n-marked points. Rank-level duality connects a conformal block associated to one Lie algebra to a conformal block for a different Lie algebra. In this talk we discuss relations among conformal blocks divisors that arise from rank-level duality. (Received September 22, 2014)

1105-14-259 **Thomas Lam**, **Changzheng Li**, **Leonardo Mihalcea** and **Mark Shimozono*** (mshimo@math.vt.edu), Department of Mathematics, MC 0123, 460 McBryde Hall, Virginia Tech, 225 Stanger Street, Blacksburg, VA 24060. *Equivariant Quantum K-theory of flag varieties and K-theory of affine Grassmannians.* Preliminary report.

Analogous to Peterson's theorem in quantum cohomology, we present a conjecture which asserts (after localization) that the torus-equivariant quantum K-theory of flag varieties G/B is isomorphic to the convolution algebra of the torus-equivariant K-theory of the affine Grassmannian of G. It is given as an explicit correspondence of Schubert classes. (Received September 22, 2014)

1105-14-271 **Jimmy Dillies*** (jdillies@georgiasouthern.edu), Statesboro, GA 30460. *Elliptic Varieties and Mirror Symmetry.*

In this talk, we explore some relations between mirror elliptic varieties and their underlying fibrations. (Received September 22, 2014)

1105-14-280 **Kaisa Taipale*** (taipale@umn.edu), **Anna Bertiger** and **Elizabeth Beazley**. *Equivariant quantum cohomology of the Grassmannian: combinatorics and geometry.* Preliminary report.

Schubert calculus, quantum cohomology, and the Peterson isomorphism overlap to showcase beautiful and puzzling combinatorial patterns. In particular, the Grassmannian is the setting for elegant tricks like the quantum and equivariant quantum rim-hook rules for quantum products. This talk will discuss the equivariant quantum cohomology of the Grassmannian in view of the Peterson isomorphism, with reference to both symmetric function theory and geometry. (Received September 22, 2014)

1105-14-288 **David E. Anderson*** (anderson.2804@math.osu.edu). *Divisors on Bott-Samelson varieties.*

I will explain how to compute the cone of effective divisors on a Bott-Samelson variety $X = X(\alpha_1, \ldots, \alpha_d)$. When the word $(\alpha_1, \ldots, \alpha_d)$ is reduced, so X maps birationally to a Schubert variety in G/B, the answer is simple (and known). For non-reduced words, the cone is more complicated, but tractable. (Received September 22, 2014)

1105-14-306 **Prakash Belkale*** (belkale@email.unc.edu), CB #3250, Phillips Hall, UNC-Chapel Hill, Chapel Hill, NC 27599, and **A. Gibney** and **S. Mukhopadhyay**. *Nonvanishing of conformal blocks divisors on the moduli space of curves.*

Conformal blocks (associated to a simple complex Lie algebra, n representations and a level ℓ) form vector bundles on the moduli spaces of stable pointed curves. One can view them as generalizing classical invariant theory, while at the same time being objects associated to the moduli of curves. They give rise to nef line bundles in genus 0.

After a brief introduction to conformal blocks I will discuss recent work (joint with Gibney and Mukhopadhyay) on the nonvanishing properties of these divisors (in genus 0). We view the non-vanishing question as a higher Chern class generalization of the non vanishing statements of classical invariant theory (Horn, Saturation conjectures). (Received September 23, 2014)

1105-14-310 **Angela C Gibney*** (agibney@math.uga.edu), Athens, GA 30605, and **Prakash Belkale** (belkale@email.unc.edu) and **Swarnava Mukhopadhyay**. *Vanishing and identities of conformal blocks divisors on the moduli space of curves.*

I will talk about joint work with Belkale and Mukhopadhyay, in which we study aspects of vector bundles of conformal blocks on the moduli space of curves, using the quantum cohomology of Grassmannians. For example, we show that above the critical level, which we introduce, all vector bundles of type A conformal blocks on $\overline{M}_{0,n}$ are trivial. Complementary vanishing results hold for divisors above the theta level in all types. We uncover

new level-rank symmetries between pairs of critical level conformal blocks divisors, and other identities as well, all of which give information about the maps they define. (Received September 23, 2014)

1105-14-328 **Anders Buch*** (asbuch@math.rutgers.edu), **Pierre-Emmanuel Chaput**, **Leonardo Mihalcea** and **Nicolas Perrin**. *A Chevalley formula for equivariant quantum K-theory of cominuscule varieties.* Preliminary report.

I will speak about a uniform Chevalley formula for multiplying with a divisor in the equivariant quantum K-theory ring of any cominuscule variety. The family of cominuscule varieties includes Grassmannians of type A, Lagrangian Grassmannians, maximal orthogonal Grassmannians, quadric hypersurfaces, and two exceptional varieties of type E. I will also discuss some applications. This is work in progress with P.-E. Chaput, L. Mihalcea, and N. Perrin. (Received September 23, 2014)

15 ► Linear and multilinear algebra; matrix theory

1105-15-150 **J Ding*** (jiudin@gmail.com), Depart of Mathematics, Hattiesburg, MS 39406-5045, **N Rhee**, Department of Mathematics and Statistics, Kansas City, MO 64110, and **C Zhang**, Department of Mathematics, Hattiesburg, MS 39406-5045. *Solving the Yang-Baxter-tyoe Matrix Equation.*

The matrix equation $AXA = XAX$ is called the Yang-Baxter-type matrix equation because of its similarity in format to the classic Yang-Baxter equation which is closely related to knot theory, braid groups, and etc. We present some recent work on solving this equation and analyze the structure of the solution set for different classes of matrix A. (Received September 16, 2014)

16 ► Associative rings and algebras

1105-16-225 **Daniel Orr*** (dorr@vt.edu) and **Mark Shimozono** (mshimo@math.vt.edu). *Elliptic Hall algebra, spherical DAHA, and symmetric function operators.* Preliminary report.

Schiffmann and Vasserot have proved an isomorphism between the elliptic Hall algebra and a projective limit of the spherical double affine Hecke algebras of type $GL(n)$. More recently, Bergeron, Garsia, Leven, and Xin have constructed a realization of the elliptic Hall algebra in terms of symmetric function operators. We establish a precise connection between all three objects in the title and discuss applications of our approach. (Received September 21, 2014)

1105-16-290 **R. Parimala*** (parimala@mathcs.emory.edu), Department of Mathematics & CS, 400 Dowman Drive, Atlanta, GA 30322, and **Jean-Pierre Tignol** and **Richard Weiss**. *On the Kneser–Tits conjecture.*

We explain a correspondence between the Whitehead group and the group of R-equivalence classes of an isotropic simple simply connected linear algebraic groups, following P. Gille. This leads to the triviality of the Whitehead group for certain groups of type E_8 via the study of R-equivalence classes on certain adjoint groups of type D_{2n}. (Received September 23, 2014)

17 ► Nonassociative rings and algebras

1105-17-81 **Ismail Demir*** (idemir@ncsu.edu). *On classification of Leibniz algebras.*

Leibniz algebras are certain generalization of Lie algebras. In this talk, we give the classification of non-Lie solvable three dimensional Leibniz algebras using a new approach involving the canonical forms for the congruence classes of matrices for bilinear forms which can easily be used to classify higher dimensional Leibniz algebras. This is a joint work with Kailash C. Misra and Ernie Stitzinger. (Received September 05, 2014)

1105-17-107 **Allison McAlister*** (armcalis@ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695-8205. *Classifying Several Classes of Leibniz Algebras.*

We extend results related to maximal subalgebras and ideals from Lie to Leibniz algebras. In particular, we classify elementary Leibniz algebras and minimal non-elementary Leibniz algebras. In both cases, there are types of these algebras with no Lie algebra analogue. (Received September 11, 2014)

1105-17-112 **Tiffany Burch*** (tmmyers@ncsu.edu). *Supersolvable Leibniz Algebras.* Preliminary report. Malcev algebras and Leibniz algebras are generalizations of Lie algebras. Classical theorems in Lie algebras have found extensions to Malcev algebras. It is the purpose of this paper to extend some of the Lie and Malcev algebra results, particularly supersolvable results, to Leibniz algebras. (Received September 11, 2014)

1105-17-236 **Tevian Dray*** (tevian@math.oregonstate.edu), Dept of Mathematics, Oregon State University, Corvallis, OR, **John Huerta** (jhuerta@math.ist.utl.pt), CAMGSD, Instituto Superior Técnico, Lisboa, Portugal, **Joshua Kincaid** (kincajos@math.oregonstate.edu), Dept of Physics, Oregon State University, **Corinne A. Manogue** (corinne@physics.oregonstate.edu), Dept of Physics, Oregon State University, **Aaron Wangberg** (awangberg@winona.edu), Winona State University, Winona, MN , and **Robert A. Wilson** (r.a.wilson@qmul.ac.uk), School of Mathematical Sciences, Queen Mary, University of London, London, United Kingdom. *Magic squares of Lie groups.*

The Tits-Freudenthal magic square yields a description of certain real forms of the exceptional Lie algebras in terms of a pair of division algebras. At the group level, the first two rows are well understood geometrically, with the minimal representations of F_4 and E_6 expressed in terms of the Albert algebra. In the third row, the minimal representation of E_7 consists of "Freudenthal triples", essentially a pair of Albert algebra elements.

We summarize here several recent results at the group level. First, we describe how to use Cartan decompositions involving all 5 real forms of E_6 to identify chains of real subgroups of the particular real form $SL(3,\mathbb{O})$. Second, we give a new description of Freudenthal triples in terms of "cubies", the components of an antisymmetric rank-3 representation of (generalized) symplectic groups, thus providing a unified, geometric interpretation of Freudenthal triples as a single object, a new description of the minimal representation of E_7, and an interpretation of the group $Sp(6,\mathbb{O})$. Along the way, we also discuss the closely related "2×2" magic square of orthogonal groups. (Received September 21, 2014)

1105-17-251 **Pamela E Harris*** (pamela.harris@usma.edu), Department of Mathematical Sciences, 646 Swift Road, West Point, NY 10996, and **Erik Insko**. *On the exceptional Lie algebras and their exponents.*

It was shown by Kostant that if $\mathfrak{g}$ is a simple Lie algebra with highest root $\tilde{\alpha}$, then the q-multiplicity of the zero-weight in the adjoint representation (the representation whose highest weight $\tilde{\alpha}$ is the highest root) is given by: $m_q(\tilde{\alpha},0) = q^{e_1} + q^{e_2} + \cdots + q^{e_r}$, where $e_1,\ldots,e_r$ are the exponents of $\mathfrak{g}$. In this talk, we define the *Weyl alternation set* associated to the zero-weight and the highest root of each exceptional Lie algebra as the elements of the Weyl group for which the value of Kostant's partition function is positive. Using this supporting set we can provide the value of the q-analog of Kostant's partition function and thus provide a purely computational proof of the result regarding the exponents of the exceptional Lie algebras G_2, F_4, E_6, E_7, and E_8. (Received September 22, 2014)

1105-17-355 **Daniel P Brice*** (dbrice@mytu.tuskegee.edu), 70-346 John A. Kenney Hall, Tuskegee University, Tuskegee, AL 36088. *Derivations of Parabolic Lie Algebras with Applications to Zero Product Determined Algebras.*

Working over a characteristic-zero, algebraically-closed field, we characterize the derivation algebras of Parabolic subalgebras of reductive Lie algebras as the direct sums of certain easily-described ideals. We go on to use this direct sum decomposition to show that the said derivation algebras are zero product determined with respect to the Lie bracket. (Received September 23, 2014)

20 ► Group theory and generalizations

1105-20-54 **William J Floyd*** (floyd@math.vt.edu), Department of Mathematics, 225 Stanger Street, Virginia Tech, Blacksburg, VA 24060-0123. *Cannon's Conjecture, subdivision rules, and expansion complexes.*

This is a survey talk on Cannon's Conjecture, finite subdivision rules, and expansion complexes. Cannon's Conjecture states that if G is a negatively-curved group whose Gromov boundary is a 2-sphere, then G has a properly discontinuous, cocompact, isometric action on hyperbolic 3-space. Finite subdivision rules were defined by Cannon, Floyd, and Parry as models for the recursive structure on the Gromov boundary of disks at infinity. Expansion complexes arose from an important example of Bowers and Stephenson as part of their analysis of the pentagonal subdivision rule. (Received August 28, 2014)

1105-20-78 **Bhama Srinivasan** and **C. Ryan Vinroot*** (vinroot@math.wm.edu). *Jordan decomposition of real-valued characters of finite reductive groups with connected center.*

Let $\mathbf{G}$ be a reductive group with connected center defined over a finite field $\mathbb{F}_q$ with q elements, and let $G = \mathbf{G}(\mathbb{F}_\mathbf{q})$ be the finite group of $\mathbb{F}_q$-points. We classify all irreducible complex characters of G which are real-valued through the Jordan decomposition of characters. The main tool is a uniqueness result of Digne and Michel for the Jordan decomposition of characters when the center is connected. (Received September 04, 2014)

1105-20-177 **W. Dale Garraway*** (dgarraway@ewu.edu), c/o dept of math, 216 Kingston hall, ewu, Cheney, WA 99004. *Properties of The Sierpinski Family as Determined by the Group D_8^3.* Preliminary report.

It is well known that the Sierpinski family of fractals can be generated by the Group D_8^3. Here we explore the relationship between subgroups of D_8^3 and how the associated cosets can be identified with 'properties' of the associated fractals. (Received September 18, 2014)

1105-20-185 **Daniel K Nakano*** (nakano@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Cohomology for Finite Exceptional Groups of Lie Type.*

In this talk I will first give a survey on known results and techniques for computing cohomology for finite Chevalley groups with coefficients in an irreducible representation. For finite classical groups of Lie type this has a nice uniform answer without too many restrictions on the prime. Later in the talk I will discuss the problem for exceptional groups and explain where many of the mysteries and difficulties remain in these computations. (Received September 19, 2014)

22 ► Topological groups, Lie groups

1105-22-18 **Semeon Arthamonov*** (semeon.artamonov@rutgers.edu), 3472 BPO Way, Piscataway, NJ 08854, and **Andrei Mironov**, **Alexei Morozov** and **Andrey Morozov**. *HOMFLY polynomial calculus for links and AENV conjecture.*

Recently Aganagic, Ekholm, Ng, and Vafa conjectured a relation between the augmentation variety in the large N limit of the colored HOMFLY and quantum A-polynomials. In this talk I will describe the methods used for direct confirmation of this conjecture for certain links.

It appears that colored knot polynomials possess an internal structure (we call it Z-expansion). Developing ideas of Garoufalidis we show explicitly that for the large families of links the corresponding colored HOMFLY polynomial for symmetric and anti-symmetric representations can be presented as a truncated sum of a certain q-hypergeometric series. The latter allows us to extend the formulas for the arbitrary symmetric representations and study the asymptotic of the colored HOMFLY polynomials for large symmetric representations.

In addition I will say a few words about the extension of Z-expansion beyond the symmetric representations for some simplest examples. Although for generic representation we no longer have truncated q-hypergeometric series we still have some interesting structure beyond the HOMFLY and superpolynomials. In particular, the introduction of the recently developed fourth grading in all existing examples can be presented as an elegant redefinition of the constituents of Z-expansion. (Received June 30, 2014)

1105-22-52 **Nathaniel Bushek*** (bushek@unc.edu), Department of Mathematics, UNC-Chapel Hill, CB # 3250, Phillips Hall, Chapel Hill, NC 27599, and **Shrawan Kumar**, Department of Mathematics, UNC-Chapel Hill, CB # 3250, Phillips Hall, Chapel Hill, NC 27599. *Descent of line bundles to the GIT quotients $(G/B \times G/B \times G/B)//G$.*

Let G be a simple, connected, algebraic group over $\mathbb{C}$, B a Borel subgroup, and $T \subset B$ a maximal torus. Let Q be the root lattice, Λ the weight lattice, and d the least common multiple of the coefficients of the highest root θ of $\mathfrak{g}$, the Lie algebra of G, written in terms of the simple roots. Consider the diagonal action of G on the projective variety $X = G/B \times G/B \times G/B$. Then, for any triple (λ, μ, ν) of dominant integral weights there is a G-linearized line bundle $\mathcal{L}$ on X. Such a line bundle is said to descend to the GIT quotient $\pi : X(\mathcal{L})^{ss} \to X(\mathcal{L})//G$ if there exists a line bundle $\hat{\mathcal{L}}$ on $X(\mathcal{L})//G$ such that $\mathcal{L} \mid_{X(\mathcal{L})^{ss}} \cong \pi^* \hat{\mathcal{L}}$. We show that $\mathcal{L}$ descends if $\lambda, \mu, \nu \in d\Lambda$ and $\lambda + \mu + \nu \in \Gamma$, where Γ is a specified lattice, depending on the type of $\mathfrak{g}$, satisfying $dQ \subset \Gamma \subset Q$. (Received September 24, 2014)

1105-22-67 **Michael P Cohen***, michael.cohen@ndsu.edu, and **Robert R Kallman**. *Openly Haar null sets and conjugacy in Polish groups.*

J. P. R. Christensen defined and studied a notion of measure-theoretically small subsets of a Polish topological group G, the Haar null sets. These comprise a rich σ-ideal which coincides with the class of Haar measure zero

sets in case G is locally compact. But in the non-locally compact setting open questions abound. I'll discuss some of these problems along with the history of the theory. Then I'll present some recent results (joint with Robert R. Kallman) connecting some properties of the Haar null ideal of a given non-abelian group G with the dynamical properties of the group's action on itself by conjugation. (Received September 03, 2014)

1105-22-187 **Jason Polak*** (jpolak@jpolak.org) and **Jayce Getz**. *An Example of Relative Endoscopy.* For a reductive algebraic group G with Lie algebra $\mathfrak{g}$ and involution $\theta : G \to G$, we define relative orbital integrals with respect to G^θ acting on $\mathfrak{g}_1 = \{x \in \mathfrak{g} : \theta(x) = -x\}$. We demonstrate an explicit calculation with the example of $\mathrm{U}_2 \times \mathrm{U}_2 \hookrightarrow \mathrm{U}_4$ that suggests a hidden law of endoscopy lurking in this situation. Along the way, we will glimpse some of the difficulties in formulating a relative fundamental lemma. (Received September 19, 2014)

1105-22-211 **Oscar Chacaltana**, **Jacques Distler** and **Anderson Trimm***, atrimm@physics.utexas.edu. *Symmetric polynomials, exceptional Lie algebras, and superconformal indices of four-dimensional "class S" quantum field theories.*

I will discuss the superconformal index of the class of theories introduced in J. Distler's talk. The superconformal index is an invariant which counts protected states in a superconformal field theory. This is exact non-perturbative information about the theory, which can be used to test strong-coupling dualities. For a class S theory of type $\mathfrak{j} = ADE$ defined by an n-punctured Riemann surface C, the superconformal index takes the form of an infinite sum involving symmetric polynomials labeled by a representation of $\mathfrak{j}$ and a nilpotent orbit in $\mathfrak{j}_{\mathbb{C}}$. In this talk, I will take a limit of the index in which the symmetric polynomials are given by Hall-Littlewood polynomials, and I will show how to use this limit of the index to classify theories of type $\mathfrak{j} = E_6$. (Received September 20, 2014)

1105-22-214 **Jun Yu*** (yu_jun@mit.edu), Massachusetts Institute of Technology, Department of Mathematics, E18, Room 374, 77 Massachusetts Avenue, Cambridge, MA 02139. *Abelian subgroups of algebraic simple groups.*

We discuss the classification of elementary abelian p-subgroups of algebraic simple groups, in particular of elementary abelian 2-subgroups. We also discuss diagonalizable maximal abelian subgroups. (Received September 20, 2014)

1105-22-274 **Uladzimir Shtukar*** (ushtukar@nccu.edu), 1801 Fayetteville Street, MTSB, r. 3253, Durham, NC 27707. *Invariant Reductive Triplets in Lie Algebras.*

Let g be a Lie algebra, and h be a subalgebra Lie at g. Suppose that the pair g,h is reductive, that means there exists a subspace m such that g=h+m and [h,m]=m. We will say also that the triplet g,h,m is reductive. A homogeneous space G/H with a reductive triplet g,h,m is called reductive; this space has some excellent geometry properties including an effective description of all invariant affine connections on the homogeneous space G/H in terms of the bilinear forms on m, that was received by K.Nomizu in Invariant affine connections on homogeneous spaces, Amer. J. Math., 76, 33-65, 1954. If S is an automorphism of Lie algebra g that saves h and m, S(h)=h and S(m)=m, then we call the reductive triplet g,h,m to be invariant with respect to S . At this case, the automorphism S generates a local affine transformation of the homogeneous space as it was proved by the author in the article Invariant connections and metrics on homogeneous spaces generated by global triplets, Math. Zametki,26,#3,449-463,1979. According to the last basic fact, it is interesting to determine all automorphisms of g that save a given reductive triplet. If g is a compact Lie algebra, then all possible reductive triplets can be formed using a unique direct sum presentation. (Received September 22, 2014)

1105-22-338 **Dan M Barbasch***, barbasch@math.cornell.edu. *Star Operations for Affine Graded Hecke Algebras.*

Affine graded Hecke algebras play an important role in the representation theory of p-adic groups. In this talk, based on joint work with Dan Ciubotaru, I will discuss star operations, which are essential for determining the unitary dual. In particular I will present some explicit results on the unitary dual for the algebra of exceptional type F4. The star operation is not the usual one coming from the group, rather a different one which is relevant to the semisimplicity of the modules. (Received September 23, 2014)

1105-22-351 **Jeffrey Adams*** (jda@math.umd.edu), Department of Mathematics, College Park, MD 20742, and **Tatiana Howard**. *Subalgebras of Real Simple Lie Algebras.* Preliminary report.

The study of reductive subalgebras of a complex simple Lie algebra $\mathfrak{g}$ has a long and rich history. Borel and de Siebenthal classified the reductive subalgebras of $\mathfrak{g}$ of the same rank. We consider the corresponding problem when $\mathfrak{g}_0$ is a real simple Lie algebra. It turns out that in the classical case this reduces to the classification

of semismple symmetric spaces, due to Berger from the 1950s. In the exceptional case it amounts to some Lie algebra cohomology calculations which we describe, and give tables of the results. (Received September 23, 2014)

30 ► Functions of a complex variable

1105-30-165 **James T Gill***, 220 N. Grand Blvd., Saint Louis, MO 63103, and **Steffen Rohde**.
Random Riemann surface uniformization.

If you glue together isomorphic equilateral triangles (or squares) randomly and forever, what sort of surface do you have? Of course, this question only makes sense when we specify the random process and the type of surface. We show that for a variety of processes that the Riemann surface formed by this gluing is almost surely parabolic. This turns out to be surprisingly determined because of the doubling metric property of the complex plane. (Received September 17, 2014)

34 ► Ordinary differential equations

1105-34-218 **Daniel Maroncelli** and **Jesus Rodriguez*** (rodrigu@ncsu.edu). *Existence theory for nonlinear Sturm-Liouville problems with unbounded nonlinearities.*

In this work we provide conditions for the existence of solutions to nonlinear Sturm-Liouville problems of the form,

$$(p(t)x'(t))' + q(t)x(t) + \lambda x(t) = f(\varepsilon, x(t))$$

subject to

$$ax(0) + bx'(0) = 0 \text{ and } cx(1) + dx'(1) = 0.$$

Our approach will be topological, utilizing both degree theory and the Lyapunov-Schmidt procedure. (Received September 21, 2014)

1105-34-248 **Michael Freeze** (freezem@uncw.edu), Mathematics and Statistics, UNC-Wilmington, Wilmington, NC 28403, **Yaw Chang*** (changy@uncw.edu), Mathematics and Statistics, UNC-Wilmington, Wilmington, NC 28403, and **Wei Feng** (fengw@uncw.edu), Mathematics and Statistics, UNC-Wilmington, Wilmington, NC 28403. *On Ratio-Dependent Food Chain Model, Part I: Ordinary Differential Equation Model.*

We study a new model obtained as an extension of a three-species food chain model with ratio-dependent functional response. In part one of the talk, we present the Ordinary Differential equation Mode. We provide non-persistence and permanence results and investigate the stability of all possible equilibria in relation to the ecological parameters. Results are obtained for the trivial and prey-only equilibria where the singularity of the model prevents linearization, and the remaining semi-trivial equilibria are studied using linearization. We provide a detailed analysis of conditions for existence, uniqueness, and multiplicity of coexistence equilibria, as well as permanent effect for all species. The complexity of the dynamics in this model is theoretically discussed and graphically demonstrated through various examples and numerical simulations. (Received September 22, 2014)

1105-34-249 **N S Hoang***, Department of Mathematics, University of West Georgia, Carrollton, GA.
Stability results of some abstract evolution equations.

The stability of the solution to the equation $\dot{u} = A(t)u + G(t,u) + f(t)$, $t \geq 0$, $u(0) = u_0$ is studied. Here $A(t)$ is a linear operator in a Hilbert space H and $G(t,u)$ is a nonlinear operator in H for any fixed $t \geq 0$. We assume that $\|G(t,u)\| \leq \alpha(t)\|u\|^p$, $p > 1$, and the spectrum of $A(t)$ lies in the half-plane $\operatorname{Re}\lambda \leq \gamma(t)$ where $\gamma(t)$ can take positive and negative values. We proved that the equilibrium solution $u(t) \equiv 0$ to the equation is Lyapunov stable under persistantly acting perturbations $f(t)$ if $\sup_{t\geq 0} \int_0^t \gamma(\xi)\, d\xi < \infty$ and $\int_0^\infty \alpha(\xi)\, d\xi < \infty$. In addition, if $\int_0^t \gamma(\xi)\, d\xi \to -\infty$ as $t \to \infty$, then we proved that the equilibrium solution $u(t) \equiv 0$ is asymptotically stable under persistantly acting perturbations $f(t)$. Sufficient conditions for the solution $u(t)$ to be bounded and for $\lim_{t\to\infty} u(t) = 0$ are proposed and justified. (Received September 22, 2014)

1105-34-263 **Kristen Abernathy*** (abernathyk@winthrop.edu). *Sufficient Conditions for Existence of Solutions of Nonlinear Differential Equations with Nonlocal Boundary Conditions.*

We present easily verifiable sufficient conditions for the existence of solutions to nonlinear ordinary differential equations subject to nonlocal boundary conditions. These conditions are based on the solution space of the corresponding linear, homogeneous problem and on the size of the nonlinear perturbation. The results presented here are more general nonlinearities than those found in (Rodriguez, 2009) and (Rodriguez and Taylor, 2008). (Received September 22, 2014)

1105-34-342 **Amal El Moghraby*** (amoghraby@gmail.com), 3606 chance rd, greensboro, NC 27410. *Time-independent manifolds from time-dependent data.*

Lagrangian Coherent Structures (LCS) play a key role in understanding the underlying dynamics of a velocity field in the form x = f(x,t). LCS in a certain field act as organizers of transport and are obtained by following the Lagrangian trajectories x(t), the solution to the above differential equation. In this study we use a Lagrangian diagnostic to compute LCS for the Duffing Oscillator. We show that by using an appropriate advection termination time, one can retrieve a time-independent instance of the LCS from a time-dependent velocity field. (Received September 23, 2014)

1105-34-361 **A Abebe*** (abraham@temple.edu), **M Chhetri** and **R Shivaji**. *Positive solutions for a class of multiparameter elliptic systems.*

We consider an elliptic system of the form

$$\left.\begin{array}{rll} -\Delta_p u = \lambda_1 f_1(u) + \mu_1 \frac{g_1(v)}{v^{\alpha_1}} & \text{in} & \Omega; \\ -\Delta_q v = \lambda_2 \frac{f_2(u)}{u^{\alpha_2}} + \mu_2 g_2(v) & in & \Omega; \\ u = v = 0 & \text{on} & \partial\Omega, \end{array}\right\}$$

where $p, q > 1$, $\Delta_m w := |\nabla w|^{m-2}\nabla w$ is the m-Laplacian operator for $m > 1$, $\Omega \subset \mathbb{R}^N$ is a bounded domain with smooth boundary, $\lambda_i, \mu_i > 0$ are parameters and $0 \leq \alpha_i < 1$ are fixed constants for $i = 1, 2$. The nonlinearities f_i, $g_i : [0, \infty) \to \mathbb{R}$ are continuous functions satisfying certain p, q-sublinear or combined sublinear conditions at infinity. When $g_1(0) < 0$ and $f_2(0) < 0$, we discuss existence of a positive solution for $\lambda_i + \mu_i >> 1$ for $i = 1, 2$. We also discuss a multiplicity result when $\alpha_1 = 0 = \alpha_2$. Method of sub- and supersolutions are employed to establish these results.
(Received September 24, 2014)

35 ► Partial differential equations

1105-35-24 **Kazuo Yamazaki***, 401 Mathematical Sciences Building, Dept. of Math., Oklahoma State University, Stillwater, OK 74078. *Component reduction for regularity criteria of the three-dimensional magnetohydrodynamics systems.*

We review recent results on the Prodi-Serrin type regularity criteria of the Navier-Stokes equations, magnetohydrodynamics system and other partial differential equations related to fluids. In particular, we discuss component reduction results of such criteria. Our discussion may include micro-polar and magneto-micropolar fluid systems, surface quasi-geostrophic equations and incompressible porous media equation governed by Darcy's law. If time permits, we shall discuss global regularity issues of these equations as well. (Received July 25, 2014)

1105-35-33 **Sarath Sasi*** (sasi@ntis.zcu.cz), **Pavel Drábek** and **Anoop Thazhe Veetil**. *Weighted quasilinear eigenvalue problems in exterior domains.*

We consider the following weighted eigenvalue problem in the exterior domain:

$$\begin{cases} -\Delta_p u = \lambda K(x)|u|^{p-2}u & \text{in } B_1^c, \\ u = 0 & \text{on } \partial B_1, \end{cases}$$

where Δ_p is the p-Laplace operator with $p > 1$, and B_1^c is the exterior of the closed unit ball in $\mathbb{R}^N$ with $N \geq 1$. There is no restriction on the dimension N in terms of p, i.e., we allow both $1 < p < N$ and $p \geq N$. The weight function K is locally integrable on B_1^c and is allowed to change its sign. For some appropriate choice of w, a positive weight function on the interval $(1, \infty)$, we prove that the Beppo-Levi space $\mathcal{D}_0^{1,p}(B_1^c)$ is compactly embedded into the weighted Lebesgue space $L^p(B_1^c; w(|x|))$. The existence of the positive eigenvalue for the above problem is proved for K such that $\text{supp}K^+$ is of non-zero measure and $|K| \leq w$. Further, we discuss the positivity, the regularity and the asymptotic behaviour at infinity of the first eigenfunctions. (Received August 12, 2014)

1105-35-35 **Anoop Thazheveetil*** (anoop@ntis.zcu.cz), **Pavel Drabek** and **Sarath Sasi**. *On the structure of the second eigenfunctions of the p- Laplacian.*

We consider the the second eigenvalue λ_2 of the Dirichlet p-Laplacian on the unit ball in $\mathbb{R}^N$. We show that the eigenfunctions corresponding to λ_2 are nonradial. Further, we discuss some open problems on the structure of the nodal set of the second eigenfunctions as well. (Received August 14, 2014)

1105-35-36 **Abraham Abebe**, **Maya Chhetri** and **Lakshmi Sankar***, lakshmi@ntis.zcu.cz, and **Ratnasingham Shivaji**. *Positive solutions for a class of superlinear semipositone systems on exterior domains.*

We study the existence of a positive radial solution to the nonlinear eigenvalue problem

$$\left.\begin{array}{lll} -\Delta u &= \lambda K_1(|x|)f(v) & \text{in } \Omega_e, \\ -\Delta v &= \lambda K_2(|x|)g(u) & \text{in } \Omega_e, \\ u(x) &= v(x) = 0 & \text{if } |x| = r_0(> 0), \\ u(x) &\to 0, v(x) \to 0 & \text{as } |x| \to \infty, \end{array}\right\}$$

where $\lambda > 0$ is a parameter, $\Delta u = \operatorname{div}(\nabla u)$ is the Laplace operator, $\Omega_e = \{x \in \mathbb{R}^n \mid |x| > r_0, n > 2\}$, and $K_i \in C^1([r_0, \infty), (0, \infty)); i = 1, 2$ are such that $K_i(|x|) \to 0$ as $|x| \to \infty$. Here f, $g : [0, \infty) \to \mathbb{R}$ are C^1 functions such that they are negative at the origin (semipositone) and superlinear at infinity. We establish the existence of a positive solution for λ small via degree theory and rescaling arguments. (Received August 14, 2014)

1105-35-38 **Pavel Drabek*** (pdrabek@kma.zcu.cz), NTIS, University of West Bohemia in Pilsen, Univerzitni 8, 306 14 Pilsen, Czech Rep. *Eigenvalue problem for the p-Laplacian: results and open questions.*

In this talk we discuss the nonlinear homogeneous eigenvalue problem for the p-Laplacian with $1 < p < \infty$. We focus on different variational characterizations of the eigenvalues as well as on the properties of the eigenfunctions. We also discuss solvability of perturbed problems. Namely, we mention Landesman-Lazer type results for the p-Laplacian and present different points of view of the Fredholm alternative at the first eigenvalue: variational and bifurcation approaches. The results presented in this talk were obtained with the speaker and his coauthors Paul Binding, Jan Čepička, Lyonell Boulton, Manuel DelPino, Petr Girg, Gabriela Holubová, Yin Xi Huang, Raul Manasevich, Stephen Robinson, Peter Takáč and Michael Ulm during the last two decades. Besides these results we address also some open problems which are left in this field. (Received August 16, 2014)

1105-35-45 **Thinh T Kieu*** (thinh.kieu@ung.edu), Gainesville Campus, 3820 Mundy Mill Rd., Oakwood, GA 30566, and **Luan T. Hoang** (lluan.hoang@ttu.edu), 2500 Broadway & Boston, Lubbock, TX 79409. *Interior estimates for generalized Forchheimer flows for slightly compressible fluids in porous media.*

The generalized Forchheimer flows are studied for slightly compressible fluids in porous media with time-dependent Dirichlet boundary data for the pressure. We derive, for all time, the interior L^∞-estimtes for the presure and its partial derivatives, and the interior L^2-estimates for its Hessian. The De Giorgi and Ladyzhenskaya-Uralsetva iteration techniques are utilized and adapted to the specific structures of the equations for both pressure and its gradient. These are combined with the uniform Gronwall-type bounds in establishing asymptotic estimates when time tends to infinity. (Received August 24, 2014)

1105-35-58 **Azmy Ackleh**, **Baoling Ma*** (bxm4254@louisiana.edu) and **Robert Miller**. *A General Nonautonomous Nonlinear Structured Population Model: Existence-Uniqueness Results and Finite Difference Approximations.*

We derive a structured population model which is mathematically very general and has applications in ecology, epidemiology, cell biology, etc. A finite difference method is developed to approximate the solution of the model. Convergence of the numerical approximations to a unique weak solution of bounded total variation is proved. Some applications of the model are provided at the end. (Received August 29, 2014)

1105-35-61 **Gung-Min Gie*** (gungmin.gie@louisville.edu), Department of Mathematics, University of Louisville, 328 Natural Sciences Building, Louisville, KY 40292, and **Chang-Yeol Jung** (cjung@unist.ac.kr) and **Roger Temam** (temam@indiana.edu). *Analysis of mixed elliptic and parabolic boundary layers with corners.*

We study the asymptotic behavior at small diffusivity of solutions to a convection-diffusion equation in a rectangular domain. The diffusive equation is supplemented with a Dirichlet boundary condition, which is smooth along each edge, but only continuous at the corners. To resolve the discrepancy between the diffusive and corresponding limit solutions, we construct an asymptotic expansion of the diffusive solution at any arbitrary, but fixed, order with respect to the small diffusivity parameter. Here, to manage some singular effects near the

corners, the so-called elliptic and ordinary corner correctors are added in the asymptotic expansions as well as the parabolic and classical boundary layer functions. The validity of our asymptotic expansions is established in suitable Sobolev spaces. (Received September 01, 2014)

1105-35-73 **Leandro Recova** and **Adolfo J Rumbos*** (arumbos@pomona.edu), Department of Mathematics, Pomona College, 640 N. College Avenue, Claremont, CA 91711. *Multiple Solutions to Superlinear, Asymmetric, Semilinear Elliptic Problems via Morse Theory.* Preliminary report.

We present multiplicity results for the boundary value problem

$$\begin{cases} -\Delta u = g(x,u) & \text{in } \Omega; \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where Ω is a smooth bounded domain in $\mathbb{R}^N$ ($N \geq 2$) and $g\colon \overline{\Omega} \times \mathbb{R} \to \mathbb{R}$ is a differentiable function with $g(x,0) = 0$ for all $x \in \Omega$. We assume that $g(x,s)$ is asymptotically linear in s for large negative values of s and that $g(x,s)$ has superlinear, but subcritical, growth in s for large positive values of s. We consider both asymptotic resonance and non–resonance for negative values of s. We use minimax methods in critical point theory and infinite–dimensional Morse theory. (Received September 04, 2014)

1105-35-74 **Alexey Cheskidov** and **Mimi Dai*** (mdai@uic.edu). *The existence of a global attractor for the forced critical surface quasi-geostrophic Equation in L^2.*

We prove that the critical surface quasi-geostrophic equation driven by a force f possesses a compact global attractor in $L^2(\mathbb{T}^2)$ provided $f \in L^p(\mathbb{T}^2)$ for some $p > 2$. (Received September 04, 2014)

1105-35-82 **Brent O Young*** (bojy77@gmail.com), 2550 NC Hwy 242 South, Benson, NC 27504. *Landau Damping in Relativistic Plasmas.*

We examine the phenomenon of Landau Damping in relativistic plasmas via a study of the relativistic Vlasov-Poisson system (rVP) on the torus for initial data sufficiently close to a spatially uniform steady state. We find that if the steady state is regular enough (essentially in a Gevrey class of appropriate degree) and that the deviation of the initial data from this steady state is small enough in a certain norm, the evolution of the system is such that its spatial density approaches a uniform constant value sub-exponentially fast (i.e. $\exp(-C|t|^{\overline{\nu}})$ for $\overline{\nu} \in (0,1)$). We take as *a priori* assumptions that solutions launched by such initial data exist for all times and that the various norms in question are continuous in time. We must also assume a kind of "reverse Poincaré inequality" on the Fourier transform of the solution. In spirit, this assumption amounts to the requirement that there exists $0 < \varkappa < 1$ so that the mass in the annulus $\varkappa \leq |v| < 1$ is uniformly small for all t. Typical velocity bounds for solutions to rVP launched by small initial data (at least on $\mathbb{R}^6$) imply this bound. (Received September 05, 2014)

1105-35-86 **Junping Shi*** (jxshix@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187. *Elliptic Systems of Schrödinger type with quadratic nonlinearities.*

It is known that Second Harmonic Generation (SHG) can occur when the optical material has a $\chi(2)$ (i.e. quadratic) nonlinear response instead of conventional Kerr $\chi(3)$ material. Here we consider the soliton solutions of nonlinear SHG Schrödinger system in a higher dimensional space. We prove the existence of a positive ground state solution for all parameter range, and we also study the continuity of the ground states and the asymptotic behavior of the ground state when the parameter approaches zero or infinity. The uniqueness of positive solution is also proved in some cases. We also consider the multiplicity of the solutions and the case of system on a bounded domain. This is a joint work with Leiga Zhao (Beijing University of Chemical Technology) and Fukun Zhao (Yunnan Normal University). (Received September 07, 2014)

1105-35-96 **Vasilii Kurta*** (vvk@ams.org). *A Liouville comparison principle for solutions of quasilinear singular parabolic inequalities.* Preliminary report.

We obtain a Liouville comparison principle for entire weak solutions (u,v) of quasilinear singular parabolic second-order partial differential inequalities of the form $u_t - A(u) - |u|^{q-1}u \geq v_t - A(v) - |v|^{q-1}v$ in the half-space $\mathbb{S} = \mathbb{R}_+ \times \mathbb{R}^n$, where $n \geq 1$, $q > 0$ and the differential operator A satisfies the α-monotonicity condition. Model examples of the operator A are the well-known p-Laplacian operator, defined by the relation $\Delta_p(w) := \operatorname{div}_x\left(|\nabla_x w|^{p-2}\nabla_x w\right)$, and its well-known modification, defined by $\widetilde{\Delta}_p(w) := \sum_{i=1}^n \frac{\partial}{\partial x_i}\left(\left|\frac{\partial w}{\partial x_i}\right|^{p-2}\frac{\partial w}{\partial x_i}\right)$. (Received September 09, 2014)

1105-35-104 **Jiahong Wu*** (jiahong.wu@okstate.edu), Department of Mathematics, 401 Mathematical Sciences, Oklahoma State University, Stillwater, OK 74078. *The 2D MHD equations with partial dissipation.*

This talk presents recent work on the global regularity problem concerning the two-dimensional (2D) magnetohydrodynamic (MHD) equations with only partial or fractional dissipation. Due to the nonlinear coupling between the evolution equations of the velocity and the magnetic field in the MHD system, the global regularity problem can be extremely difficult when only partial dissipation is present. We will report recent efforts on several partial or fractional dissipation cases and will cover both incompressible and compressible flows. (Received September 11, 2014)

1105-35-117 **Jun Wang*** (wangj1816@gmail.com), 1362 S mount vernon Ave apt B, williamsburg, VA 23185, and **Junping Shi** (jxshix@wm.edu), williamsburg, VA 23185. *Standing waves of a weakly coupled Schrödinger system with distinct potential functions.*

In this talk we study the following semilinear elliptic equations of the form

$$\begin{cases} -\varepsilon^2\Delta u + P(x)u = \mu u^3 + \beta v^2 u & \text{in } \mathbb{R}^N, \\ -\varepsilon^2\Delta v + Q(x)v = \nu v^3 + \beta u^2 v & \text{in } \mathbb{R}^N, \\ u, v > 0, \quad u, v \in H^1(\mathbb{R}^N), \end{cases}$$

where $N \leq 3$, $\mu, \nu > 0$, ε is a small positive parameter, $P(x)$ and $Q(x)$ are positive potentials. This type of system arises, in particular, in models in Bose-Einstein condensates theory. We consider the case that $\beta > 0$ is sufficiently large. First, we prove the existence and multiplicity of positive solutions of this system. Second, we describe the concentration phenomena for these positive solutions. Finally, we obtain some sufficient conditions for the nonexistence of positive ground state solutions. This seems to be the first results on the multiplicity and concentration of positive solutions of this coupled system for $\beta > 0$ sufficiently large. (Received September 12, 2014)

1105-35-121 **Mayukh Mukherjee*** (mayukh@live.unc.edu). *Extremal values of the (fractional) Weinstein functional on Riemannian manifolds.*

We make a study of Weinstein functionals (first defined by Michael Weinstein) on compact Riemannian manifolds with boundary with Dirichlet boundary conditions, and also on the hyperbolic space $\mathbb{H}^n$. As is known, the Weinstein functional maximiser gives standing wave solutions to nonlinear Schrödinger and Klein-Gordon equations. The aim of the talk is to establish that the maximum value of the Weinstein functional on $\mathbb{H}^n$ is the same as that on $\mathbb{R}^n$ and the related fact that the maximum value of the Weinstein functional is not attained on $\mathbb{H}^n$, when maximisation is done in the Sobolev space $H^1(\mathbb{H}^n)$, proving a conjecture made by Christianson-Marzuola-Metcalfe-Taylor and also answers questions raised in several other papers (one by Banica, for example). If time permits, we shall try to prove that a corresponding version of the conjecture will hold for the Weinstein functional with the fractional Laplacian as well. (Received September 12, 2014)

1105-35-129 **Ahmad El Soufi**, UMR CNRS 7350, Universite F. Rabelais, Parc de Grandmont, 37200 Tours, France, and **Evans M Harrell*** (harrell@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160. *Placing an obstacle to optimize the heat trace.*

We consider the Dirichlet problem for the Laplacian on Euclidean domains, from which a spherical obstacle is removed, and attempt to place the obstacle so as to maximize or minimize Z(t), the trace of the heat kernel.

For suitable domains we characterize the optimal placement of the obstacle inside a domain. We find that for each t the maximizing position of the center of the obstacle belongs to the "heart" of the domain, while the minimizing situation occurs either in the interior of the heart at a point where the obstacle is in contact with the outer boundary.

Similar statements hold for the spectral zeta function and the regularized determinant. (Received September 14, 2014)

1105-35-131 **David G Costa*** (costa@unlv.nevada.edu), 4505 Maryland Parkway, Department of Mathematical Sciences/UNLV, Box 454020, Las Vegas, NV 89154-4020. *On a Class of Biharmonic Equations with Critical Growth and Singular Potential.*

We consider a class of nonlinear perturbations $f(u)$ of the biharmonic operator $\Delta^2 + V(x)$ with a singular potential $V(x)$. After proving a compactness result for a critical Sobolev embedding, we show existence of a nonzero solution when $f(u)$ has critical growth. This is joint work with Guoqing Zhang. (Received September 14, 2014)

1105-35-141 **Mauricio Alexander Rivas*** (rivasma@wfu.edu). *Unconstrained Variational Principles for Linear Elliptic Eigenproblems.*

We analyze the set of critical points of a parametrized functional that arises in the study of linear elliptic eigenvalue problems. These critical points are shown to be certain eigenfunctions, and corresponding critical values of the functional are shown to be related to the associated eigenvalues. The functional is twice differentiable, and a Morse index theory is defined and used to characterize which eigenvalue is associated to the critical point. The results are exemplified for unconstrained variational principles for eigenproblems for the Laplacian subject to various boundary conditions. This is joint work with Professor Giles Auchmuty. (Received September 15, 2014)

1105-35-162 **Jerome Goddard II*** (jgoddard@aum.edu) and **R. Shivaji** (shivaji@uncg.edu). *Existence, stability, and bifurcation results for positive solutions for classes of semilinear elliptic boundary value problems with nonlinear boundary conditions.*

In this talk, we will investigate the stability properties of nontrivial positive steady state solutions of semilinear initial-boundary value problems with nonlinear boundary conditions. In particular, we will employ a Principle of Linearized Stability for this class of problems to prove sufficient conditions for stability and instability of positive steady state solutions. These results shed some light on the combined effects of the reaction term and the boundary nonlinearity on stability properties. If time permits, we will also discuss existence results and provide complete bifurcation curves in the case of dimension one. (Received September 17, 2014)

1105-35-164 **Azmy S. Ackleh**, **Baoling Ma** and **Tingting Tang*** (txt2339@louisiana.edu). *Well-posedness and finite difference approximations for a general coupled system of SI structured population model.*

In this talk, we present a new and general class of SI (SIR, SEIR) structured population models with a wide range of applications. The model consists of a system of quasilinear hyperbolic partial differential equations coupled with a system of nonlinear ordinary differential equations. We develop a second order high resolution finite difference scheme to approximate the solution of the model. Convergence of the numerical approximations to a weak solution with total bounded variation has been proved. Applications of the model are presented to demonstrate the generality. (Received September 17, 2014)

1105-35-167 **Byungjae Son*** (b_son@uncg.edu), 1723 Walker Avenue, Apt 307, Greensboro, NC 27403, and **Ratnasingham Shivaji**. *Bifurcation and Multiplicity results for classes of p Laplacian equations.* Preliminary report.

We study positive solutions to boundary value problems of the form:

$$\begin{cases} -\Delta_p u = \lambda\{u^{p-1-\alpha} + f(u)\} \text{ in } \Omega, \\ u = 0 \text{ on } \partial\Omega, \end{cases}$$

where $\Delta_p u := \text{div}(|\nabla u|^{p-2}\nabla u)$; $p > 1$ is the p-Laplacian operator of u, $\lambda > 0$, $\alpha \in (0, p-1)$ and Ω is a bounded domain in $\mathbb{R}^N; N \geq 1$ with smooth boundary $\partial\Omega$. Here $f : [0, \infty) \to \mathbb{R}$ is a nondecreasing C^1 function with $f(0) = 0$. We first establish that for $\lambda \approx 0$ there exist positive solutions bifurcating from the trivial branch $(\lambda, u \equiv 0)$ at $(0, 0)$. We further discuss an existence result for all $\lambda > 0$ and a multiplicity result for a certain range of λ under additional assumptions of f. We employ the method of sub-super solutions to establish our results. (Received September 17, 2014)

1105-35-172 **Matthew Rudd*** (mbrudd@sewanee.edu). *Perron's method for p-harmonious functions.*

I will discuss joint work with David Hartenstine (Western Washington University) on p-harmonious functions; these continuous functions satisfy certain statistical functional equations and approximate p-harmonic functions. I will review some earlier existence results on strictly convex domains and then show how to apply Perron's method to obtain solutions on more general domains. (Received September 18, 2014)

1105-35-178 **Padhi Seshadev** and **Jaffar Ali Shahul-Hameed*** (jahameed@fgcu.edu). *On the Multiplicity of Positive Solutions of Elliptic Equations in an Annulus.* Preliminary report.

In this talk, we will discuss the multiplicity of positive solutions of the equation

$$-\Delta u = \lambda g(|x|) f(u), \ R_1 < |x| < R_2$$

$x \in R^n, N \geq 1$ subject to a linear mixed boundary condition at R_1 and R_2.

We use Leggert-Williams multiple fixed point theorems to obtain our result. (Received September 18, 2014)

1105-35-182 **Yulian An*** (an_yulian@hotmail.com) and **Junping Shi** (shij@math.wm.edu). *Exact Multiplicity of Positive Solutions for a p-Laplacian Equation with Positive Convex Nonlinearity.* Preliminary report.

A p-Laplacian nonlinear elliptic equation with positive and p-superlinear nonlinearity and Dirichlet boundary condition is considered. We first prove the existence of two positive solutions when the spatial domain is symmetric or strictly convex by using a priori estimates and topological degree theory. For the ball domain in $\mathbb{R}^N$ with $N \geq 4$ and the case that $1 < p < 2$, we prove that the equation has exactly two positive solutions when a parameter is less than a critical value. Bifurcation theory and linearization techniques are used in the proof of the second result. (Received September 19, 2014)

1105-35-217 **Stephen C. Preston** and **Alejandro Sarria*** (alejandro.sarria@colorado.edu). *Remarks on a local-in-space formulation of axisymmetric ideal fluids.* Preliminary report.

We consider the 3d incompressible axisymmetric Euler equations at the point $(r, z) = (1, 0)$, which in this case represents the intersection between the solid boundary of a cylinder with $z-$axis as axis of symmetry and its base. A system of odes (in the time variable) involving Lagrangian trajectories and pressure-Hessian related terms is studied, and preliminary results on the pressure are discussed. (Received September 21, 2014)

1105-35-220 **Santosh Bhattarai*** (bhattarais@trocaire.edu), Trocaire College, 360 Choate Ave, Buffalo, NY 14220. *Existence and stability of solitary waves for a coupled system of nonlinear Schrodinger type equations.*

We prove existence and stability results of solitary-wave solutions to coupled 1-dimensional nonlinear Schrödinger equations with power-type nonlinearities arising in several models of modern physics. The existence of solitary waves is obtained by solving a variational problem subject to two independent constraints. The set of minimizers is shown to be stable and further information about the structures of this set are given. This work extends the results previously obtained by R. Cipolatti and W. Zumpichiatti ; N. V.Nguyen and Z-Q.Wang ; and M. Ohta. (Received September 21, 2014)

1105-35-233 **Wei Feng*** (fengw@uncw.edu) and **Xin Lu** (lux@uncw.edu). *On Reaction-Diffusion Models of Resource Competition and Mating Interference.*

We study reaction-diffusion models for closed related biological species (u and v) under resource competition and mating interference from v-species to u-species. In the case of bounded habitat, conditions for coexistence or competitive exclusion are obtained. In the case of unbounded habitat, the effect of one-sided sexual competition makes the trivial state and u-dominance state both unstable, the v-dominance state asymptotically stable with attraction regions and convergent rates depending on the biological parameters. We further prove that for a family of wave speeds, there exist traveling wave solutions connecting the u-dominance state and the v-dominance state at infinities. This confirms an earlier conjecture that unbalanced mating interference will lead to competitive exclusion. These results can also be obtained on an extended model with instantaneous effects of resource competition and temporal delay on mating interference. Through a transformation into three-equation system, we prove that the temporal delay does not affect the stability of the steady states and the existence of the traveling waves, but causes changes on the attraction regions and convergence rates. Finally, numerical simulations are also presented to illustrate the theoretical results. (Received September 21, 2014)

1105-35-300 **Nsoki Mavinga*** (nmaving1@swarthmore.edu) and **M. Nkashama**. *Bifurcation and multiplicity for elliptic equations with nonlinear boundary conditions.*

We present multiplicity results for solutions of second order elliptic partial differential equations with nonlinear boundary conditions. We establish a priori estimates and use topological degree and bifurcation from infinity arguments. (Received September 22, 2014)

1105-35-316 **Michael A Freeze, II*** (freezem@uncw.edu), Dept. of Mathematics and Statistics, 601 South College Road, Wilmington, NC 28403, and **Yaw Chang**, **Wei Feng** and **Xin Lu**. *On Ratio-Dependent Food Chain Model, Part II: Reaction-Diffusion System.*

We study the dynamical structure of an extension of a simple food chain model to a reaction-diffusion system that includes a super-predator consuming both prey and predator. Straightforward criteria for the existence of a positive global attractor and the presence of a positive steady-state solution as well as conditions for uniqueness and stability of the coexistence state are provided. Numerical simulations demonstrate the feasibility of the identified conditions. (Received September 23, 2014)

1105-35-336 **John M Neuberger*** (john.neuberger@nau.edu), Dept of Math and Stat, Box 5717, NAU, Flagstaff, AZ 86011, and **James W Swift** and **Nandor Sieben**. *Invariant Subspaces and Linear Systems for Newton's Method applied to Semilinear Elliptic PDE: The Sierpinski Gasket.* Preliminary report.

We are interested in semilinear elliptic boundary value problems of the form $\Delta u + f(u) = 0$ on the Sierpinski Gasket S. Our approach is to discretize the Laplacian on finite graphs with 3^ℓ vertices, i.e., the pre-gaskets S_ℓ, for various levels ℓ. The well-known phenomenon of high multiplicities for even low eigenvalues causes the standard implementation of the GNGA (Gadient Newton Galerkin Algorithm, Neuberger-Swift [2001]) to have difficulties. By extending the consideration of symmetry to include some kinds of so-called local symmetries, we are able to reduce the dimensions of the Hessian-gradient linear systems for many Newton search directions. In this way we can efficiently and effectively study several of the first few bifurcation branches arising from the case given by $f(u) = f_s(u) = su + u^3$. (Received September 23, 2014)

1105-35-341 **Lucas Castle*** (lcastle@ncsu.edu). *Optimal Control in a Free Boundary Fluid-Elasticity Interaction.*

We establish existence of an optimal control for the problem of minimizing flow turbulence in the case of a nonlinear fluid-structure interaction model in the framework of the known local well-posedness theory. If the initial configuration is regular, in an appropriate sense, then a class of sufficiently smooth control inputs contains an element that minimizes, within the control class, the vorticity of the fluid flow around a moving and deforming elastic solid. This is a joint work with L. Bociu, K. Martin (NC State University), and D. Toundykov (University of Nebraska-Lincoln). (Received September 23, 2014)

1105-35-343 **Kristina Martin*** (kmmarti6@ncsu.edu), North Carolina State University, Dept. of Mathematics, Stinson Dr., Box 8205, Raleigh, NC 27606, and **Lorena Bociu**, **Lucas Castle** and **Daniel Toundykov**. *Optimal Control in a Free Boundary Fluid-Elasticity Interaction.*

We consider an optimal control problem involving a free boundary fluid-elasticity interaction described by Navier Stokes coupled with the equations of nonlinear elastodynamics. We prove that turbulence in the fluid flow can be controlled by a body force on the fluid, and derive the first order optimality conditions on the optimal control. This is a joint work with Lorena Bociu, Lucas Castle (North Carolina State University), and Daniel Toundykov (University of Nebraska, Lincoln). (Received September 23, 2014)

1105-35-353 **M. N. Nkashama*** (nkashama@math.uab.edu), Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294-1170, and **N. Mavinga** (mavinga@swarthmore.edu), Department of Mathematics and Statistics, Swarthmore College, Swarthmore, PA 19081. *Eigenvalue-curves and nonlinear elliptic equations.* Preliminary report.

We show the existence of some eigenvalue-curves connecting the Steklov spectrum to the Neumann-Robin spectrum for linear second order elliptic equations. We then consider nonlinear problems. (Received September 23, 2014)

37 ► Dynamical systems and ergodic theory

1105-37-69 **Aminur Rahman*** (ar276@njit.edu), 323 Martin Luther KIng Jr.Blvd, Department of Mathematical Sciences, Culimore Hall, Newark, NJ 07102. *Further Analysis of Discrete Dynamical Models of the RS Flip-Flop Circuit.*

Logical R-S flip-flop circuits are investigated once again in the context of discrete planar dynamical systems, but this time starting with simple bilinear (minimal) component models based on fundamental principles. The dynamics of the minimal model is described in detail, and shown to exhibit some of the expected properties, but not the chaotic regimes typically found in simulations of physical realizations of R-S flip-flop circuits. Any physical realization of an ideal logical circuit must necessarily involve small perturbations and possibly some symmetry-breaking of any exact mathematical model. Therefore, perturbed forms of the minimal model are also analyzed in considerable detail. It is proved that perturbed minimal models can exhibit chaotic regimes as well as some of the bifurcation features present in several more elaborate and less fundamentally grounded dynamical models that have been investigated in the recent literature. Validation of the complexity of the dynamics discovered for the perturbed models is also provided by numerical simulation and computation of such dynamical indicators as Lyapunov exponents. (Received September 03, 2014)

1105-37-108 **Lorenzo A Sadun*** (sadun@math.utexas.edu). *Tiling spaces and cohomology.*
The cohomology of a tiling space X gives a tremendous amount of information about X, and about maps from X to other tiling spaces. I will go over the definition of tiling cohomology, in particular Pattern-Equivariant Cohomology. I'll then show how H^1 parametrizes deformations, and how a subgroup of H^1 parametrizes topological conjugacies. One can further associate a distinguished class in $H^1(X, R^d)$ to any homeomorphism between a tiling space X and another tiling space Y. If time permits, I will also present some recent results about the rigidity of cut-and-project tiling spaces, and show how tiling cohomology can be used to solve problems in Diophantine analysis. (Received September 11, 2014)

1105-37-221 **Jean Savinien*** (jean.savinien@univ-lorraine.fr), Institut Elie Cartan de Lorraine, bat A, Ile du Saulcy, F-57046 Metz, France. *Aperiodic Tilings and Noncommutative Geometry.*
I will survey some results obtained so far for aperiodic tilings using the tools of noncommutative geometry. Some works of J. Pearson, J. Bellissard, A. Julien, J. Kellendonk, D. Lenz, and the speaker will be reviewed. (Received September 21, 2014)

39 ► Difference and functional equations

1105-39-50 **Paul Eloe*** (peloe1@udayton.edu), **Ferhan Atici** and **Zi Ouyang**. *Multi-term Linear Fractional Nabla Difference Equations with Constant Coefficients.*
We shall consider a linear fractional nabla (backward) difference equation with constant coefficients. We apply a transform method to construct formal solutions. Sufficient conditions in terms of the coefficients are given so that the formal solutions are convergent and thus, solutions. Of interest, we consider fractional equations with three or more terms. As a corollary, we exhibit new summation representations of a discrete exponential function, a^t, $t = 0, 1, \ldots$. (Received August 26, 2014)

1105-39-51 **Jayant Singh*** (jayant.singh@ndsu.edu), 1125 17th Ave N Apt. 203, Fargo, ND 58102, and **Nikita Barabanov**. *Stability Analysis of Discrete time Recurrent Neural Networks.*
Recurrent Neural Networks (RNN) have shown promise in diverse applications including Pattern Recognition, and Modeling of systems. We consider the problem of stability of RNN. One of the famous approaches is based on Theory of Absolute stability. But there exist stable systems, for which theory of Absolute stability does not hold true. We have proposed a new stability criteria, based on Reduction of Dissipativity Domain. Some new results in this area will be presented. (Received August 26, 2014)

1105-39-66 **Gro Hovhannisyan*** (ghovhann@kent.edu), 6000 Frank Ave, NW, North Canton, OH 44720. *Integration of nonlinear equations on a time scale by inverse scattering method.* Preliminary report.
By using Ablowitz-Ladik hierarchy we derive time-space scale versions of nonlinear Schrodinger, Toda lattice and some other dynamic equations. Extending the inverse scattering method we describe the solutions of these nonlinear dynamic equations on a time-space scale. (Received September 03, 2014)

1105-39-134 **Nika Lazaryan*** (lazaryans@vcu.edu), Richmond, VA , and **Hassan Sedaghat** (hsedagha@vcu.edu). *The Dynamics of a Rational Planar System.*
We study a rational planar system consisting of one linear-affine and one linear-fractional difference equation by folding it into a second-order rational semilinear equation. We investigate the global stability profile and the boundedness of solutions for positive folding parameters and nonnegative initial conditions. We provide some results on periodic nature of solutions and pose some open problems and conjectures. (Received September 15, 2014)

41 ► Approximations and expansions

1105-41-88 **Jeffrey P. Ledford*** (jpledford@vcu.edu), 1015 Floyd Avenue, P.O. Box 842014, Richmond, VA 23284. *Bivariate Interpolation with the Poisson Kernel.* Preliminary report.
In this talk we introduce the bivariate Poisson interpolation operator and prove various properties of this operator. The main result concerns functions whose Fourier transforms are concentrated near the origin, specifically functions belonging to the Paley-Wiener space PW_{B_β}. We show that one may recover these functions from their samples on a complete interpolating sequence for $[-\delta, \delta]^2$ by using the Poisson interpolation operator, provided that $0 < \beta < (3 - \sqrt{8})\delta$. (Received September 08, 2014)

45 ► Integral equations

1105-45-254 **Jon Jacobsen*** (jacobsen@g.hmc.edu), **Mark Lewis** and **Yu Jin**. *Integrodifference Models for Persistence in Temporally Varying River Environments.*

We consider integrodifference population models for growth and dispersal in the presence of advective flow and study population persistence in the context of both periodic and random kernel parameters. For the random setting we consider two persistence metrics and show they are mathematically equivalent. (Received September 22, 2014)

46 ► Functional analysis

1105-46-294 **Zachary J. Abernathy*** (abernathyz@winthrop.edu). *A Nonlinear Sturm-Liouville Problem on Time Scales.* Preliminary report.

Recently, F.A. Davidson and B.P. Rynne have developed an approach to studying linear Sturm-Liouville problems on an arbitrary time scale using the functional analytic theory of Hilbert spaces. This unifies and generalizes the standard Sturm-Liouville theory for ordinary differential equations and difference equations, and the Hilbert space setting allows for analogues of typical constructions such as eigenfunction expansions. In this talk, we will survey this existing theory and apply it to the search for sufficient conditions for the existence of solutions to a related nonlinear Sturm-Liouville problem. (Received September 22, 2014)

1105-46-327 **Teffera M. Asfaw*** (teffera6@vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Variational inequalities for perturbed noncoercive operators of monotone type in reflexive Banach spaces.* Preliminary report.

Let X be a real reflexive locally uniformly convex Banach space with locally uniformly convex dual X^*. Let K be a nonempty, closed and convex subset of X and $f^* \in X^*$. Let $\phi : X \supseteq D(\phi) \to (-\infty, \infty]$ be a proper, convex and lower semicontinuous function. New existence results are given for solvability of variational inequality problems of the type VIP(T + A + S.K, ϕ, f*) where the operator $T + A + S$ is possibly noncoercive, $T : X \supseteq D(T) \to 2^{X^*}$ is maximal monotone, $A : X \supseteq D(A) \to 2^{X^*}$ is densely defined maximal monotone and $S : X \supseteq D(S) \to 2^{X^*}$ is bounded pseudomonotone. The existence results developed herein are applied to study existence of generalized solution(s) in $X = L^p(0, T; W_0^{1,p}(\Omega))$ (with suitable $p > 1$) of a certain nonlinear parabolic boundary problem. (Received September 23, 2014)

49 ► Calculus of variations and optimal control; optimization

1105-49-148 **Oleksandr Misiats***, 150 N University str, West Lafayette, IN 47907. *Ginzburg-Landau Model of Superconductivity with Prescribed Topological Degrees on the Boundary.*

Superconductivity is a complete loss of resistivity that occurs in most metals below a certain, extremely low critical temperature. The key feature of this physical phenomenon is the vortices, or the points where the external magnetic field penetrates the bulk of a superconductor, thus destroying superconductivity. We model the superconducting vortices using the Ginzburg-Landau functional with a specific (semi-stiff, or degree) boundary condition that creates the same "quantized" vortices as the external magnetic field. In my talk, I will discuss the issue of well-posedness of such modelling, which reduces to the question of the existence of minimizers for a Ginzburg-Landau functional in certain functional classes with semi-stiff boundary conditions. I will also describe the vortex structure of the Ginzburg-Landau minimizers, which may be useful in predicting the locations of the vortices depending on the geometry of a superconductor. (Received September 16, 2014)

51 ► Geometry

1105-51-13 **Xianfeng David Gu*** (gu@cs.stonybrook.edu), 2425 CSE Building, Computer Science Department, Stony Brook University, Stony Brook, NY 11794-4400, and **Feng Luo** (fluo@math.rutgers.edu), Department of Mathematics, Rutgers University, Hill Center-Busch Campus, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Computational Conformal Geometric Methods.*

This survey focuses on different methods in computational conformal geometry. Conformal geometry aims at computing conformal mappings, conformal modules, uniformization, conformal metrics by prescribed curvatures, holomorphic differentials, quasi-conformal mappings, Teichmuller maps and so on. Different computational methods on surfaces will be covered, including harmonic mapping, holomorphic differential, circle packing and discrete Ricci flow, and so on. Theories, computational algorithms and real applications will be briefly introduced. (Received May 23, 2014)

1105-51-113 **Feng Luo*** (fluo@math.rutgers.edu), **D. Gu**, **J. Sun** and **T. Wu**. *Discrete uniformization theorem for polyhedral surfaces.*

We introduce a notion of discrete conformality for polyhedral surfaces and prove a discrete version of the uniformization theorem. The result can be considered as a counter-part of Koebe-Andreev-Thurston's circle packing theorem in the polyhedral setting. We will discuss the role of Ptolemy identity in discrete conformality and some of the related open problems including a discrete Riemann mapping conjecture. This is a joint work with David Gu, Jian Sun and Tianqi Wu. (Received September 12, 2014)

1105-51-151 **Ludmil Katzarkov**, **Gabriel Kerr*** (gdkerr@math.ksu.edu) and **Maxim Kontsevich**. *Mirrror symmetry for quasi-affine toric varieties.*

Mirror symmetry for proper and affine toric varieties has been studied from several different perspectives. Using constructible sheaves on a mirror skeleton yields one such approach and generalizes to the case of quasi-affine varieties. However, the existence of a partially wrapped Fukaya category mirror has only recently been explored. In this talk, I will describe such a category and outline a proof that it is equivalent to the derived category of equivariant coherent sheaves on the quasi-affine toric. This equivalence factors through GIT quotients and yields a new proof of mirror symmetry for toric stacks. I will conclude with speculations on the relation between this version, the Fukaya-Seidel approach and stability conditions. (Received September 16, 2014)

1105-51-154 **Ailsa M Keating*** (keating@math.columbia.edu). *Mirror symmetry for singularities of type $T_{p,q,r}$.* Preliminary report.

We present some versions of mirror symmetry for the unimodal singularities of type $T_{p,q,r}$. We will consider some symplectic invariants of the real four-dimensional Milnor fibres of these singularities, and explain how they correspond to coherent sheaves on certain blow-ups of the projective space $\mathbb{P}^2$. Time allowing, we hope to emphasize how the relations between different "flavours" of invariants (e.g., versions of the Fukaya category) match up on both sides. (Received September 16, 2014)

1105-51-158 **Heather M Lee*** (mxli@math.berkeley.edu), Department of Mathematics, 970 Evans Hall, University of California, Berkeley, BERKELEY, CA 94720. *Wrapped Fukaya category of punctured Riemann surfaces via pairs of pants decompositions.* Preliminary report.

Let H be a punctured Riemann surface that is a hypersurface in $(\mathbb{C}^*)^2$. We computed the wrapped Fukaya category $\mathcal{W}(H)$ by first decomposing H into pairs of pants, and then reconstructing its wrapped Floer complexes from those for various pairs of pants. They are glued together in the sense that the restrictions of the wrapped Floer complexes from two adjacent pairs of pants to the cylindrical piece that adjoins them agree. The A_∞-structures of $\mathcal{W}(H)$ are given by those in the pairs of pants. As a work in progress, we hope to demonstrate homological mirror symmetry by showing the category of singularities of the mirror Landau-Ginzburg model can also be constructed in the same way from local affine pieces that are mirrors of the pairs of pants. (Received September 16, 2014)

1105-51-255 **John C Bowers*** (jbowers@cs.umass.edu) and **Ileana Streinu**. *Lang's Universal Molecule Algorithm.*

Robert Lang's Universal Molecule algorithm, a landmark in modern computational origami, is the main component of his widely used TreeMaker program for origami design. It computes a crease pattern of a convex polygonal region, starting with a compatible metric tree. Although it has been informally described in several publications, neither the full power nor the inherent limitations of the method are well understood. In this talk we introduce a rigorous mathematical formalism to relate the input metric tree, the output crease pattern and

the folded uniaxial origami base produced by the Universal Molecule algorithm. We characterize the family of tree-like 3D shapes that are foldable from the computed crease patterns and give a correctness proof of the algorithm. This is joint work with Ileana Streinu. (Received September 23, 2014)

1105-51-257 **Kimberly E Stubbs*** (kstubbs@unca.edu), 196 Curtis Creek Rd, Candler, NC 28715.
Geometric Representations of Dedekind's Proof of Irrationality.

In *Essays on the Theory of Numbers*, Richard Dedekind gives a general algebraic proof that if N is a positive integer that is not the square of an integer, then $\sqrt{N}$ is irrational. In the 1960's, Stanley Tennenbaum gives the geometric representation of Dedekind's proof for which $N = 2$. In this talk we'll look at the geometric representations of Dedekind's proof for which $N = 3, 6, 8\&12$ and their constructions which are similar to the construction for the $N = 2$ case. (Received September 22, 2014)

1105-51-261 **Md Ashraful Alam*** (ashraful@cs.umass.edu) and **Ileana Streinu** (istreinu@smith.edu). *Star unfolding polygons.*

In this talk we introduce a new type of unfolding of convex polyhedra known as geodesic star unfoldings. They are a generalization of shortest-path star unfoldings of 3D convex polyhedra and have a very simple characterization. We also address several problems concerning the existence of shortest-path star unfoldings on specifi ed source point sets, and of reconstructing shortest-path star unfoldings with given ridge tree combinatorics. (Received September 23, 2014)

1105-51-266 **Saar David Hersonsky*** (saarh@math.uga.edu). *Approximating conformal maps.* Preliminary report.

The Riemann Mapping Theorem asserts that any simply connected planar domain which is not the whole of it, can be mapped homeomorphically by a conformal mapping onto the open unit disk, that is, the domains are *conformally equivalent*. Rodin and Sullivan were the first ti prove Thurston's celebrated conjecture that a scheme based on the Koebe-Andreev-Thurston Circle Packing Theorem converges to the Riemann mapping.

More recently, Chow and Luo found profound applications of circle mappings to the study of Ricci flows on surfaces. There are also related important applications of circle packings to due to David, Luo and Yau, David, Zeng, Luo and Yau, and Sass, Stephenson and Brock.

We will describe our inroads towards a resolution of Stephenson's question from the 90's, which concerns the possibility of approximating the Riemann Mapping by a sequence of finite networks. (Received September 22, 2014)

1105-51-270 **Jonathan Matthew Clark*** (jonathanmclark@charter.net), 2305 Georgetown Road Apt. #13, Cleveland, TN 37311. *An Application of A Generalized Parametrization of Conic Sections.*

Using linear algebraic techniques applied to parametric equations, we generate parametrizations for conic sections which explicitly allow us to connect the two-dimensional and three-dimensional definitions of conics. We analyze one of these parametrizations in order to show the validity of this technique and show its implicitization. We then use this to generate a focus-tracing curve which predicts the location of each focus on a conic whenever one is generated by planar intersections of cones. (Received September 22, 2014)

1105-51-307 **Stephen J Kleene*** (skleene@gmail.com), 8 Blackstone blvd #1, Providence, RI 02906, and **Niels Martin Møller**. *Non-compactness of moduli spaces of finite topology embedded minimal surfaces.*

In joint work with Niels Martin Møller, we show that the space $M(k, g)$ of embedded minimal surfaces with k ends and genus g is non-empty when $k = 4$ by explicitly constructing a family of degenerating surfaces. Time permitting, we discuss analogous constructions for general k. (Received September 23, 2014)

1105-51-333 **Dane P. Mayhook*** (dmayhook@math.fsu.edu), Department of Mathematics, 1017 Academic Way, Tallahassee, FL 32306. *Conformal Tilings & Type.* Preliminary report.

This talk will introduce the type problem in the context of conformal tilings. The combinatorics underlying a conformal tiling are often given by an expansion complex associated with a finite subdivision rule. Bowers & Stephenson have shown that if a subdivision rule τ with one face type is dihedrally symmetric (plus other mild conditions), then the conformal tiling for any expansion complex associated to τ is of parabolic type–that is, it tiles the plane $\mathbb{C}$. I will discuss some of the machinery behind this result, and a generalization to the case where τ is merely rotationally symmetric. (Received September 23, 2014)

52 ► Convex and discrete geometry

1105-52-130 **Michael J. Mossinghoff*** (mimossinghoff@davidson.edu), Department of Mathematics & Computer Science, Davidson College, Davidson, NC 28035-6996. *Connections with discrete geometry: Reinhardt polygons.*

A *Reinhardt polygon* is a convex n-gon that is optimal in a number of geometric problems, for example, it has maximal perimeter relative to its diameter. Many Reinhardt polygons exhibit a particular periodic structure, and these are well understood. However, for certain values of n, such as $n = 30$ and $n = 42$, some *sporadic* Reinhardt polygons also occur. We characterize the integers n for which sporadic Reinhardt n-gons exist, and determine a bound on their number, using arithmetic information. It is interesting that for small n, the periodic Reinhardt n-gons far outnumber the sporadic ones. We use methods in number theory to address the question of whether this continues to hold for large integers. This is joint work with Kevin Hare. (Received September 14, 2014)

1105-52-160 **Edward T Crane*** (edward.crane@bristol.ac.uk). *The Koebe-Andreev-Thurston theorem: proofs, generalizations and computation.* Preliminary report.

I will survey many known proofs of the Koebe-Andreev-Thurston theorem. In its simplest form this states that for any triangulation T of the 2-sphere, there exists a collection of closed discs in the Riemann sphere with disjoint interiors, one for each vertex of T, such that for every edge of T the corresponding discs are tangent. Moreover, the resulting circle packing is unique up to Möbius transformations and reflections.

I will explain how the different proofs allow some wonderful generalizations of the Koebe-Andreev-Thurston theorem. I will also discuss numerical techniques that are available for computing circle packings in the sphere. Some of these techniques are proven to converge while others are heuristic, but fast.

I will conclude with a brief exposition of joint work with James Ashe and Ken Stephenson on the existence and uniqueness of branched circle packings with continuously parameterized critical points. This is a step in a program to understand circle packing analogs of rational maps. I will illustrate with a discrete version of the classical Ahlfors function, which is a proper branched coverings of degree two from the unit disc to an annulus. (Received September 17, 2014)

1105-52-226 **William E Wood*** (bill.wood@uni.edu), Department of Mathematics, University of Northern Iowa, Cedar Falls, IA 50614. *Cube Tilings and Discrete Extremal Length in Dimension $n > 2$.*

Extremal length is a conformal invariant that transfers naturally to the discrete setting, giving square tilings as a natural combinatorial analog of two-dimensional conformal mappings. We explore recent work generalizing these ideas to n-dimensional cube tilings, including a look at what happens as we move from the plane, some conditions for tilability, and computational questions. (Received September 21, 2014)

1105-52-301 **Ileana Streinu*** (istreinu@smith.edu), Computer Science Department, Smith College, Northampton, MA 01063. *Maxwell's Problem, 150 years later: from bridges to nano-mechanics.*

Finding a combinatorial characterization for (minimally) rigid bar-and-joint frameworks in dimensions higher than 3 is an elusive, long standing open problem in rigidity theory, originating in the work of James Clerk Maxwell from the 19th century. In this survey I will summarize our current state of knowledge on Maxwell's problem, and present a range of applications, from building bridges to analyzing the stability of macro-molecules such as proteins or crystalline matter. (Received September 23, 2014)

1105-52-319 **Chaim Goodman-Strauss*** (strauss@uark.edu), Department of Mathematical Sciences, SCEN 309, University of Arkansas, Fayetteville, AR 72701. *On Matching Rules.*

For fifty years it has been known that it is undecidable whether a given set of tiles admits a tiling of the plane — that is, that there is and can be no general understanding of the consequences of choosing one set of local conditions on a set of tiles versus another. (This undecidability most famously implies the existence of "aperiodic" sets of tiles, sets of tiles that admit tilings, but admit no periodic tilings, and many specific simple examples of such aperiodic sets are known.) We survey many recent constructions that highlight some of the subtleties of matching rules: results on the intrinsic universality of tiling, the self-assembly of arbitrary hierarchical tilings, and the enforcement of non-deterministic substitution tilings. (Received September 23, 2014)

53 ► Differential geometry

1105-53-8 **Lovejoy S Das*** (ldas@kent.edu), 330 University Dr. NE, University Dr., New Philadelphia, OH 44663. *Second Order Parallel Tensors on Lorentzian Para r-Sasakian Manifolds with a coefficient alpha.*

Abstract: Levy [5] had proved that a second order symmetric non singular tensor on a space of constant curvature is a constant multiple of the metric tensor. Sharma [6] has proved that a second order parallel tensor in a Kaehler Space of constant holomorphic sectional curvature is a linear combination with constant coefficients of the Kaehlerian metric and the fundamental 2-form. In this paper, we have shown that a second order symmetric parallel tensor on a Lorentzian Para r-Sasakian manifold (briefly LP-r Sasakian manifold) with a coefficient alpha is a constant multiple of the metric tensor and we have also proved that there is no non zero skew symmetric second order parallel tensor on a Lorentzian Para r-Sasakian manifold with a coefficient alpha. (Received April 19, 2014)

1105-53-15 **Bianca Santoro*** (bsantoro@ccny.cuny.edu). *Bifurcation of periodic solutions to the singular Yamabe problem on spheres.*

In this talk, we describe how to obtain uncountably many periodic solutions to the singular Yamabe problem on a round sphere, that blow up along a great circle.

These are (complete) constant scalar curvature metrics on the complement of a circle inside S^m, $m \geq 5$, that are conformal to the round (incomplete) metric and periodic in the sense of being invariant under a discrete group of conformal transformations.

Furthermore, for $5 \leq m \leq 7$, the solutions come from bifurcating branches of constant scalar curvature metrics on the compact quotient.

This is joint work with R. Bettiol (Notre Dame) and P. Piccione (USP). (Received May 28, 2014)

1105-53-34 **Christine Breiner*** (cbreiner@fordham.edu) and **Tobias Lamm**. *Compactness results for biharmonic maps.*

Critical points for the functional $E(u) = \int |\Delta u|^2$ are called biharmonic maps and are natural fourth order analogues of harmonic maps. Compactness theory for harmonic maps in two dimensions is well understood. In this talk we will discuss recent work with T. Lamm in which we determine energy quantization and the C^0 limit picture for sequence of approximate biharmonic maps from four dimensional manifolds into spheres. In particular, when the approximate map is in $L \log L$ we demonstrate that the energy does not concentrate. Moreover, we determine that if the $L \log L$ norm of the approximate maps does not concentrate, the image of the bubbles are connected without necks. (Received August 13, 2014)

1105-53-41 **Thomas A Ivey*** (iveyt@cofc.edu). *Integrability and Isometric Immersions of Surfaces.* Preliminary report.

Abstract: The problem of isometrically immersing a given Riemannian surface into Euclidean 3-space is locally solvable in the real-analytic category, but aside from topological restrictions little is known about the existence of global embeddings or the size of the space of non-rigid deformations a given surface has. We analyze the problem as an exterior differential system, and find that there are four distinct metrics (up to scale) for which the system is Darboux-integrable. This means that, in theory, all isometric immersions for these metrics can be produced by solving linear systems of ODE. For three of these metrics (those with positive curvature) there is also a Weierstrass-type representation, so that immersions can be determined by quadrature given a holomorphic curve on an affine quadric in $\mathbb{C}^3$.

This is joint work with Jeanne Clelland, Ben McKay and Peter Vassiliou. (Received August 22, 2014)

1105-53-53 **Robert L. Bryant*** (bryant@math.duke.edu), Duke Mathematics Department, PO Box 90320, Durham, NC 27708-0320. *Some exceptional geometry of rolling surfaces.* Preliminary report.

The mechanical system of one rigid surface rolling over another without twisting or slipping is a staple of non-holonomic mechanics and has been studied from a number of different points of view. The differential equations that describe this motion turn out to be a special case of a system of PDE studied by Élie Cartan in 1910. Remarkably, Cartan showed that such systems can have a symmetry group with dimension as large as 14 (and that, in this case, the symmetry group is isomorphic to the exceptional group G_2). For example, it turns out that a sphere of radius 1 rolling over a sphere of radius 3 belongs to this highly symmetric case.

In recent years, there have been some surprising developments; Nurowski and An have discovered a remarkable convex surface in 3-space whose differential constraints that describe its rolling over the flat plane have G_2-symmetry.

In this talk, I will describe the history of this problem, the geometry that goes into its study, and the recent developments, including some results of my own that provide progress in classifying the pairs of surfaces whose rolling constraints have exceptional symmetry. (Received August 27, 2014)

1105-53-70 **D.H. Phong**, **Jian Song*** (jiansong@math.rutgers.edu), **Jacob Sturm** and **Xiaowei Wang**. *The Ricci flow on the sphere with marked points.*

The Ricci flow on the 2-sphere with marked points is shown to converge in all three stable, semi-stable, and unstable cases. In the stable case, the flow was known to converge without any reparametrization, and a new proof of this fact is given. The semi-stable and unstable cases are new, and it is shown that the flow converges in the Gromov-Hausdorff topology to a limiting metric space which is also a 2-sphere, but with different marked points and hence a different complex structure. The limiting metric space carries a unique conical constant curvature metric in the semi-stable case, and a unique conical shrinking gradient Ricci soliton in the unstable case. (Received September 03, 2014)

1105-53-97 **Jeffrey Jauregui***, jaureguj@union.edu. *Lower semicontinuity of the ADM mass.* Preliminary report.

In general relativity a number of problems involve taking a limit (in some topology) of a sequence of asymptotically flat manifolds of nonnegative scalar curvature. It is of both geometric and physical interest to determine how the ADM (total) mass of such spaces behaves when passing to the limit. After giving several examples, I will discuss the main results on proving that the ADM cannot increase in the limit, for some natural choices of topology. (Received September 09, 2014)

1105-53-118 **Irina A Kogan*** (iakogan@ncsu.edu). *Invariant variational calculus.*

Systems of differential equations and variational problems arising in geometry and physics often admit a group of symmetries. As was first recognized by S. Lie, these problems can be rewritten in terms of group-invariant objects: differential invariants, invariant differential forms, and invariant differential operators. Differential invariants and invariant differential operators constitute a differential algebra with often non-trivial but computable structure. In this talk we will discuss how to perform variational calculus in terms of group-invariant objects. (Received September 12, 2014)

1105-53-132 **Netanel Samuel Blaier*** (netanel@math.mit.edu). *A higher dimensional generalization of the Johnson homomorphism using quantum Massey products.* Preliminary report.

Many problems in symplectic topology can be phrased as questions about the topology of the symplectomorphism group. We consider the problem of identifying the symplectic isotopy class of a symplectomorphism $\phi : M \to M$ which acts trivially on cohomology. When $M = \Sigma_g$ is a surface, the group of such symplectomorphism is well known to low dimensional topologists : it is the Torelli group, an important but poorly understood subgroup with many interesting connections to other areas of mathematics. In the early 1980's, Dennis Johnson revolutionized the study of this group by introducing a sequence of homomorphisms τ_k detecting delicate intersection-theoretic information. We show that the definition of the Johnson homomorphisms can be extended to higher dimensions using the A_∞-algebra structure on the Morse complex coming from quantum Massey products on mapping tori. As a sample application, we consider a pencil of degree d hypersurfaces in $\mathbb{P}^3$ with base locus B, and form a symplectic blowup of small energy $M = Bl_B\mathbb{P}^3$. Explicitly computing the second quantum Johnson homomorphism associated to certain symplectomorphism $\phi : M \to M$, we prove that it represents a nontrivial symplectic isotopy class. (Received September 14, 2014)

1105-53-245 **Jason Cantarella***, UGA Mathematics Department, Athens, GA 30602, and **Clayton Shonkwiler**. *Concentration of Measure and Berglund's DiFinetti-type theorems for Random Polygonal Knots.* Preliminary report.

This talk discusses new approaches to considering random knots. In previous work, we've introduced a measure on the manifold of closed space polygons with n edges and total length 2 (up to translation) by pushing forward the measure from the Stiefel manifold of 2-frames in complex n-space $V_2(\mathbb{C}^n)$ using a version of the Hopf map.

The larger question here is the conjecture that almost every closed random polygon (for large n) is knotted. Michael Berglund has recently proved that k-edge sections of an n-edge closed polygon are close in distribution to k-edge sections of the corresponding (open) random walk and provided bounds on the difference in distributions.

In this talk, we discuss Berglund's results and compare them to the results that one can obtain using concentration of measure on the Stiefel manifold. We learn that the situation is somewhat more delicate than one might expect from a first reading of the concentration of measure theorems, but that there is still interesting information to be extracted with these methods. (Received September 22, 2014)

1105-53-269 **Fernando Schwartz*** (fernando@math.utk.edu) and **Alexandre Freire** (freire@math.utk.edu). *Geometric inequalities for hypersurfaces.*

The classic Pólya-Szegö and Alexandrov-Fenchel inequalities bound the total mean curvature of a convex surface in Euclidean space in terms of its capacity and area. In this talk I will present my joint work with A. Freire in which we generalize these inequalities to arbitrary dimensions using Huisken and Ilmanen's inverse mean curvature flow. (Received September 22, 2014)

1105-53-275 **Clayton Shonkwiler*** (clayton@math.colostate.edu), Department of Mathematics, 1874 Campus Delivery, Fort Collins, CO 80523-1874, and **Jason Cantarella**. *A New Algorithm for Sampling Closed Equilateral Random Walks.* Preliminary report.

A random walk in 3-space is a classical object in geometric probability, given by choosing a direction at random, taking a step, and repeating n times. Since the directions of the steps are independent random variables, random walks are easy to sample and many of their statistical properties can be determined analytically. Random walks are used in polymer physics to describe the possible configurations of a "linear" polymer composed of n identical monomers.

However, many biological polymers are "ring" polymers; to model these we must add the constraint that the random walk closes up. In this situation the directions of the steps are no longer independent and both sampling and explicit computations become much harder.

In this talk I will describe an unbiased sampling algorithm for closed equilateral random walks. The justification for the fact that it is unbiased uses the toric symplectic structure on the configuration space of closed walks, but the algorithm itself is purely combinatorial. (Received September 22, 2014)

1105-53-285 **Mihai Bailesteanu*** (mihaib@ccsu.edu), Central Connecticut State University, 120 Marcus White Hall, New Britain, CT 06050. *Geometric methods to study PDE's.* Preliminary report.

We discuss the application of a well-known technique used in geometric flows (especially in Ricci flow) to various PDEs. The method involves proving the positivity of a well-chosen Harnack quantity. For example, using this method one can reprove one of Hamilton's first curve shortening flow Harnack inequlity. However, we show that the same method can be used to study other PDE equations, like Fisher's equation, Allen-Cahn equation and others. (Received September 22, 2014)

1105-53-354 **T. H. Wears*** (wearsth@longwood.edu). *Lorentzian Ricci Solitons on a 5-dimensional Nilpotent Lie Group.* Preliminary report.

We present the classification of all left-invariant Lorentzian metrics on a five-dimensional connected, simply-connected nilpotent Lie group that has a basis consisting of vectors $\mathbf{E}_1$, $\mathbf{E}_2$, $\mathbf{E}_3$, $\mathbf{E}_4$, $\mathbf{E}_5$, with bracket structure generated by the relations $[\mathbf{E}_1, \mathbf{E}_5] = \mathbf{E}_3$ and $[\mathbf{E}_2, \mathbf{E}_4] = \mathbf{E}_5$. In addition, we classify all left invariant Lorentzian Ricci soliton and algebraic Ricci soliton metrics on the Lie group in question and provide a detailed comparison between Lorentzian Ricci solitons and Riemannian Ricci solitons. (Received September 23, 2014)

1105-53-356 **Jason Cantarella** and **Jason Parsley*** (parslerj@wfu.edu). *Helicity of vector fields, configuration spaces, and cohomology classes.*

We consider the helicity of a vector field, which calculates the average linking number of the field's flowlines. Helicity is invariant under certain diffeomorphisms of its underlying manifold – we seek to understand which ones.

Extending to differential (k+1)-forms on domains in R^{2k+1}, we express helicity as a cohomology class. This topological approach allows us to find a general formula for how much helicity changes when the form is pushed forward by a diffeomorphism of the domain. We classify the helicity-preserving diffeomorphisms on a given domain, finding new ones on the two-holed solid torus and proving that there are no new ones on the standard solid torus. This approach also leads us to define submanifold helicities: differential (k+1)-forms on n-dimensional subdomains of R^m. (Received September 23, 2014)

54 ► General topology

1105-54-76 **Steven Clontz*** (steven.clontz@gmail.com), 2428 E University Dr #910, Auburn, AL 36830. *Game-theoretic strengthenings of Menger's property.*

A certain topological game introduced by Hurewicz characterizes Menger's covering property whenever the first player lacks a winning strategy. It was later shown by Telgarsky (and later by Scheepers using a different argument) that for metric spaces, the second player having a winning strategy characterizes the stronger property of σ-compactness.

A k-Markov strategy relies only on the round number of the game and the last k moves of the opponent. We factor out Scheepers' proof to show that for regular spaces, the second player having a winning 1-Markov strategy characterizes σ-compactness; also, for second-countable spaces, the presence of a winning perfect information strategy for the second player implies the existence of a winning Markov strategy for that player. We then show that for all k, the existence of a winning k-Markov strategy for the second player implies the existence of a winning 2-Markov strategy. The second player has a winning 2-Markov (but no 1-Markov) strategy for this game when played upon a one-point Lindelof-ication of discrete ω_1 in ZFC, and assuming an additional axiom due to Scheepers, the second player has a winning 2-Markov strategy for this game for a one-point Lindelof-ication of discrete k. (Received September 04, 2014)

1105-54-80 **Marithania Silvero*** (marithania@us.es). *3-BKL positive links and their Conway polynomials.*

In 1989, P. Cromwell proved that positive links have Conway polynomial with positive coefficients. Positive links include those links which are closure of positive braids in terms of Artin generators.

A link is said to be BKL-positive if it can be expressed by a positive braid word using the generators introduced by Birman, Ko and Lee in 1998. Not every BKL-positive link is positive. In this talk we show that BKL-positive links with braid index 3 have Conway polynomial with positive coefficients. (Received September 05, 2014)

1105-54-84 **Akira Iwasa*** (iwasa@uscb.edu). *Preservation of countable compactness and pseudocompactness by forcing.* Preliminary report.

Juhász and Weiss proved that the compactness of a Hausdorff space is preserved by any forcing if the space is scattered. Countable compactness can be destroyed by forcing even if the space is scattered. We discuss conditions of a space under which the countabble compactness of the space is preserved by forcing. We consider preservation of pseudocompactness as well. (Received September 07, 2014)

1105-54-122 **Alexander Varchenko*** (anv@email.unc.edu), Chapel Hill, NC. *Title: K-theory of the cotangent bundle of a partial flag variety as a Bethe algebra.* Preliminary report.

A conjectural description of the quantum K-theory algebra of a partial flag variety will be given. (Received September 13, 2014)

1105-54-149 **Alan S Dow*** (adow@uncc.edu), Mathematics and Statistics, UNC Charlotte, 9201 University City Blvd, Charlotte, NC 28223. *An update on Moore-Mrowka.*

A Moore-Mrowka space is a compact space of countable tightness that is not also sequential. In the 1970's Ostaszewski and Fedorchuk independently constructed compact S-spaces that were not sequential from the set-theoretic assumption diamond. In 1989 Balogh proved that the PFA implied there were no Moore-Mrowka spaces. A special type of Moore-Mrowka spaces arises from the existence of an initially omega1-compact non-compact space of countable tightness. CH and PFA each imply each initially omega1-compact space of countable tightness is compact. Rabus [and later Koszmider-Juhasz-Soukup] prove it is consistent to have non-compact initially omega1-compact countably tight [even first countable] spaces. Two glaring omissions are the status of Moore-Mrowka under CH and of both questions under Martin's Axiom. A final related problem is Arhangelskii's question of whether first-countable initially omega1-compact spaces are necessarily of cardinality at most the continuum. (Received September 16, 2014)

1105-54-174 **Jan P. Boronski** (jan.boronski@osu.cz), Ostrava, Czech Rep, **Gary Gruenhage*** (garyg@auburn.edu), Auburn, AL 36849, and **George Kozlowski** (kozloga@auburn.edu), Auburn, AL 36849. *1/k-homogeneous long solenoids.*

We study nonmetric analogues of Vietoris solenoids. Let Λ be an ordered continuum, and let $\vec{p} = \langle p_1, p_2, \dots \rangle$ be a sequence of positive integers. We define a natural inverse limit space $S(\Lambda, \vec{p})$, where the first factor space is the nonmetric "circle" obtained by identifying the endpoints of Λ, and the nth factor space, $n > 1$, consists of $p_1 p_2 \cdot \dots \cdot p_{n-1}$ copies of Λ laid end to end in a circle. We prove that for every cardinal $\kappa \geq 1$, there is an ordered continuum Λ such that $S(\Lambda, \vec{p})$ is $\frac{1}{\kappa}$-homogeneous; for $\kappa > 1$, Λ is built from copies of the long line. Our

example with $\kappa = 2$ provides a nonmetric answer to a question of Neumann-Lara, Pellicer-Covarrubias and Puga-Espinosa from 2005, and with $\kappa = 1$ provides an example of a nonmetric homogeneous circle-like indecomposable continuum. Finally, we employ a cohomology argument to prove that for each ordered continuum Λ, as $\vec{p}$ varies there are 2^{ω}-many nonhomeomorphic spaces $S(\Lambda, \vec{p})$. (Received September 18, 2014)

1105-54-176 **Ziqin Feng***, Department of Mathematics and Statistics, Auburn, AL 36849. *A note on Structuring Mechanisms.*

A space has countable (F)-property if it has countable point network satisfying the Collins-Roscoe structuring mechanism. Some sufficient conditions for $C_p(X)$ having countable (F)-property are given. As a corollary,we prove that if X is Corson compact, $C_p(X)$ satisfies countable (F). This answers a question raised by Tkachuk. (Received September 18, 2014)

1105-54-186 **Andrzej Szymanski*** (andrzej.szymanski@sru.edu), Department of Mathematics, Slippery Rock University, Slippery Rock, PA 16057. *On set theoretic convexities induced by multifunctions.* Preliminary report.

We define and study convexity structures that are induced by any multifunction defined on all non-empty finite subsets of a given space. It turns out that any set theoretic convexity structure (in van de Vel's sense) is representable in this form. Our approach encompasses as diverse structures as transitive sets and transitive closures (playing a very important role in set theory and model theory) and convex sets in a vector space. (Received September 19, 2014)

1105-54-192 **Alexander Shibakov*** (ashibakov@tntech.edu). *On the sequential order of countable groups.* Preliminary report.

We present a model without countable topological groups of nontrivial sequential orders. (Received September 19, 2014)

1105-54-241 **Ana Mamatelashvili*** (azm0105@auburn.edu), 221 Parker Hall, Auburn University, Auburn, AL 36849. *Tukey Order and Subsets of ω_1.*

The Tukey order compares cofinal complexity of partially ordered sets. In this talk we will consider partially ordered sets of the form $\mathcal{K}(S)$, where S is a subset of ω_1 and $\mathcal{K}(S)$ denotes the collection of all compact subsets of S ordered by inclusion.

We begin by considering various order properties of these partially ordered sets. Most interestingly, we show that for unbounded S, $\mathcal{K}(S)$ has calibre $(\omega_1, \omega_1, \omega)$ if and only if $\overline{S}\backslash S$ is bounded and either S is locally compact or $\omega_1 < \mathfrak{b}$. The case for calibre (ω_1, ω) was settled by Todorčević.

Next we single out a few special Tukey classes and assign most $\mathcal{K}(S)$'s to these classes. For instance, the Tukey class of the Σ-prodcut of ω_1-many copies of ω is composed of precisely those $\mathcal{K}(S)$'s for which S is stationary, not co-stationay and $\overline{S}\backslash S$ is unbounded.

Time permitting, we will also consider the Tukey relation between posets of the form $\mathcal{K}(S)$ and $\mathcal{K}(M)$, where M is a separable metrizable space. (Received September 22, 2014)

1105-54-258 **Tetsuya Ishiu*** (ishiut@miamioh.edu), 123 Bachelor Hall, Oxford, OH 45014. *Some results on the products of connected linearly ordered sets.*

We will present some results about the products of connected linearly ordered spaces that are nowhere real, i.e. do not contain a copy of the real line. In particular, we shall outline the proof that there is no continuous surjection from a compact nowhere real connected linearly ordered space onto the product of two connected nowhere real linearly ordered spaces. So, there cannot be any analogue of Peano Curve for connected nowhere real linearly ordered spaces. Some other results will also be discussed. (Received September 22, 2014)

1105-54-277 **Pankaj S Joshi*** (psj@tifr.res.in), Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Bombay, 400 005, India. *Topology in General Relativity.*

We consider here some of the important applications of topology in general relativity. In particular, the topologies on the space of all Lorentzian metrics is considered, and we point out the 'problem of non-uniqueness' which has major implications on the nature and structure of space-time singularities and their visibility properties, and other important features of general relativistic space-times. The causal structure of space-times are discussed and their connection to space-time topology is investigated. An important issue is the nature and structure of space-time singularities. Their genericity and stability is a major unresolved issue, especially when singularities are visible. This involves the issues of topology of space-time under consideration and those related to the

measure defined on the same. Recent results in this connection will be discussed. (Received September 22, 2014)

1105-54-298 **Peter Nyikos***, Department of Mathematics, University of South Carolina, Columbia, SC 29208. *The structure of locally compact, locally connected, T_5 spaces under PFA(S)[S].* Preliminary report.

Under PFA(S)[S], a class of forcing models of ZFC with some features of the PFA and others of V=L, Frank Tall has shown the consistency of all T_5 (hereditarily normal, including Hausdorff) manifolds of dimension > 1 being metrizable. This is an easy corollary of the following theorem:

Theorem 1. Assume PFA(S)[S]. *Let X be a locally compact, locally connected T_5 space. Every component of X is the union of an open Lindelöf space L and countably many disjoint, closed, connected, countably compact noncompact spaces, each of which includes uncountably many cut points of the component and has exactly one point in the closure of L.*

Corollary. Assume PFA(S)[S]. *Every locally compact, locally connected, T_5 space is hereditarily collectionwise normal and hereditarily countably paracompact.*

Theorem 2. Under PFA(S)[S], *every (clopen) component of every locally compact, locally connected, T_5 space is the union of a closed, rim-finite, monotonically normal subspace and a family of disjoint open Lindelöf subspaces.* (Received September 22, 2014)

1105-54-324 **John E Porter*** (jporter@murraystate.edu), Department of Mathematics & Statistics, Faculty Hall 6C, Murray State University, Murray, KY 42071. *A note on the Collins-Roscoe Structuring Mechanism and D-spaces.* Preliminary report.

A new connection between the Collins-Roscoe mechanism and D-spaces is established. We prove that point-additively Noetherian (F) spaces are D-spaces improving on a result of Yuming Xu who showed that well-orderd (F) spaces are D-spaces. As an application, finite products of well-ordered (F) spaces, protometrizable, and/or elasitc spaces are hereditarily D-spaces. (Received September 23, 2014)

1105-54-332 **Jerry Vaughan** and **Catherine Payne***, capayne2@uncg.edu. *Continuous functions on ψ-spaces.*

Let $\psi(\kappa, \mathcal{M})$ be a ψ-space with underlying set $\kappa \cup \mathcal{M}$ where κ is an infinite cardinal number and $\mathcal{M}$ is a maximum almost disjoint family (MADF) of countably infinite subsets of κ. A MADF $\mathcal{M} \subset [\kappa]^\omega$ is called rich provided for every continuous function $f : \psi(\kappa, \mathcal{M}) \to \mathbb{R}$, there exists $r \in \mathbb{R}$ such that $\left|f^{-1}(r)\right| = |\psi(\kappa, \mathcal{M})| = |\mathcal{M}|$. A cardinal κ is called a rich cardinal if every MADF $\mathcal{M} \subset [\kappa]^\omega$ is rich. We prove that $\kappa \leq \mathfrak{c}$ is rich if and only if $\mathfrak{a} = \mathfrak{c}$, where $\mathfrak{a}$ is the minimum cardinality of a MADF on ω and $\mathfrak{c}$ is the cardinality of the continuum. The first example of a rich MADF was the well known MAFD $\mathcal{M}$ on $\kappa = \omega$ due to S. Mrówka with the property that for every continuous $f : \psi(\omega, \mathcal{M}) \to \mathbb{R}$, there exists $r \in \mathbb{R}$ such that $\left|\psi(\omega, \mathcal{M}) \setminus f^{-1}(r)\right| \leq \omega$. (Received September 23, 2014)

1105-54-334 **Laszlo Zsilinszky*** (laszlo@uncp.edu), Pembroke, NC 28304. *On complete metrizability of the Hausdorff metric topology.*

It is well-known that the Hausdorff metric topology τ_{H_d} induced by the Hausdorff distance on the hyperspace $CL(X)$ of nonempty closed subsets of a metric space (X, d) is completely metrizable, if (X, d) is a *complete metric* space; however, complete metrizability of the hyperspace may not automatically follow, if X is *completely metrizable*, since τ_{H_d} is sensitive to the metric of the base space X. Indeed, it will be demonstrated that there is a completely metrizable space X with compatible metrics d, d' such that $(CL(X), \tau_{H_d})$ is completely metrizable, but $(CL(X), \tau_{H_{d'}})$ contains a closed copy of the rationals. The methods used, including topological games and elementary submodels, can be generalized to obtain a characterization of complete metrizablity of the Hausdorff metric topology. Other completeness properties of these hyperspaces, as well as some open problems, will also be discussed. (Received September 23, 2014)

1105-54-340 **Jerry E Vaughan*** (j_vaugha@uncg.edu), Department of Mathematics and Statistics, University of North Carolina at Greensboro, P. O. Box 26170, Greensboro, NC 27402-617, and **Catherine Payne**. *ψ spaces on an uncountable cardinal κ with a MAD family of cardinality κ.*

We prove in ZFC that if $\kappa > \omega$ and $\mathcal{M} \subset [\kappa]^\omega$ is a infinite maximal almost disjoint family of countably infinite subsets of κ with $|\mathcal{M}| = \kappa$, then $\mathcal{M}$ is a rich MAD family. This means that for every continuous real valued function $f : \psi(\kappa, \mathcal{M}) \to \mathbb{R}$, there exists $r \in \mathbb{R}$ such that $|f^{-1}(r)| = \kappa$. As a corollary we get that the cardinal $\mathfrak{c}$ is a rich cardinal. It is consistent that all cardinals are rich, and also consistent that some cardinals (e.g., ω_1) are not rich. (Received September 23, 2014)

55 ► Algebraic topology

1105-55-28 **Mustafa Hajij*** (mhajij1@math.lsu.ledu), Baton Rouge, LA 70808. *Quantum spin networks and q-Series.*

We use the skein theory associated with the Kauffman bracket skein module to study the tail of the colored Jones polynomial of alternating links. we generalize this study further to quantum spin networks and study their tail using skein theory. In most cases, it turns out that the tail these trivalent graphs are interesting number-theoretic q-series. In particular, certain trivalent graphs give a skein theoretic proof for the Andrews-Gordon identities for the two variable Ramanujan theta function as well to corresponding identities for the false theta function. Finally, we give a product formula that the tail of such graphs satisfies. (Received August 01, 2014)

1105-55-161 **Lew Ludwig*** (ludwigl@denison.edu), 100 West College Street, Granville, OH 43023. *The mosaic number of a knot.*

In 2008, Lomonaco and Kauffman introduced the notion of knot mosaics - a distinct set of tiles in an $n \times n$ grid to represent the projection of a knot - as a possible model for quantum knots. Since that time, it has been shown that knot mosaics are equivalent to tame knot theory (2012: Kuriya, Shebab). In this presentation, we will consider several infinite families of knots with known mosaic number (the smallest $n \times n$ grid for a given knot), as well as the mosaic number for small knots. Several open questions will also be presented. (Received September 17, 2014)

1105-55-184 **Paul S Aspinwall*** (psa@cgtp.duke.edu). *Exoflops in Two Dimensions.*

Mirror symmetry for Calabi-Yau complete intersections in toric varieties leads to a "phase" picture. Each phase presents the derived category of the Calabi-Yau in a different way but all these categories are equivalent. A very common but relatively unexplored phase is the "exoflop" where the Calabi-Yau becomes has more than one component. We explore such phases for K3 surfaces. (Received September 19, 2014)

1105-55-232 **Carl Hammarsten*** (chammar@gwu.edu), Department of Mathematics, Monroe Hall, 2115 G Street NW, Washington, DC 20052. *Combinatorial Heegaard Floer Homology and Decorated Heegaard Diagrams.* Preliminary report.

Heegaard Floer homology is a collection of invariants for closed oriented three-manifolds, introduced by Ozsvath and Szabo in 2004. The simplest version is defined as the homology of a chain complex coming from a Heegaard diagram of the three manifold. In the original definition, the differentials count the number of points in certain moduli spaces of holomorphic disks, which are hard to compute in general. More recently, Sarkar and Wang (2008) and Ozsvath, Stipsicz, and Szabo (2010) have determined combinatorial methods for computing this homology with Z_2 coefficients. Both methods rely on the construction of very specific Heegaard diagrams for the manifold, which are generally very complicated. We introduce the idea of a decorated Heegaard diagram. That is, a Heegaard diagram together with a collection of embedded paths satisfying certain criteria. Using this decorated Heegaard diagram, we present a combinatorial definition of a chain complex which is homotopically equivalent to the Heegaard Floer one, yet significantly smaller. (Received September 21, 2014)

1105-55-299 **Seung Yeop Yang*** (syyang@gwmail.gwu.edu) and **Jozef H. Przytycki**. *Torsion of Quandle Homology Groups of Takasaki Quandles.*

Niebrzydowski and Przytycki proved that the torsion subgroup of $H_n^Q(T(\mathbb{Z}_3))$ is annihilated by 3, for $n > 1$, and Nosaka generalized this result, p annihilates the torsion of $H_n^Q(T(\mathbb{Z}_p))$ when p is prime. Our goal is to extend the result of Niebrzydowski, Nosaka, and Przytycki about the torsion subgroup of quandle homology groups of Takasaki quandles. (Received September 22, 2014)

57 ► Manifolds and cell complexes

1105-57-3 **Stavros Garoufalidis*** (stavros@math.gatech.edu), School of Math, Georgia Tech, 686 Cherry Street, Atlanta, GA 30332-0160. *Knots and q-series.*

A knot is an embedded circle in 3-space, that is allowed to move as long as it does not cross itself. A powerful quantum knot invariant is the Jones polynomial, a Laurent polynomial in a variable q, with integer coefficients. Witten gave a gauge-theory interpretation of the Jones polynomial. Kashaev linked the growth rate of the Jones polynomials of parallels of the knot at roots of unity with the hyperbolic volume of the knot via the Volume Conjecture. Khovanov identified the coefficients of the Jones polynomial with the Euler characteristic of a homology theory. Recently, three independent ways to associate q-series to knot invariants were discovered.

We will give concrete examples of those q-series, give empirical relations of their asymptotics, as well as some proofs using methods of complex analysis. Parts of the lecture involve joint work with Thang Le, Rinat Kashaev, Tudor Dimofte and Don Zagier. (Received April 16, 2014)

1105-57-12 **Matt Mastin*** (mastinjm@wfu.edu), Department of Mathematics, Wake Forest University, Winston-Salem, NC 27106, and **Jason Parsley** (parslerj@wfu.edu) and **Jason Cantarella** (cantarel@math.uga.edu). *The ("Complete") Census of Link Diagrams.* Preliminary report.

Until now, computer tabulations have begun by first reducing the (giant) set of all link diagrams, often through highly clever means; then they proceed to test whether links are equivalent. Our project, the Census of Link Diagrams (COLD), creates a database of all link diagrams, up to a certain crossing number. From there, we reduce to a complete tabulation of both prime and composite links. The first goal of the project is to tabulate the complete set of link diagrams through 9 crossings. We then will leave the computation running in the cloud in order to tabulate higher crossing number diagrams. This project is joint with Jason Cantarella at the University of Georgia and Jason Parsley at Wake Forest University. (Received July 14, 2014)

1105-57-30 **Micah W. Chrisman*** (mchrisma@monmouth.edu). *Applications of Virtual Knot Theory to Knots in 3-Manifolds.*

Knots in compact orientable 3-manifolds can be studied using the method of virtual covers. Let K be a knot on a compact oriented 3-manifold N. Suppose N admits a covering space $\Pi : \Sigma \times (0,1) \to N$ where Σ is a compact oriented surface. Suppose additionally that there is a knot $\mathfrak{k}$ in $\Sigma \times (0,1)$ such that $\Pi(\mathfrak{k}) = K$. Then we say that $\mathfrak{k}^{\Sigma\times(0,1)}$ is a virtual cover of K^N, denoted $(\mathfrak{k}^{\Sigma\times(0,1)}, \Pi, K^N)$. The knot $\mathfrak{k}$ stabilizes to a virtual knot v called the virtual knot associated to the virtual cover. Under many circumstances, the associated virtual knot v is itself an invariant of K in N. Virtual knot invariants applied to v detect geometric properties of K in N. We present a general algebraic theory of virtual covers that is based on the notion of commensurable manifolds. The theory will be illustrated with some new examples and applications. (Received August 09, 2014)

1105-57-55 **Ben Webster*** (bwebster@virginia.edu), University of Virginia, Charlottesville, VA 22904. *Isomorphisms between knot homology theories for* $\mathfrak{sl}_n$.

One very important collection of invariants for any knot or link are those associated by Reshetikhin and Turaev to the representations of $\mathfrak{sl}_n$. Over the past decade or so, mathematicians have had a lot of success at defining categorifications of these invariants, and a lot less success at figuring out whether they've defined one categorification in a bunch of different ways, or a bunch of different ones. Luckily, we now know that the former is true. I'll explain how, based on work of many people including Cautis, Mackaay, Yonezawa, Rose, Queffelec, Lauda and of course, myself. (Received August 28, 2014)

1105-57-60 **Tyler Lawson**, **Robert Lipshitz*** (lipshitz@math.columbia.edu) and **Sucharit Sarkar**. *On a Khovanov homotopy type.*

We will discuss recent progress on understanding and applying L-Sarkar's "Khovanov homotopy type". (Received August 29, 2014)

1105-57-62 **Louis H Kauffman*** (kauffman@uic.edu), Mathematics Department, University of Illinois at Chicago, 851 South Morgan Street, Chicago, 60607-7045. *Quantum Link Invariants and Rotational Virtual Knot Theory.* Preliminary report.

This talk is self-contained. We define quantum link invariants via augmented solutions to the Yang-Baxter equation. We show how the bracket polynomial model of the Jones polynomial fits into this framework and we show how many other invariants fit into this framework. We also briefly discuss how quantum link invariants can be formulated in terms of Hopf algebras. Then we discuss how classical knot theory extends to virtual knot theory and to rotational virtual knot theory. In rotational virtual knot theory one adds virtual crossings and augments the Reidemeister moves by detour moves that are regular homotopies of the arc moved in the detour. We then prove the Theorem: Every quantum link invariant of classical links extends to an invariant of rotational virtual knots and links. This theorem shows that Rotational Virtual Knot Theory is the proper domain for the study of quantum link invariants. The talk will consider many examples and questions that arise. (Received September 02, 2014)

1105-57-63 **Nelson Colon**, Department Of Mathematics, The University of Iowa, Iowa city, IA 52242, and **Charles Frohman*** (charles-frohman@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Frobenius Algebras Derived from the Kauffman Bracket Skein Algebra.* Preliminary report.

If the variable in the Kauffman bracket A is set equal to $e^{\pi \mathbf{i}/N}$ where N is an odd integer, then the Kauffman bracket skein algebra of a compact oriented surface F, $K_N(F)$ is a ring extension of $\chi(F)$ the $SL_2\mathbb{C}$-characters of the fundamental group of F.

We can derive an algebra from $K_N(F)$ by either passing to the field of fractions of $\chi(F)$, or specializing at a place $\phi : \chi(F) \to \mathbb{C}$. In either case, the action of $K_N(F)$ on itself by left multiplication leads to a trace on $K_N(F)$ taking values in the base field.

We work examples to show that the fields constructed this way are usually Frobenius algebras. (Received September 02, 2014)

1105-57-91 **Colin Adams*** (cadams@williams.edu), **Orsola Capovilla-Searle** (ocapovilla@brynmawr.edu), **Jesse Freeman** (jesse.s.freeman@williams.edu), **Daniel Irvine** (dirvine@umich.edu), **Samantha Petti** (snp1@williams.edu), **Daniel Vitek** (dvitek@math.princeton.edu), **Ashley Weber** (sweber@math.brown.edu) and **Sicong Zhang** (zhangsc91@gmail.com). *Multi-crossing number of knots and the Kauffman bracket polynomial.*

A multi-crossing (or n-crossing) of a knot is a crossing with n strands passing straight through it. The n-crossing number of a knot $c_n(K)$ is the least number of n-crossings in any n-crossing projection of the knot. We generalize previous results for $n = 2, 3, 4$ to obtain the following upper bound on the span of the Kauffman bracket polynomial of a knot K. For $n \geq 3$, $\text{span}(< K >) \leq ([n^2/2] + 4n - 8)c_n(K)$. We use this to help produce the first table of values of $c_n(K)$ for various knots of small crossing number. (Received September 08, 2014)

1105-57-95 **Sam Nelson*** (knots@esotericka.org) and **Selma Paketci**. *Finite Type Enhancements.* Preliminary report.

We enhance the biquandle counting invariant for classical and virtual knots using elements of biquandle-labeled truncated Polyak algebras, encounterng connections with parity and cocycle invariants aong the way. (Received September 09, 2014)

1105-57-103 **Charles D. Frohman** and **Joanna Kania-Bartoszynska*** (jkaniaba@nsf.gov), National Science Foundation, Arlington, VA 22230. *Topological Quantum Field Theory underlying quantum hyperbolic geometry.*

First steps needed in order to construct a topological quantum field theory underlying quantum hyperbolic geometry are to understand the structure of the unreduced Kauffman bracket skein algebra of a compact orientable surface with boundary. We describe this algebra and show that, working over a field of fractions over the characters of the surface, it is a Frobenius algebra. We give a specific computation for the algebra of a connected sum of two copies of $S^1 \times S^2$. (Received September 10, 2014)

1105-57-105 **Louis H. Kauffman*** (kauffman@uic.edu), 5530 South Shore Drive, Apt 7C, Chicago, IL 60637-1946. *Unitary Braiding and Majorana Fermions.* Preliminary report.

A Majorana Fermion is an elementary particle that is its own anti-particle. It was conjectured by Majorana that the neutrino has this property. It has been more recently conjectured that single electrons are composed of two Majorana Fermions, and there is some experimental evidence for this statement. Majorana Fermions change phase when encircling one another, and it is possible to construct unitary representations of the Artin braid group, based on Majorana Fermions. These representations can do partial topological quantum computing. This talk will explain the author's point of view on this arena. (Received September 11, 2014)

1105-57-111 **Eric J Rawdon*** (ejrawdon@stthomas.edu). *What knots lurk inside other knots?*

For a fixed knot configuration, subknots are the knot types seen in the open subarcs of the configuration. For nice knot configurations (like ones minimized with respect to some knot energy), the subknots are typically simpler knot types than the host knot type. We compare and contrast the set of subknots coming from KnotPlot configurations, tight knot configurations, and random configurations. This is joint work with Ken Millett and Andrzej Stasiak. (Received September 11, 2014)

1105-57-115 **Yuanan Diao*** (ydiao@uncc.edu), Department of Mathematics and Statistics, UNC Charlotte, 9201 University City Blvd., Charlotte, NC 28223, and **Gabor Hetyei** (ghetyei@uncc.edu), Department of Mathematics and Statistics, UNC Charlotte, 9201 University City Blvd., Charlotte, NC 28223. *Tutte polynomials, relative Tutte polynomials and virtual knot theory.*

In this talk, I will present a new version of the Tutte polynomial (called relative Tutte polynomial) defined on plane graphs with certain restricted edges that are not subject to the usual contraction/deletion operation. I will then show how this Tutte polynomial can be used to compute the Jones polynomial of a virtual knot from its face graph, in a way very similar to the case of the classical knots. (Received September 12, 2014)

1105-57-119 **Allison K Henrich*** (henricha@seattleu.edu), Seattle University, 901 12th Ave, PO Box 222000, Seattle, WA 98122, and **Slavik Jablan** and **Inga Johnson**. *Invariants of Pseudoknots.* Preliminary report.

Pseudoknots are equivalence classes of knot diagrams where some crossing information may be unknown. Recently, two major invariants of pseudoknots have been defined: (1) a probabilistic invariant called the weighted resolution set and (2) a combinatorial invariant that is derived from the Gauss diagram of the pseudoknot. Before this work, it was conjectured that the weighted resolution set was a complete invariant of pseudoknots. We have just proven this conjecture false, using the Gauss-diagrammatic invariant. In this talk, we present our counterexample and proof. (Received September 12, 2014)

1105-57-123 **Adam M Lowrance*** (adlowrance@vassar.edu). *Alternating distances of knots.*

An alternating distance is a knot invariant that measures how far away a knot is from alternating. Examples include dealternating number, alternation number, Turaev genus, and alternating genus. In this talk, we give examples of families of knots where the difference between two of the above alternating distances becomes arbitrarily large. The proofs often use Khovanov or knot Floer homology. (Received September 13, 2014)

1105-57-144 **Annette Marie Honken*** (annette-honken@uiowa.edu), Department of Mathematics, University of Iowa, 14 Maclean Hall, Iowa City, IA 52242. *Mapping Distance One Neighborhoods within Knot Distance Graphs.* Preliminary report.

DNA can become knotted during biological processes such as recombination and replication. Type II topoisomerases are proteins tasked with keeping DNA unknotted. They act on double-stranded circular DNA by breaking the backbone of the DNA, allowing another segment of DNA to pass through, and re-sealing the break. Thus, a crossing change on a knot models the action of this protein on DNA. The distance between two knots, K_1 and K_2, is defined to be the minimum number of crossing changes required to obtain K_1 from K_2 or vice versa. Hence, to focus on the action of the type II topoisomerase on DNA, we look at knots of distance one.

We create a graph of this information by letting the set of vertices be knots and placing an edge between two vertices if the two knots represented by these vertices are of distance one. A neighborhood of a vertex, v, is the set of vertices with which v is incident via an edge. Using graph theoretical and topological tools, we examine graphs of knot distances and define a mapping of distance one neighborhoods. How this relates to Dehn surgery on the double-branched cover of a knot will be briefly mentioned. (Received September 22, 2014)

1105-57-183 **Mark E. Kidwell** (mek@usna.edu), 368 Dewey Drive, Annapolis, MD 21401, and **Joshua Lee Steves*** (m156432@usna.edu), 2320 Blue Bonnet Blvd, Houston, TX 77030. *Pretzel Knots and Tesselations.* Preliminary report.

I would like to show that in general given integers p, q, r greater than 1, there is a homomorphism from $\pi(\mathbb{S}^3 \backslash K)$, the fundamental group of the complement of a (p,q,r) pretzel knot, onto $\triangle(p,q,r)$, the group generated by reflections of a triangle with angles $\pi/p, \pi/q, \pi/r$ on a tessellated plane in a suitable geometry. The geometry will be chosen to be spherical, Euclidean, or hyperbolic based on whether or not $1/p + 1/q + 1/r$ is $>, =, or <$ than 1 respectively. This work has been motivated by an example from Herbert Seifert, who used a similar homomorphism onto a tessellated hyperbolic plane to prove that the (7, -3, 5) pretzel knot, which has Alexander polynomial equal to 1, was not the unknot. In addition to Seifert's example, I will use examples from each geometry to show how these groups operate and what can be learned about pretzel knots by employing this homomorphism. (Received September 19, 2014)

1105-57-196 **Christopher W Scaduto*** (scaduto@math.ucla.edu), UCLA Dept. of Mathematics, 520 Portola Plaza, Los Angeles, CA 90095-1555. *Instantons and odd Khovanov homology.*

Consider the double cover of the 3-sphere branched over a link. We will discuss how the instanton homology of this 3-manifold is related to the Khovanov homology of the link. When signs (integer coefficients) are taken into account, the relevant link homology is odd Khovanov homology, which is genuinely distinct from Khovanov

homology. This material is motivated by work of Ozsváth and Szabó in the Heegaard-Floer setting. (Received September 19, 2014)

1105-57-200 **W. Edwin Clark**, **Masahico Saito*** (saito@usf.edu) and **Leandro Vendramin**. *Quandle Invariants of Composite Knots and Extensions.*

Quandle colorings and cocycle invariants are studied for composite knots, and applied to chirality, cocycle invariants and abelian extensions. Formulas are given for computing the cocycle invariant from the number of colorings of composite knots. Relations to corresponding abelian extensions of quandles are studied, and extensions are examined for the table of small connected quandles, called Rig quandles. Summaries of computer calculations are presented. (Received September 19, 2014)

1105-57-209 **Uwe Kaiser*** (ukaiser@boisestate.edu), Department of Mathematics, Boise State University, Boise, ID 83725. *On the structure of link homotopy skein modules.* Preliminary report.

We discuss presentations of the Hoste-Przytycki link homotopy skein modules of oriented 3-manifolds. It is known by previous results that relations for the modules are determined inductively from certain *string topology pairings* defined by intersecting singular tori and oriented links. We describe the module of $S^2 \times S^1$ in detail. We also discuss in general how to find presentations for the modules of connected sums and 3-manifolds with non-trivial JSJ decomposition. (Received September 20, 2014)

1105-57-216 **Stephan M Wehrli*** (smwehrli@syr.edu), 215 Carnegie, Syracuse University, Syracuse, NY 13244. *Quantum sutured annular Khovanov homology.*

To a link in a thickened annulus, Asaeda-Przytycki-Sikora assigned a triply-graded homology group which categorifies the Kauffman bracket skein module of the thickened annulus. It was recently shown by Grigsby, Licata, and myself that this homology group carries a natural action of the Lie algebra $\mathfrak{sl}_2$. In my talk, I will introduce a deformation of this homology theory which carries an action of the quantum group $\mathsf{U}_q(\mathfrak{sl}_2)$. I will also discuss computational results showing that the deformed theory depends nontrivially on the parameter q. (Received September 20, 2014)

1105-57-224 **Stefan Friedl** and **Daniel S Silver*** (silver@southalabama.edu), Dept. of Mathematics and Statistics, University of South Alabama, Mobile, AL 36688, and **Susan G Williams**. *The Turaev and Thurston norms.* Preliminary report.

Thurston introduced in 1976 a norm on the first cohomology of a 3-manifold. Inspired by this definition Turaev introduced in 2002 a norm on the first cohomology of a finite 2-complex. We show that if N is the exterior of a link in a rational homology sphere, then the Thurston norm agrees with a suitable variation of the Turaev norm defined on any 2-skeleton of N. (Received September 21, 2014)

1105-57-234 **Mikhail Khovanov** and **Lev Rozansky*** (rozansky@math.unc.edu). *Positive half of the Witt algebra acts on triply graded link homology.*

The appearance of the variable q is an essential feature of the theory quantum invariants in 3d topology. Under categorification q turns into a $\mathbb{Z}$-grading of a link homology. We will show that the triply graded link homology categorifying the HOMFLY-PT polynomial has a structure of a module over the positive half of the Witt algebra (that is, the algebra of formal vector fields on a complex line), the $\mathbb{Z}$-degree being the eigenvalue of one of its generators. (Received September 21, 2014)

1105-57-237 **Adam Simon Levine*** (asl2@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08540. *Satellite operators and piecewise-linear concordance.*

Every knot in the 3-sphere bounds a piecewise-linear (PL) disk in the 4-ball, but Akbulut showed in 1990 that the same is not true for knots in the boundary of an arbitrary contractible 4-manifold. We strengthen this result by showing that there exist a homology sphere Y that bounds a contractible 4-manifold and a knot $K \subset Y$ that does not bound a PL disk in any homology 4-ball bounded by Y. We also describe how a variety of knot invariants arising from Heegaard Floer homology may be used to obstruct the existence of such disks. (Received September 22, 2014)

1105-57-247 **J. Scott Carter*** (carter@southalabama.edu), Department of Mathematics and Statistics, ILB 325, Mobile, AL 36688, and **Seiichi Kamada** (skamada@sci.osaka-cu.ac.jp), Division of Mathematics & Physics, Division of Mathematics & Physics, Osaka City University, Osaka, 558-8585, Japan. *Braided Manifolds in All Dimensions.*

Following Kamada's notion of a braid chart that is used to describe a surface braid, we construct higher dimensional charts for simple branched covers of the n-sphere whose branched set is a give knotted oriented

$(n-2)$-dimensional manifold. the talk will focus upon examples, and the speaker hopes to end with a collection of problems that are central tot eh theory. (Received September 22, 2014)

1105-57-264 **Sandy Ganzell*** (sganzell@smcm.edu). *Ideals Generated by Local Moves in Link Diagrams.* Preliminary report.

For a given set M of local moves in a link diagram, we define and study ideals in the ring of Laurent polynomials. For a given positive integer n, if two diagrams differ by a sequence of moves in M then their n-cabled Jones polynomials will be equal in the induced quotient ring. The ideals are used to study both the local moves and the Jones polynomial itself. (Received September 22, 2014)

1105-57-278 **Michael A. Abel*** (maabel@vce.edu) and **Matt Hogancamp**. *An algebraic construction of colored HOMFLY-PT homology.* Preliminary report.

We construct complexes of Soergel bimodules which categorify the Young idempotents corresponding to one-column partitions. Using these categorical idempotents, we construct a triply graded link homology theory which categorifies the HOMFLY-PT polynomial colored by one-column partitions. This link homology theory specializes to Khovanov-Rozansky homology in the uncolored case. (Received September 22, 2014)

1105-57-287 **Jing Wang*** (gwjwang@gwu.edu) and **Jozef Przytycki**. *Quiver Homology: Khovanov Approach and Barycentric Subdivision Approach.*

Few years after Khovanov homology was introduced as the categorification of Jones polynomial for knots, its version for graphs was developed by Helme-Guizon and Rong, Later in 2005, Przytycki observed the relation with Hochschild homology. In this talk, I will define quiver homology (homology of directed graphs) via two different approaches. Our first approach generalizes Khovanov type graph homology to non-commutative algebra case by considering abstract simplicial complex structure. In an alternative approach, we apply homology theory of a small category with functor coefficients and follow the idea of multi-paths proposed by Turner and Wagner. In particular, we can realize it as the barycentric subdivision from the first definition. (Received September 22, 2014)

1105-57-293 **Patricia Cahn*** (pcahn@math.upenn.edu) and **Vladimir Chernov**. *The Classification of V-Transverse Knots and Loose Legendrians.*

We classify knots in a 3-manifold M that are transverse to a nowhere zero vector field V, up to the corresponding isotopy relation. When V is the co-orienting vector field of a contact structure, these knots are the same as pseudo-Legendrian knots, which were introduced by Benedetti and Petronio. We show that two loose Legendrian knots with the same overtwisted disk in their complement are Legendrian isotopic if and only if they are pseudo-Legendrian isotopic, generalizing results of Dymara and Ding-Geiges. V-transverse knots are naturally framed. We show that each framed isotopy class contains infinitely many V-transverse isotopy classes whose elements are pairwise distinct up to V-transverse homotopy, provided that one of the following conditions holds: V is a co-orienting vector field of a tight contact structure; the manifold M is irreducible and atoroidal; or, the Euler class of a 2-dimensional bundle orthogonal to V is a torsion class. We also give examples of infinite sets of distinct V-transverse isotopy classes whose representatives are all V-transverse homotopic and framed isotopic. (Received September 22, 2014)

1105-57-295 **Hugh Howards** and **Jason Parsley*** (parslerj@wfu.edu). *Brunnian spheres in higher dimensions.*

We demonstrate that convex Brunnian links exist for every dimension $n \geq 3$ by constructing explicit examples. These examples are three-component links which are higher-dimensional generalizations of the Borromean rings. (Received September 22, 2014)

1105-57-296 **Claus Ernst*** (claus.ernst@wku.edu), Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101. *Loop numbers in knot diagrams.* Preliminary report.

For a given knot diagram D one can traverse the knot diagram and count the number of loops created by the traversal. The number of loops created depends on the starting point in the diagram D and on the traversal direction. Looking at the minimum or maximum number of loops over all starting points and directions one can define loop numbers of the diagram D. If one looks over all minimal diagrams D of a knot type these loop numbers become knot invariants. In this talk we make some elementary observations about such loop numbers. (Received September 22, 2014)

1105-57-297 **Y. Diao**, **C Ernst**, **E Rawdon** and **U Ziegler*** (uta.ziegler@wku.edu), Department of Computer Science, Western Kentucky University, 1906 College Heights Blvd, Bowling Green, KY 42101. *How confinement conditions effect topological and geometric properties of random polygons.*

A polymer in confinement is represented by an N-segment, unit-length, free-jointed, closed polygon in spherical confinement. Our algorithm generates segments sequentially and each segment is added based on mathematically derived cumulative conditional probability density functions. This talk discusses the outcomes of a study which investigates the dependence of the knotspectrum and geometric properties of these polygons on the length of the polygons (with fixed confinement size) and on the confining radii (with fixed polygon length). (Received September 22, 2014)

1105-57-314 **Oliver Dasbach***, Department of Mathematics, Baton Rouge, LA 70803, and **Anastasiia Tsvietkova**, CA. *Volume estimates from link diagrams, and from the colored Jones polynomial.*

We will give estimates for the hyperbolic volume of link complements coming from the combinatorics of their diagrams. We will relate those estimates to the colored Jones polynomial. (Received September 23, 2014)

1105-57-348 **Krzysztof K. Putyra** and **Alexander N. Shumakovitch*** (shurik@gwu.edu), Monroe Hall, 2115 G St. NW, room 240, Department of Mathematics, The George Washington University, Washington, DC 20850. *Knot invariants arising from homological operations on Khovanov homology.* Preliminary report.

There are several homological operations that can be defined between even and odd Khovanov homology theories using the unified even/odd Khovanov homology theory developed by Putyra. We discuss these homological operations and show how they can give rise to new knot invariants with interesting properties. (Received September 23, 2014)

58 ► Global analysis, analysis on manifolds

1105-58-9 **Saman Moradian Jahoudbejari*** (saman_com69@yahoo.com), Shahed alley, Janbazan street, 4351846443 Fouman, Guilan, Iran. *Numerical Analysis and Partial Differential Equations.* Preliminary report.

We study two quite different approaches to understanding the complexity of fundamental problems in numerical analysis. We show that both hinge on the question of understanding the complexity of the following problem, which we call PosSLP: Given a divisionfree straight-line program producing an integer N, decide whetherN >0. We show that PosSLP lies in the counting hierarchy, and we show that if A is any language in the Boolean part of PR accepted by a machine whose machine constants are algebraic real numbers, then A 2 PPosSLP. Combining our results with work of Tiwari, we show that the Euclidean Traveling Salesman Problem lies in the counting hierarchy – the previous best upper bound for this important problem (in terms of classical complexity classes) being PSPACE (Received May 04, 2014)

1105-58-292 **Manousos Maridakis*** (manousos.maridakis@rutgers.edu), Hill Center for mathematical Sciences, Bush Campus, Piscataway, NJ 08854. *The concentration principle for Dirac operators.*

The symbol map of a Fredholm Operator is carrying essential topological and geometrical information about the underline manifold. Our approach to this direction is by studying Dirac operators involving a perturbation term. In particular we think of operators of the form $\mathcal{D}+s\mathcal{A}:\Gamma(E)\to\Gamma(F)$ over a Riemannian manifold (X,g) for special bundle maps $\mathcal{A}:E\to F$ and study their behavior as $s\to\infty$. We start with a simple criterion that insures localization. Two main aspects of localization are being examined : First is the separation of the spectrum of this family of operators into low and high eigenvalues for large s. Second is the observation that eigenvectors corresponding to low eigenvalues L^2 concentrate near the singular set of the perturbation bundle map $\mathcal{A}$. This gives a new localization formula for the index of $\mathcal{D}$ in terms of the singular set of $\mathcal{A}$. (Received September 22, 2014)

65 ► Numerical analysis

1105-65-1 **Susanne C Brenner*** (brenner@math.lsu.edu), Department of Mathematics, Center for Computation & Technology, Louisiana State University, Baton Rouge, LA 70803. *Novel Finite Element Methods for Optimal Control Problems with PDE Constraints.*

Let Ω be a bounded convex polygonal domain in $\mathbb{R}^2$. A model elliptic optimal control problem with pointwise state constraints is to find the minimizer of the functional

$$J(y,u) = \int_\Omega (y - y_d)^2\,dx + \beta \int_\Omega u^2\,dx,$$

where $(y,u) \in H_0^1(\Omega) \times L_2(\Omega)$ are subjected to the constraints

$$\int_\Omega \nabla y \cdot \nabla v\,dx = \int_\Omega uv\,dx \qquad \forall\, v \in H_0^1(\Omega),$$
$$\psi_1 \le y \le \psi_2 \qquad \text{a.e. in } \Omega.$$

We will present finite element methods for this optimal control problem that are based on the reformulation of the problem as a fourth order elliptic variational inequality for y, discuss their *a priori* and *a posteriori* error analyses, and introduce post-processing procedures that generate approximations of the optimal control u from the approximations of the optimal state y.

This talk is based on joint work with C.B. Davis, J. Gedicke, L.-Y. Sung, H. Zhang and Y. Zhang. (Received September 22, 2014)

1105-65-17 **Frank. Etin-Osa Bazuaye*** (febazuaye@yahoo.com), Department of Mathematics and Statistics, University of Portharcourt, Portharcourt, Rivers state, +234, Nigeria, and **U. A. Osisiogu** (uaosisiogu1@yahoo.com), Dept. of Mathematics and Applied Statistics., Ebonyi State University, Abakiliki, Ebonyi State, +234, Nigeria. *Construction of Extended Exponential General Linear Methods.*

This paper is concerned with the construction, Numerical Analysis of Extended Exponential General Linear Methods. These methods are related to Butcher, Ostermann and Calvo and Palencia Methods, but, in contrast to the later, make use of higher terms of the exponential and related matrix functions. This feature enables us to derive the order conditions which in turn aided in the construction of family of methods of higher order. Numerical experiments indicate that Extended Exponential General Linear Methods perform better than existing Methods. (Received June 13, 2014)

1105-65-19 **Alexander Linke**, **Michael Neilan**, **Leo Rebholz*** (rebholz@clemson.edu) and **Nick Wilson**. *A connection between coupled and penalty projection timestepping schemes with FE spatial discretization for the Navier-Stokes equations.*

We prove that in finite element settings where the divergence-free subspace of the velocity space has optimal approximation properties, the solution of Chorin/Temam projection methods for Navier-Stokes equations equipped with grad-div stabilization with parameter γ, converge to the associated coupled method solution with rate γ^{-1} as $\gamma \to \infty$. We prove this first for backward Euler schemes, and then extend the results to BDF2 schemes, and finally to schemes with outflow boundary conditions. Several numerical experiments are given which verify the convergence rate, and show how using projection methods in this setting with large grad-div stabilization parameters can dramatically improve accuracy. (Received July 02, 2014)

1105-65-20 **Xiaoming He*** (hex@mst.edu), Department of Mathematcis and Statistics, 400 W 12th St, Missouri University of Science and Technology, Rolla, MO 65401, and **Jian Li**, **Yanping Lin** and **Ju Ming**. *A multi-physics domain decomposition method for Navier-Stokes-Darcy model.*

The Navier-Stokes-Darcy model arises in many interesting real world applications, including groundwater flows in karst aquifers, interaction between surface and subsurface flows, industrial filtrations, fractured reservoir, and so on. This model describes the free flow of a liquid by the Navier-Stokes equation and the confined flow in a porous media by the Darcy equation; the two flows are coupled through interface conditions.

This presentation discusses a multi-physics domain decomposition method for solving the coupled steady state Navier-Stokes-Darcy system with the Beavers-Joseph interface condition. The wellposedness of this system is first showed by using a branch of singular solutions and the existing theoretical results on the Beavers-Joseph interface condition. Then Robin boundary conditions on the interface are constructed based on the physical interface conditions to decouple the Navier-Stokes and Darcy parts of the system. A parallel iterative domain decomposition method is developed according to these Robin boundary conditions and then analyzed for the

convergence. Numerical examples are presented to illustrate the features of this method and verify the theoretical results. (Received July 02, 2014)

1105-65-22 **Xuping Xie*** (xupingxy@vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Numerical Analysis of Stabilized POD-ROMs.*

In this talk, we present a theoretical and numerical investigation of a new stabilized proper orthogonal decomposition reduced order model (POD-ROM). We will pose a particular emphasis on the specific filtering procedure used in the derivation of this POD-ROM. We will include numerical tests for several challenging computational settings, as well as an error analysis for the finite element discretization of the new POD-ROM. (Received September 22, 2014)

1105-65-25 **Lili Ju***, Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Fast Explicit Integration Factor Methods for Semilinear Parabolic Equations.*

In this talk, we present an explicit numerical method and its fast implementation for the solution of a wide class of semilinear parabolic equations including the Allen-Cahn equation as a special case. The method combines decompositions of compact spatial difference operators on a regular mesh with stable and accurate exponential time integrators and efficient discrete FFT-based algorithms. It can deal with stiff nonlinearity and both homogeneous and inhomogeneous boundary conditions of different types based on multistep approximations and analytic evaluations of time integrals. Numerical experiments demonstrate effectiveness of the new method for both linear and nonlinear model problems. (Received July 28, 2014)

1105-65-26 **Zhu Wang*** (zwangdr@gmail.com), Department of Mathematics, 1523 Greene Street, University of South Carolina, Columbia, SC 29208. *Reduced-Order Modeling of Complex Fluid Flows.*

In many scientific and engineering applications of complex fluid flows such as the flow control and optimization problem, computational efficiency is of paramount importance. Thus, model reduction techniques are frequently used. To achieve a balance between the low computational cost required by a reduced-order model and the complexity of the target turbulent flows, appropriate closure modeling strategies need to be employed. In this talk, we present reduced-order modeling strategies synthesizing ideas originating from proper orthogonal decomposition and large eddy simulation, develop rigorous error estimates and design efficient algorithms for the new reduced-order models. (Received July 29, 2014)

1105-65-32 **Amanda Diegel*** (diegel@math.utk.edu), **Steve Wise**, **Xiaobing Feng** and **Cheng Wang**. *Analysis of Mixed FEMs for Cahn-Hilliard-Flow Models.*

Here I present the analysis of both first order and second order (in time) numerical schemes for Cahn-Hilliard-flow equations. The time discretizations are based on a convex splitting of the energy of the equations and we use a continuous Galerkin discretization of space. Our schemes are unconditionally energy stable with respect to a spatially discrete analogue of the continuous free energy of the system and are unconditionally uniquely solvable. Furthermore, we prove that the discrete phase variable is bounded in $L^\infty(0,T;L^\infty)$ and the discrete chemical potential is bounded in $L^\infty\left(0,T;L^2\right)$, for any time and space step sizes, in two and three dimensions, and for any finite final time T. We subsequently prove that these variables converge with optimal rates in the appropriate energy norms in both two and three dimensions. (Received August 10, 2014)

1105-65-39 **Youngjoon Hong*** (hongy@indiana.edu), 831 E. 3rd Street, Bloomiongton, IN 47405. *Numerical methods for inviscid primitive equations of the atmosphere with humidity and saturation.*

In this talk, I will present a finite volume scheme to solve the two dimensional inviscid primitive equations of the atmosphere with humidity and saturation, in presence of topography and subject to physically plausible boundary conditions to the system of equations. In that respect, a version of a projection method is introduced to enforce the compatibility condition on the horizontal velocity field, which comes from the boundary conditions. The resulting scheme allows for a significant reduction of the errors near the topography when compared to more standard finite volume schemes. In the numerical simulations, we first present the associated good convergence results that are satisfied by the solutions simulated by our scheme when compared to particular analytic solutions. We then report on numerical experiments using realistic parameters. Finally, the effects of a random small-scale forcing on the velocity equation is numerically investigated. (Received August 16, 2014)

1105-65-47 **Michael J Neilan*** (neilan@pitt.edu) and **Duygu Sap** (duygusap@googlemail.com).
Stokes Elements on Cubic Meshes Yielding Divergence-Free Approximations.

Using a finite element exterior calculus framework, conforming piecewise polynomial spaces with respect to cubic meshes are constructed for the Stokes problem in arbitrary dimensions yielding exactly divergence–free velocity approximations. We first discuss the construction of the lowest order case, its implementation, and convergence analysis. We then introduce finite element spaces with continuous pressure approximations leading to a system of less unknowns. Finally, numerical experiments are shown verifying the theoretical results. (Received August 25, 2014)

1105-65-59 **Daniel X Guo*** (guod@uncw.edu), 601 South College Road, Wilmington, NC 28403-5970.
Convergence and stability of second order Semi-Lagrangian method for the time-dependent partial differential equations.

A second-order Semi-Lagrangian method was proposed to compute the numerical solutions of time-dependent partial differential equations. This method was based on Lagrangian trajectory or the integration from the departure points to the arrival points (regular nodes). The departure points were traced back from the arrival points along the trajectory of the path. The convergence and stability were investigated for the different circumstances. (Received August 29, 2014)

1105-65-64 **Abner J Salgado*** (asalgad1@utk.edu). *A diffuse interfase model for two-phase ferrofluid flows.* Preliminary report.

We develop a model describing the behavior of two-phase ferrofluid flows using phase field-techniques and present an energy-stable numerical scheme for this model. For a simplified version of this model and the corresponding numerical scheme we prove, in addition to stability, convergence and as by-product existence of solutions. With a series of numerical experiments we illustrate the potential of these simple models and their ability to capture basic phenomenological features of ferrofluids such as the Rosensweig instability. (Received September 02, 2014)

1105-65-65 **Susanne Brenner**, **Peter Monk** and **Jiguang Sun*** (jiguangs@mtu.edu), Fisher 313, MTU, 1400 Townsend Dr., Houghton, MI 49931. *C0IPG Method for Biharmonic Eigenvalue Problems.*

We investigate the C^0 interior penalty Galerkin (C^0 IPG) method for biharmonic eigenvalue problems with the boundary conditions of the clamped plate, the simply supported plate, and the Cahn-Hilliard type. We prove the convergence of the method and present numerical results to illustrate its performance. We also compare the C^0 IPG method with the Argyris C^1 finite element method and the Ciarlet-Raviart mixed finite element method. (Received September 02, 2014)

1105-65-75 **Stefan R. Schnake*** (schnake@math.utk.edu). *A MATLAB Toolbox for Discontinuous Galerkin Finite Element Differential Calculus.*

This talk covers a Matlab implementation of a newly developed discontinuous Galerkin finite element (DGFE) differential calculus (by Feng, Lewis, and Neilan) for approximating the derivatives of weakly differentiable and piecewise weakly differentiable functions. I will first introduce the DGFE derivative definition, its main properties, and give an algebraic representation for the DGFE derivative. Then I shall describe in detail the design of the Matlab Toolbox for implementing the DGFE differential calculus. Numerical experiments and results will be demonstrated using the Toolbox. (Received September 04, 2014)

1105-65-99 **James V Lambers*** (james.lambers@usm.edu), 118 College Dr #5045, Hattiesburg, MS 39402. *Approximate diagonalization of variable-coefficient differential operators through similarity transformations.*

Approaches to approximate diagonalization of variable-coefficient differential operators using similarity transformations are presented. These diagonalization techniques are inspired by the interpretation of the Uncertainty Principle by Fefferman, known as the SAK Principle, that suggests the location of eigenfunctions of self-adjoint differential operators in phase space. The similarity transformations are constructed using canonical transformations of symbols and anti-differential operators for making lower-order corrections. Numerical results indicate that the symbols of transformed operators can be made to closely resemble those of constant-coefficient operators, and that approximate eigenfunctions can readily be obtained. (Received September 09, 2014)

1105-65-120 **Mine Akbas Belenli*** (miakbasb@metu.edu.tr), Middle East Technical University, Department of Mathematics, Ankara, 06800, and **Songul Kaya Merdan** and **Leo G. Rebholz**. *An explicitly decoupled variational multiscale method for incompressible, non-isothermal flows.*

We propose, analyze and test a fully decoupled, but still unconditionally stable and optimally accurate, variational multiscale stabilization (VMS) for incompressible, non-isothermal fluid flows. The VMS stabilization is implemented as a post-processing step, and thus can be used with existing codes. A full numerical analysis of the method is given that proves unconditional stability with respect to the timestep size, and that the method converges optimally in both time and space. Numerical tests are provided that confirm the theoretical results, and test the method on a benchmark problem for Marsigli flow. (Received September 12, 2014)

1105-65-152 **Elyse M. Garon*** (elyse.garon@eagles.usm.edu), 309 North Pine Street, Gramercy, LA 70052, and **James V. Lambers** (james.lambers@usm.edu), 118 College Dr #5045, Hattiesburg, MS 39406. *Computing Eigenfunctions of Differential Operators with Piecewise Constant Coefficients Using the Uncertainty Principle.* Preliminary report.

As part of an effort to develop more accurate and efficient numerical methods for solving PDE with piecewise constant coefficients, we will describe an approach to computing a basis of eigenfunctions. These eigenfunctions will have the form of trigonometric functions that change frequency at discontinuities; therefore, amplitude, frequency, and phase shift are the only parameters that need to be determined. Properties such as continuity, periodicity, and orthogonality can be used to eliminate some of these parameters. To find the remaining parameters, iteration will be used. Fefferman's SAK principle, based on the Uncertainty Principle, provides excellent initial guesses for iteration. Numerical results will demonstrate the effectiveness of this approach. (Received September 16, 2014)

1105-65-159 **Yanlai Chen*** (yanlai.chen@umassd.edu), North Dartmouth, MA 02747, and **Bernardo Cockburn** (cockburn@math.umn.edu), Minneapolis, MN 55455. *Superconvergence Properties of Variable-degree HDG Methods when hanging nodes are present.*

The discontinuous Galerkin method is known to handle nonconforming meshes easily. In the simple setting of steady-state, pure diffusion, the presence of hanging nodes does degrade the order of accuracy of the classic discontinuous Galerkin methods for a wide class of meshes. This can also be shown to hold for the so-called hybridizable discontinuous Galerkin methods. However, since these methods are more accurate than all the classic discontinuous Galerkin methods, one wonders if the presence of the hanging nodes has an adverse effect on their remarkable superconvergence properties on unstructured meshes. We provide the first, rigorous a priori error analysis that shows that the superconvergence properties of the hybridzable discontinuous Galerkin methods remain unaffected by the presence of hanging nodes for the so-called semimatching nonconforming meshes. We also present quantification of the degradation when general nonconforming meshes are used. Finally we discuss an extension of these results to case in which the degree of the local polynomial approximation changes from element to element. (Received September 16, 2014)

1105-65-166 **Yanlai Chen**, **Bernardo Cockburn** and **Bo Dong*** (bdong@umassd.edu). *Superconvergent HDG methods for linear, stationary, third-order equations in one-space dimension.*

We design and analyze *the first* hybridizable discontinuous Galerkin methods for stationary, third-order linear equations in one-space dimension. The methods are defined as discrete versions of characterizations of the exact solution in terms of local problems and transmission conditions. They provide approximations to the exact solution u and its derivatives $q := u'$ and $p := u''$ which are piecewise-polynomials of degree k_u, k_q and k_p, respectively. We consider the methods for which the difference between these polynomial degrees is at most two. We prove that all these methods have superconvergence properties which allows us to prove that their numerical traces converge at the nodes of the partition with order at least $2\,k+1$, where k is the minimum of k_u, k_q, k_p. This allows us to use an element-by-element post-processing to obtain new approximations for u, q and p converging with order at least $2k+1$ uniformly. Numerical results validating our error estimates are displayed. (Received September 17, 2014)

1105-65-175 **Andreas C Aristotelous***, aaristot@temple.edu, and **Ohannes A Karakashian** and **Steven M Wise**. *Second Order in Time, Adaptive Discontinuous Galerkin Methods for a Cahn-Hilliard Equation with a Mass Source.*

Fully discrete discontinuous Galerkin Finite Element methods with variable time steps and adaptive meshes in space are developed for the fourth order Cahn-Hilliard equation with an added nonlinear reaction term motivated from biological applications. The second order in time accurate methods are formulated and analyzed in both

two and three dimensions. Convergence under mesh modification is demonstrated and simulation results in two dimensions are provided. (Received September 18, 2014)

1105-65-179 **Kamana Porwal*** (kporwal@math.lsu.edu), Office No 2087, Center for Computation and Technology, Louisiana State University, Baton Rouge, LA 70803. *A posteriori error control of discontinuous Galerkin methods for elliptic obstacle problem.*

In this talk I will present an a posteriori error estimator for various discontinuous Galerkin (DG) methods for the elliptic obstacle problem. This error estimator is obtained by the help of a nonlinear smoothing function from a DG finite element space to a CG finite element space. The error estimator is comparable with the known error estimators for conforming finite element method. Using a key property of DG methods, the analysis is performed in a unified framework. The error estimator consists of a discrete Lagrange multiplier associated with obstacle constraint which is shown to be uniformly stable on nonuniform meshes. Finally, numerical results will be presented to illustrate the performance of the error estimator. This is joint work with Dr. Thirupathi Gudi. (Received September 23, 2014)

1105-65-188 **Ryan Reed Grove*** (rgrove@clemson.edu), 201 Tiliwa Ct Apt 121, Central, SC 29630, and **Timo Heister**. *Comparison of Nonlinear and Linear Stabilization Schemes for Advection-Diffusion Equations.*

Standard finite element discretizations of advection-diffusion equations introduce unphysical oscillations around steep gradients. Therefore, stabilization must be added to the discrete formulation to obtain correct solutions. The SUPG, dCG91, and Entopy Viscosity schemes are compared using stationary and non-stationary test equations. Differences in maximum overshoot and undershoot, smear, and convergence orders are compared using code written using deal.ii. (Received September 19, 2014)

1105-65-193 **Timo Heister*** (heister@clemson.edu), **Mary F Wheeler** and **Thomas Wick**. *A massively parallel active-set algorithm for phase-field crack propagation with adaptive mesh refinement.*

We present an algorithm based on the active set strategy to simulate crack propagation using a quasi-static fracture model. The crack is discretized using a phase-field approach, which allows merging and joining of cracks. The system is solved in a monolithic fashion. We include a new strategy for adaptive mesh refinement. The whole scheme is parallelized and scales to a large number of cores. (Received September 19, 2014)

1105-65-210 **John P Roop*** (jproop@yahoo.com), Department of Mathematics, 1601 E. Market St., Greensboro, NC 27411. *Anomalous Nonlocal Generalizations of the Reaction Diffusion Equation: Analysis and Computation.* Preliminary report.

In this talk, we review several anomalous and nonlocal generalizations of the reaction diffusion equation $u_t - \nabla \cdot (\kappa \nabla u) = f(u)$. Numerical solutions to the reaction diffusion equation serve as a starting point for student research projects because a discretizations are straightforward, the equations are widely applicable, several papers have been written on the various mathematical properties, and generalizations can model anomalous diffusion and nonlocal reaction phenomena. First, the diffusion term may be generalized using a more generic anisotropic diffusion $\nabla \cdot (\kappa(|\nabla u|)\nabla u)$ used in for example image processing, the p-Laplacian, or diffusion driven instability. In addition, the diffusion term may be generalized using a fractional order diffusion operator of which several forms exist, e.g. $\nabla \cdot (\kappa \mathcal{D}^{-\beta} \nabla u)$, a fractional order integral, or $\kappa \int_{B_\epsilon} |x-\xi|^{-\alpha}(u(x)-u(\xi))d\xi$, a nonlocal fractional order convolution operator. Finally, a reaction term will satisfy the traditional analysis when it is an "operator of order zero." One generalization is when the reaction operator takes the form $\nabla \cdot (u\, B(u))$. (Received September 20, 2014)

1105-65-229 **Cody Samuel Lorton*** (clorton@uwf.edu). *An unconditionally stable discontinuous Galerkin method for the elastic wave equations in the frequency domain with large frequency.*

Wave scattering arises in many scientific and engineering fields including geosciences, materials science, and medical science, computing high frequency waves is challenging due to the shear amount of computations involved and the strongly indefinite nature of these problems. This talk is concerned with numerical approximations of elastic waves in the frequency domain which are described by the elastic Helmholtz equations. The focus of the talk is to present an interior penalty discontinuous Galerkin (IP-DG) method for the elastic Helmholtz equations. The proposed IP-DG method is proved to be unconditionally stable with respect to both frequency ω and mesh size h, while the existing numerical methods for the elastic Helmholtz equations are only proven to be stable in an asymptotic mesh regime when $\omega^\alpha h = O(1)$ for some $\alpha \geq 2$. Error estimates, which show explicit dependence on the frequency (and mesh size), are also obtained for all mesh regimes. Numerical experiments will be presented

to demonstrate the accuracy of the proposed IP-DG method and its advantages over standard finite element methods. This talk is based on a joint work with Xiaobing Feng of the University of Tennessee at Knoxville. (Received September 21, 2014)

1105-65-242 **Natasha Sharma*** (nssharma@utep.edu), 500 W. University Avenue, El Paso, TX 79968, and **Guido Kanschat**. *Convergence of an adaptive Divergence-conforming Discontinuous Galerkin Method for the Stokes Problem.*

The convergence analysis of an adaptive Discontinuous Galerkin method for the Stokes problem relies heavily on a certain quasi-orthogonality property which is difficult to establish for this saddle point problem. The difficulty arises due to the coupling of the pressure and velocity and the inability to separate them for the analysis. In this talk, we present a discrete Hodge decomposition of the velocity space thereby allowing us to obtain error estimates for the divergence-free velocity independent of the pressure and hence, prove the crucial quasi-orthogonality property. Numerical results will be presented to illustrate the performance of this method. (Received September 22, 2014)

1105-65-244 **Guglielmo Scovazzi*** (guglielmo.scovazzi@duke.edu), Room 121 Hudson Hall, Box 90287, Durham, NC 27708-0287. *A high-order, fully-coupled, upwind, compact discontinuous Galerkin method for modeling of viscous fingering in compressible porous media.*

We present a new approach for high-fidelity porous media flow simulation, based on a fully coupled, upwind, high- order discontinuous Galerkin formulation of miscible (com- pressible) displacement transport. The proposed method is flexible on complex subsurface geometries and captures the strong interaction between pressure and transported concentrations in highly compressible media. It also shows very low sensitivity to mesh orientation and its robustness and accuracy are demonstrated in a number of compressible and incompressible multiphase flow problems. (Received September 22, 2014)

1105-65-246 **Susanne C. Brenner**, **Li-yeng Sung** and **Yi Zhang*** (yzhan112@utk.edu). *C^0 Interior Penalty Methods for an Elliptic Distributed Optimal Control Problem.*

We consider an elliptic optimal control problem with pointwise state constraints on convex polygonal domains and solve it as a fourth order variational inequality for the state by C^0 interior penalty methods. The approximation of the optimal control is obtained by a post-processing procedure. We will present error estimates and numerical results both on uniform and adaptive meshes. (Received September 22, 2014)

1105-65-267 **Susanne C. Brenner**, **Christopher B. Davis*** (cbdavis@tntech.edu) and **Li-yeng Sung**. *An enriched partition of unity method for a class of variational inequalities.*

In this talk, we consider an enriched partition of unity method of some elliptic fourth order variational inequalities. As examples we will consider the displacement obstacle problem for simply supported Kirchhoff plates and an elliptic distributed optimal control problem with pointwise state constraints. With the appropriate choice of enrichment functions, we show that this method is able to obtain the optimal rate of convergence in the energy norm. This talk will consist of details of the method, convergence analysis, and numerical examples. (Received September 22, 2014)

1105-65-268 **David R Wells*** (drwells@vt.edu). *Stabilization of POD-ROMs.*

Proper Orthogonal Decomposition, or POD, is an important technique in the field of Reduced Order Modeling, or ROM. By definition, a reduced order model cannot recover all scales of motion present in the original model, which can be a source of instability that unnecessarily hinders the ROM. In this talk we will discuss stabilization techniques for POD-ROMs inspired by stabilization techniques in Finite Element methods. We will show both error estimates and numerical examples that benefit from stabilization. (Received September 22, 2014)

1105-65-317 **Hashim A Saber*** (hashim.saber@ung.edu). *Surface Modeling of the left Ventricle of the heart.* Preliminary report.

The surgical treatment of mitral valve disease has dramatically improved with the recent development of repair techniques that avoid valve replacement with artificial valve. A better understanding of the dynamics of the normal and diseased mitral valve is necessary in order to design and test new repair maneuvers that would increase the scope of this surgery.

In this talk I will explain how to produce wireframe images (model) of the left ventricle and mitral valve using Sonomicrometry distance data. The same data is used to construct the pressure-volume loops as the most reliable load independent index of left ventricular contractility. I will also discuss a proposed three-dimensional surface model that is based on three-dimensional (3D) Sonomicrometry data.

Keywords: wire frame model, left ventricle, pressure –volume loop, surface modeling, Sonomicrometry data. (Received September 23, 2014)

1105-65-344 **Yaw Kyei*** (ykyei@ncat.edu), NC. *Space-time finite volume differencing discretizations of scalar hyperbolic conservation laws with source terms.*

A Space-time finite volume differencing discretization method is applied to construct a parameterized family of two-step explicit higher-order semi-lagrangian schemes for scalar hyperbolic conservation laws with source terms in 1d. A local space-time residual error expansion for the integral form of the equation is first formulated by using general weighted quadratures to approximate flux integrals about the centroid mesh point of each local space-time control volume. Efficient quadrature approximations of the flux integrals are sought through minimization of the residual error to account for local space-time fluxes to all neighboring mesh points within the domain of dependence of new update points. Closed form parameterized descriptions of the quadrature weights and the leading viscosity coefficients in the associated residual errors are then determined and optimized to guide the right selections of time steps in relation to spatial resolutions to minimize nonphysical oscillations and guarantee uniform higher-order convergence rates. (Received September 23, 2014)

1105-65-347 **Xiaobing Feng**, Department of Mathematics, The University of Tennessee, Knoxville, TN 37996, and **Yukun LI***, Department of Mathematics, The University of Tenneseee, Knoxville, TN 37996. *Discontinuous Galerkin methods for the Cahn-Hilliard equation and the Hele-Shaw flow.*

This talk is concerned with some new convergence results for interior penalty discontinuous Galerkin (IPDG) approximations of the Cahn-Hilliard equation and its sharp interface limit known as the Hele-Shaw flow. The main result to be presented is the convergence of the numerical interfaces to the sharp interface of the Hele-Shaw flow as both the numerical mesh parameters and the phase field parameter (called the interaction length) tend to zero. The main idea for establishing this result is to derive, by a nonstandard technique, error estimates for the IPDG solutions which blows up only polynomially (instead of exponentially) in the reciprocal of the phase field parameter. Numerical experiments will also be presented to gauge the performance of the proposed IPDG methods. (Received September 23, 2014)

76 ► Fluid mechanics

1105-76-139 **Jeff Borggaard*** (jborggaard@vt.edu), Blacksburg, VA 24061, and **Serkan Gugercin** (gugercin@vt.edu), Blacksburg, VA 24061. *Feedback Control of Vortex Shedding by Cylinder Rotation Using Interpolatory Model Reduction.*

We consider a well-studied flow control problem: Stabilizing the von Kármán vortex shedding behind a circular cylinder by controlling the cylinder rotation. Our approach develops an accurate, high-dimensional linearized model about the (unstable) steady-state solution and seeks an optimal feedback control driving the discrepancy from the steady-state solution to zero over small regions in the cylinder wake. This leads to a linear quadratic regulator problem with a high-dimensional, linear differential algebraic equation (DAE) constraint. An interpolatory model reduction approach is used to develop a low-dimensional model for this DAE constraint equation that accurately captures the input-output behavior of the system. For the problem under consideration, we have one control input (the tangential velocity on the cylinder) and a dozen controlled outputs. The resulting low-dimensional DAE is used to design the linear feedback control design for the wake stabilization problem. To test the effectiveness of this control design method, we apply the feedback control law to the original problem. This involves simulating the Navier-Stokes equations with full-state feedback. (Received September 15, 2014)

1105-76-190 **Artem N. Semakin*** (arte-semaki@yandex.ru) and **Y. Rastigejev**. *A Parallel High-order Optimized Wavelet-based Adaptive Mesh Refinement Method for Global Atmospheric Chemical Transport Simulations.*

Significant difficulties associated with numerical modeling of multi-scale global Atmospheric Chemical Transport (ACT) impose severe limitations on the spatial resolution of non-adaptive grids. The interaction of numerical diffusion caused by these crude resolutions with complex velocity field of atmospheric flows leads to large numerical errors. To address the described difficulties, we have developed an Optimized Wavelet-based Adaptive Mesh Refinement (OWAMR) method for numerical simulation of multi-scale problems. The OWAMR is a 3D adaptive parallel method that minimizes the number of grid points required to resolve the finest scales. The algorithm uses a new two-parameter adaptation criterion that significantly reduces the number of grid points compared with the standard one-parameter grid adaptation. The OWAMR has been tested for several challenging ACT

problems. Particularly, it was shown that the method correctly simulates dynamics of a pollution plume traveling on a global scale producing less than 3% error. To achieve such accuracy, conventional non-adaptive techniques would require five orders of magnitude more computational resources. The obtained results demonstrate the OWAMR ability to achieve high accuracy at a low computational cost. NSF grant HRD-1036563 (Received September 22, 2014)

1105-76-206 **Laura A Miller*** (lam9@unc.edu), CB 3250 Phillips Hall, Chapel Hill, NC 27599. *Plant Leaves Reconfigure into Cone Shapes to Reduce Drag and Flutter.*

We examine how leaves roll up into drag reducing shapes in strong flows. The dynamics of the flow around the leaves of the wild ginger and tulip poplar are described and compared to simplified sheets using 3D numerical simulations and physical models. In the actual leaf, a stable recirculation zone is formed within the wake of the reconfigured cone. In physical and numerical models that reconfigure into cones, a similar recirculation zone is observed. (Received September 20, 2014)

81 ► Quantum theory

1105-81-212 **Jacques Distler***, Physics Department, University of Texas at Austin, 2515 Speedway, MS C1600, Austin, TX 78712. $\mathcal{N} = 2$ *SCFTs, Tinkertoys and Representation Theory.*

I will give a brief introduction to a very interesting class of $d = 4$, $\mathcal{N} = 2$ superconformal quantum field theories. These theories come in families, parametrized by $\mathcal{M}_{g,n}$, the moduli space of genus-g curves with n punctures. The data to specify such a theory is (1) a choice of compact Lie algebra, j, of ADE type, (2) a closed Riemann surface, C, with n punctures and (3) a decoration at each puncture, labeled by a nilpotent orbit in $\mathfrak{j}_{\mathbb{C}}$. Many of the properties of the quantum field theory are encoded directly by this data. For instance, the low-energy dynamics on the "Coulomb branch" of the theory is determined by a complex integrable system – a parabolic Hitchin system on C, where the Higgs field has simple poles, with nilpotent residues, at the punctures. If I have time, I will discuss one application, to hyperKähler quotients of instanton moduli spaces.

In a companion talk, Andy Trimm will introduce the Superconformal Index for these theories, a generating function with very interesting representation-theoretic properties. (Received September 20, 2014)

1105-81-231 **David E. V. Rose*** (davidero@usc.edu) and **Hoel Queffelec**. *Annular Khovanov homology via trace decategorification.*

Sutured annular Khovanov homology (saKh) is a homology theory for links in the thickened annulus, categorifying the Kauffman skein module of the annulus. This invariant is interesting topologically, e.g. it detects the trivial braid. In this talk, we'll discuss work relating saKh to categorified quantum groups. More specifically, we show that saKh can be recovered from categorified quantum sl(m) via trace decategorification and classical skew Howe duality. This work gives a conceptual basis for the recently discovered action of sl(2) on saKh (by Grigsby-Licata-Wehrli) and also provides the first definition of sl(n) Khovanov-Rozansky homology for links in the thickened annulus, which we in turn show carries an action of sl(n). (Received September 21, 2014)

83 ► Relativity and gravitational theory

1105-83-279 **Andrew S Goetz*** (agoetz@math.duke.edu), Duke University Mathematics Department, Box 90320, Durham, NC 27708, and **Hubert L Bray**. *Wave Dark Matter and the Tully-Fisher Relation.*

We describe a theory of wave dark matter—also known as scalar field dark matter (SFDM) and boson star dark matter or Bose-Einstein condensate (BEC) dark matter—in spherical symmetry and its relation to the Tully-Fisher relation. We show that fixing the oscillation frequency of wave dark matter near the edge of dark galactic halos implies a Tully-Fisher-like relation for those halos. We then describe how this boundary condition may yield testable predictions for this theory of dark matter. (Received September 22, 2014)

1105-83-305 **Shabnam Beheshti*** (s.beheshti@qmul.ac.uk), School of Mathematical Sciences, Queen Mary University of London, Mile End Road, London, E1 4NS, United Kingdom, and **Shadi Tahvildar-Zadeh** (shadi@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Controlled Singular Harmonic Maps in General Relativity.* Preliminary report.

Integrability and dressing techniques have been extensively utilized in the construction and analysis of exact solutions to the Einstein vacuum and Einstein-Maxwell equations. In joint work with S. Tahvildar-Zadeh, this framework is generalized to include geometric field theories which can be cast as axially symmetric harmonic maps into a variety of symmetric spaces. Applying a control-theory perspective to the solution-generating mechanism gives rise to surprising new evidence for existence–and possible non-existence–of certain singular configurations for solutions to Einstein's Equations. Main ideas will be outlined as a first step in the study of more general integrable field theories. (Received September 23, 2014)

90 ► Operations research, mathematical programming

1105-90-21 **Jai N Singh*** (jsingh@barry.edu), 3720 NW 84 Way, Cooper City, FL 33024. *Some Remarks on the Computational Complexity of Linear Programming.*

Abstract: In this paper we present some results on the computational complexity of linear programming problems based on a particular type of measure of the curvature of the central path. 2010 Mathematics Subject Classification: 90C25, 90C51 (Received July 06, 2014)

91 ► Game theory, economics, social and behavioral sciences

1105-91-49 **Po-Keng Cheng*** (ansd39@gmail.com), Mathematics Tower B-148, Stony Brook, NY 11794, and **Frank J. Fabozzi** and **Young Shin Kim**. *Speculative bubbles and Crashes: Fundamentalists and Positive-Feedback Trading.*

In this paper, we develop and examine a simple heterogeneous agent model, where the distribution of returns generated from the model takes into account two stylized facts about financial markets: fat tails and volatility clustering. Our results indicate that the relative risk tolerance between fundamentalists and positive-feedback traders determines the path of price fluctuations. Fundamentalists are more able to dominate the market when they are more willing to take risk. In our model, fundamentalists most likely cause heavy-tailedness, and positive-feedback traders cause the formation of speculative bubbles. Moreover, the attitudes toward risk of traders vary across time and the generally low level of risk bearing by fundamentalists could explain the frequent occurrence of bubbles. (Received September 12, 2014)

1105-91-219 **Arthur Holshouser**, **Harold Reiter** and **James Rudzinski*** (jerudzin@uncg.edu). *Pilesize Dynamic One-Pile Nim and Beatty's Theorem.*

In this paper, we give the Nim value analysis of a combinatorial game and show its relationship with Beatty's Theorem. The game is a one-pile counter pickup game for which the maximum number of counters that can be removed on each successive move changes during the play of the game. The move size is bounded by a move function f whose arguments are pile sizes. (Received September 21, 2014)

92 ► Biology and other natural sciences

1105-92-4 **James Sneyd*** (sneyd@math.auckland.ac.nz). *The Dynamics of Calcium: Oscillations and Waves, Experiments and Theory.*

Oscillations in the cytoplasmic concentration of calcium is one of the most ubiquitous cellular signalling mechanisms, being used to control a wide variety of cellular processes, including muscular contraction, fluid transport, gene expression and cell differentiation. In cells that are large enough, these oscillations can form periodic waves, or even spiral waves, of increased calcium concentration.

Because of such complex dynamics, over the past 20 years mathematical modelling has played an important role in the study of calcium signalling. I shall present an overview of the field, as well as a more in-depth look at a small number of particular questions. In particular, I shall look at the properties of isolated and periodic waves of calcium, the importance of homogenisation and microdomains, the role of Markov Chain

Monte Carlo approaches to fitting single-channel data, and the possible importance of homoclinic bifurcations for understanding some of the most recent experimental results. Each of these topics will require a detailed consideration of experimental data, thus illustrating the close interplay between theoretical and experimental approaches. (Received September 19, 2014)

1105-92-37 **Jan Rychtar*** (rychtar@uncg.edu), Department of Mathematics and Statistics, Greensboro, NC 27412. *Habitat selection game in structured populations.*

The important biological problem of how groups of animals should allocate themselves between different habitats has been modelled extensively. Such habitat selection models have usually involved infinite well-mixed populations. In particular the problem of allocation over a number of food patches when movement is not costly, the ideal free distribution (IFD) model is well-developed. Here we generalize (and solve) a habitat selection game for a finite structured population. We show that habitat selection in such a structured population can have multiple stable distributions (in contrast to the equivalent IFD model that is practically unique). We also define and study a "predator dilution game" where unlike in the habitat selection game, individuals prefer to aggregate (to avoid being caught by predators due to the dilution effect) and show that this model has a unique solution when movement is unrestricted. (Received August 15, 2014)

1105-92-125 **Vinodh kumar Chellamuthu***, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504, and **Azmy S. Ackleh**, **Jacoby Carter** and **Baoling Ma**. *A Mathematical Model to Control the Impact of B. dendrobatidis in Amphibian Population.*

Chytridiomycosis is a disease that poses a serious threat to amphibian populations worldwide. Several studies show that inoculation of *Janthinobacterium lividum (Jl)* could inhibit the disease. In this study, we developed a mathematical model of an amphibian juvenile-adult population in a single pond infected with chytridiomycosis caused by the fungal pathogen *Batrachochydrium dendrobatidis (Bd)* to investigate on how the inoculation of anti-Bd bacterial species *Jl* could reduce *Bd* infection on amphibians. Furthermore, we demonstrate that temperature plays an important role in the disease dynamics. We also showed how temperature variation influence the *Bd* disease on amphibians. Our findings confirm that chytrid fungus is limited by temperature and is less likely to occur at warmer ponds. Although our results predict various scenarios where it is possible for *Jl* to limit the impact of *Bd*, better understanding of the *Jl* lifecycle is needed to fully understand such interaction. (Received September 14, 2014)

1105-92-163 **Austin J Baird*** (baird@math.duke.edu) and **Laura Miller** (lam9@unc.edu). *ELECTRO-DYNAMIC SUCTION PUMPING AT SMALL SCALES.*

Dynamic suction pumping is characterized by a bidirectional elastic wave and a non-linear frequency flow relationship. This pumping mechanism has been proposed as the driving mechanism for the vertebrate embryonic heart at the tubular stage. In this study, we consider the tubular, valveless heart of a chordate, the Ascidian *Clavelina picta*. These hearts operate at a Womersley number of about 0.3. We investigate traditional dynamic suction pumping on these small scales and show computationally and experimentally that significant flow isn't achieved. We propose a different pumping mechanism that couples traveling waves of depolarization to the contraction of the boundary. Active contractile waves replace passive elastic waves, but the resulting kinematics are similar to dynamic suction pumping. This pumping mechanism can be computationally shown to drive fluid flow at the low Womersley numbers found in Ascidian hearts. We can then improve upon this mechanism by computationally modeling a rigid boundary which surrounds the elastic pumping region. This boundary is a means to computationally model the Pericardium, a rigid, pressurized, fluid filled structure which encloses the valveless Ascidian heart. (Received September 17, 2014)

1105-92-203 **D Evangelista*** (devangel@live.unc.edu), Coker Hall CB #3280, Chapel Hill, and **T Hedrick**. *Measurements and models of large flocks of Chimney Swifts entering a chimney roost at dusk.* Preliminary report.

Chimney Swifts (Chaetura pelagica) are highly maneuverable social birds notable for roosting overnight in chimneys in groups of hundreds or thousands of birds. At dusk, birds gather in large numbers from surrounding areas near a few suitable roost sites. They then enter a very small aperture within a very short time, with the whole flock employing an orderly, but dynamic, circling pattern, even as winds shift and light levels decrease. Such repeatable, reliable behavior in a convenient urban area with fixed landmarks provides an excellent opportunity to use multi-camera videography to measure three dimensional kinematics of natural flight behavior, in the field and under challenging lighting conditions. We will describe ongoing efforts to automatically track every bird in the flock. We will also discuss kinematic and information metrics appropriate for analyzing the tracks, modeling components of the behaviors, and examining differences between strongly and weakly ordered group

flight behaviors in other bird species. Information transfer within the flock may assist in accomplishing such a difficult navigational task. (Received September 20, 2014)

1105-92-208 **Antonio Mastroberardino*** (axm62@psu.edu), **Ahmed Abdelrazec**, **Folashade Agusto** and **Lea Lanz**. *Two-sex model of the HIV/AIDS Epidemic in Cuba.* Preliminary report.

Mathematical models of infectious diseases can help assess the effectiveness of prevention strategies such as random screening and contact tracing. In this talk, we present a mathematical model for the transmission dynamics of HIV/Aids in Cuba in which both prevention strategies play a role in reducing the incidence of HIV. The population is subdivided into male and female compartments to reflect the different gender dynamics. We present a qualitative analysis of the equilibria of the governing nonlinear system and discuss directions for future work. (Received September 20, 2014)

1105-92-291 **Jonathan T. Rowell*** (jtrowell@uncg.edu). *Harvesting Ideally Motivated Populations: Ecological and Evolutionary Implications.*

Although some organisms can allocate their population distributions to maximize individual fitness, not all fitness components are directly observable to the motivated individual. Mortality risk is difficult to perceive, and it may spatially vary due to the presence of environmental conditions, concealed predators, or human-induced harvesting. This non-observability can create sinks and ecological traps within the populated area. Here I consider the regional implications in a model of an ideally motivated population when there is additional mortality within a restricted area such as a harvest zone. I examine the resulting population dynamics over differing time-scales, develop a range limit profile for harvested populations, and examine the conditions by which a population is at risk of sudden collapse due to variations in different aspects of a harvesting operation (intensity, breadth, and central location). The point of collapse is then compared with the optimal harvest rate. Finally, I demonstrate that harvest zones also induce selection pressure on a heritable, non-genetic factor (proximity fitness) that creates a successional pattern that may be confused with local fitness selection or migratory response to environmental or competitive conditions. (Received September 22, 2014)

1105-92-330 **Michael A Kelley*** (kelleyma1@appstate.edu), **Ilona Reding** (imr5662@uncw.edu), **Jonathan Rowell** (jtrowell@uncg.edu) and **Jan Rychtar** (j_rychta@uncg.edu). *Friend or Foe? A Continuous Ideal Free Distribution Approach to Dynamics of Individualistic, Cooperative, and Kleptoparasitic Populations.*

Populations distribute themselves throughout their habitat based upon a range of environmental factors. In this paper, we extend a reaction-advection model of ideally motivated populations to describe the local and regional consequences of interactions between three populations distinguished by their levels of intraspecific cooperation and interspecific competition and exploitation. These populations are taken as three stereotypical expressions of cooperative-exploitative behavior in resource collection and include: a baseline non-cooperative population that engages in interference competition, obligate cooperators who initially benefit from the presence of conspecifics, and - in a pathological example of defection - kleptoparasites who require heterospecifics to extract resources from the environment. Using both analytic techniques and simulations, we determine where different populations can coexist within the environment and investigate under what conditions one population will invade another. Kleptoparasites can initiate a long term dynamic instability when invading cooperators at high resource levels. Non-cooperators and cooperators are primarily allopatric with respect to one another and capable of resisting low-level invasions. (Received September 23, 2014)

1105-92-331 **Frithjof Lutscher** and **King-Yeung Lam*** (lam.184@math.osu.edu), 100 Math Tower, 231 W 18th Ave, Columbus, OH 43210, and **Yuan Lou**. *Evolutionarily Stable Dispersal Strategy in Closed Advective Environment.*

We study a two-species competition model of reaction-diffusion-advection type in a closed advective environment, where individuals are exposed to unidirectional flow (advection) but no individuals are lost through the boundary. The two species have the same growth and advection rates but different random dispersal rates. The linear stability analysis of the semi-trivial steady state suggests that, in contrast to the case without advection, slow dispersal is generally selected against in closed advective environments. We investigate the invasion exponent for various types of resource functions, and our analysis suggests that there might exist some intermediate dispersal rate that will be selected. When the diffusion and advection rates are small and comparable, we determine criteria for the existence of singular strategies and evolutionarily stable strategies. We further show that every singular strategy is convergent stable. (Received September 23, 2014)

1105-92-339 **Ilona M Reding*** (imr5662@uncw.edu), 104 Driftwood Court, Wrightsville Beach, NC 28480, and **Michael Kelley**, **Johnathon T. Rowell** and **Jan Rychtar**. *Friend or Foe? A Continuous Ideal Free Distribution Approach to Dynamics of Individualistic, Cooperative, and Kleptoparasitic Populations.*

Populations distribute themselves throughout their habitat based upon a range of environmental factors. In this paper, we extend a reaction-advection model of ideally motivated populations to describe the local and regional consequences of interactions between three populations distinguished by their levels of intraspecific cooperation and interspecific competition and exploitation. These populations are taken as three stereotypical expressions of cooperative-exploitative behavior in resource collection and include: a baseline non-cooperative population that engages in interference competition, obligate cooperators who initially benefit from the presence of conspecifics, and - in a pathological example of defection - kleptoparasites who require heterospecifics to extract resources from the environment. Using both analytic techniques and simulations, we determine where different populations can coexist within the environment and investigate under what conditions one population will invade another. (Received September 23, 2014)

1105-92-350 **Janet Best*** (jbest@math.ohio-state.edu), 100 Math Tower, 231 W. 18th Ave, Columbus, OH 43065, and **Michael Reed** and **H Frederik Nijhout**. *Mathematical Models of Neurochemistry: Implications for Movement.*

Many neurons change brain function by projecting changes in biochemistry to distant brain regions. Understanding how these biochemical networks interact with electrophysiological networks to produce brain function both in health and disease poses new challenges for mathematical neuroscience. In this talk, recent mathematical models will be presented showing how voluntary and involuntary movements may be modulated by such networks, and some of the mathematical challenges will be discussed. (Received September 23, 2014)

1105-92-352 **Virginia B Pasour*** (virginia.b.pasour.civ@mail.mil) and **Laura A Miller** (lam9@unc.edu). *Impact of Macrophytes on Plankton Movement.*

Small-scale interactions between water and vegetation can have a significant, complex effect on water flow. Using a two-dimensional hydrodynamic model, we represent macrophytes as a simple, flexible and deforming porous layer, varying the bending stiffnesses and porosities of the plants, as well as background flow speeds and type of flow. We also give preliminary three-dimensional results. Studying velocities, shear stress, and mixing, we show that small-scale physical biological interactions can have major and important implications for plankton patchiness, movement, and ultimate destiny. (Received September 23, 2014)

93 ► Systems theory; control

1105-93-140 **Lizette Zietsman*** (lzietsma@vt.edu), Virginia Tech, Blacksburg, VA 24061, and **Jeff Borggaard** and **Serkan Gugercin**. *Comparison of $\mathcal{H}_2$- and Proper Orthogonal Decomposition-based Compensators in LQG and MinMax Control Designs.*

Low order controllers are essential for the design of real-time feedback controllers for systems described by partial differential equations (PDEs). We consider MinMax control designs that do not require full state information by using a state estimate in the feedback law. In this study we compare two reduced order modeling approaches to obtain low order state estimators for a system described by a nonlinear PDE. In the first case we investigate an $\mathcal{H}_2$-model reduction technique for linear systems. In particular, we implement the iterative rational Krylov algorithm (IRKA) to construct a low dimensional linear state estimator. This method maintains the stability properties of the original system. In the second case we construct a nonlinear compensator by including the nonlinear terms of the state equation in the differential equation for the compensator. Proper orthogonal decomposition (POD) is then used to determine a reduced order model for the resulting nonlinear equation. We apply these approaches to Burgers equation with periodic boundary conditions. This numerical study compares several different strategies for selecting the inputs to the linearized system, different sizes of the reduced-order models, and different feedback control objectives. (Received September 15, 2014)

97 ► Mathematics education

1105-97-109 **Yajing Liu*** (yajingleo@math.ucla.edu). *Link surgery formula and L-space links.*

An L-space link is a link on which all large surgeries are L-spaces. These links turn out to be rich in geometry and simple in algebra. I will present some properties and examples of L-space links in contrast to L-space knots, give

bounds on the ranks of their Floer homology and on the coefficients in the multi-variable Alexander polynomials, and show how to use Manolescu-Ozsvath link surgery formula to describe the Floer homology of surgeries on any L-space link. As an application, we compute the whole package of Heegaard Floer homology of surgeries on 2-component L-space links in terms of only the Alexander polynomial and the surgery framing. (Received September 11, 2014)

2010 MATHEMATICS SUBJECT CLASSIFICATION

Compiled in the Editorial Offices of MATHEMATICAL REVIEWS and ZENTRALBLATT MATH

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
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
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control; optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
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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