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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
1101	June 16–19, 2014	Tel Aviv, Israel	TBA	None
1102	September 20–21, 2014	Eau Claire, WI	July 29	Vol 35, No. 3
1103	October 18–19, 2014	Halifax, Canada	August 19	Vol 35, No. 3
1104	October 25–26, 2014	San Francisco, CA	September 3	Vol 35, No. 4
1105	November 8–9, 2014	Greensboro, NC	September 16	Vol 35, No. 4
1106	January 10–13, 2015	San Antonio, TX	TBA	Vol 36, No. 1
1107	March 7–8, 2015	Washington, DC	TBA	TBA
1108	March 13–15, 2015	East Lansing, MI	January 20	TBA
1109	March 27–29, 2015	Huntsville, AL	TBA	TBA
1110	April 18–19, 2015	Las Vegas, NV	TBA	TBA
1111	June 10–13, 2015	Porto, Portugal	TBA	Vol N, No. A
1112	October 3–4, 2015	Chicago, IL	TBA	TBA
1113	October 17–18, 2015	Memphis, TN	August 18	TBA
1114	October 24–25, 2015	Fullerton, CA	TBA	TBA
1115	November 14–15, 2015	New Brunswick, NJ	TBA	TBA

KNOXVILLE, TN, March 21–23, 2014

Abstracts of the 1097th Meeting.

00 ► General

1097-00-192 **Rotem Ben-Shachar*** (rotem.ben.shachar@duke.edu) and **Katia Koelle** (katia.koelle@duke.edu). *A within-host mathematical model of dengue infection and disease severity.*

Infection with dengue virus results in a wide spectrum of clinical manifestation, ranging from asymptomatic infection to dengue hemorrhagic fever. Both experimental and observational studies have focused on identifying the reasons for this variability in disease outcome and on ways to anticipate when a dengue infection may result in severe disease. These studies have indicated that excessive activation of the immune response during a dengue infection may lead to a cascade of cytokine production known as a cytokine storm, that ultimately leads to a risk of hemorrhage. We developed a within-host mathematical model of dengue infection that links viral and immunological dynamics to the risk of developing severe disease. The model includes the role of the innate immune response in limiting viral infection and in contributing to disease, as well as both the enhancing and protective roles of the adaptive immune response. We show that the model is consistent with known risk factors for developing severe disease, and reproduces the relationship between known markers of disease severity and the risk of developing severe disease. We then use the model to shed light on why these relationships might exist and in what ways these markers might be limited in their predictive power. (Received January 21, 2014)

05 ► Combinatorics

1097-05-5 **Maria Chudnovsky***, Columbia University, Department of IEOR, Mudd Bldg., 500 W 120th Street, New York, NY 10027. *Coloring graphs with forbidden induced subgraphs.*

Since graph-coloring is an NP-complete problem in general, it is natural to ask how the complexity changes if the input graph is known not to contain a certain induced subgraph H. Due to results of Kaminski and Lozin, and Hoyler, the problem remains NP-complete, unless H is the disjoint union of paths. Recently the question of coloring graphs with a fixed-length induced path forbidden has received considerable attention. Only one case of that problem remains open for k-coloring when k$\geq$ 4, and that is the case of 4-coloring graphs with no induced 6-vertex path. However, little is known for 3-coloring. Recently we settled the first open case for 3-coloring; namely we showed that 3-coloring graphs with no induced 7-vertex paths can be done in polynomial time. We also made progress on the 4-coloring question. In this talk we will discuss some of the ideas of the algorithms.

This is joint work with Peter Maceli, Juraj Stacho and Mingxian Zhong. (Received May 09, 2013)

1097-05-9 **Tri Lai*** (tmlai@indiana.edu), 2001 E Lingelbach Ln, Apt 238, Bloomington, IN 47408. *Proof of a multiparameter generalization of Aztec diamond theorem.*

We generalize Aztec diamond theorem (N. Elkies, G. Kuperberg, M. Larsen, and J. Propp, Alternating-sign matrices and domino tilings, Journal Algebraic Combinatoric, 1992) by showing that the number of tilings of a certain family of regions in the square lattice with southwest-to-northeast diagonals drawn in is given by powers of 2. We present a proof for the generalization using a bijection between tilings and non-intersecting lattice paths. (Received January 13, 2014)

1097-05-14 **Kathleen Nowak**, **Oktay Olmez** and **Sung Y Song*** (sysong@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011-2064. *Cyclotomic association schemes, difference sets and families.* Preliminary report.

By extending the idea of cyclotomic construction of strongly regular graphs and difference sets, we construct various combinatorial structures related to difference sets and families by using the cyclotomy of finite fields. We discuss the links between 'one-and-half' difference families, other types of difference sets, certain family of cyclic codes and cyclotomic association schemes. (Received November 04, 2013)

1097-05-16 **R. A. Bailey*** (rab@mcs.st-and.ac.uk), School of Mathematics and Statistics, University of St Andrews, North Haugh, St Andrews, Fife KY16 9SS, United Kingdom. *Products of association schemes.*

There are two well-known ways of forming a product of two association schemes: the direct product (also known as crossing) and the wreath product (also known as nesting). These may be generalized in interesting ways. In the generalized wreath product, several association schemes are combined; the component schemes are labelled by the elements of a partially ordered set. In the crested product, only two association schemes are combined; an inherent partition in each is used in the construction. (Received November 13, 2013)

1097-05-24 **Kai Fong Ernest Chong*** (kc343@cornell.edu), Department of Mathematics, 310 Malott Hall, Cornell University, Ithaca, NY 14853. *A numerical characterization of the flag f-vectors of completely balanced Cohen-Macaulay complexes.*

In this talk, we introduce the notion of Macaulay decomposability for simplicial complexes, and we describe its role in generalizing Macaulay representations. Using these generalized Macaulay representations, we give a numerical characterization of the flag f-vectors of completely balanced Cohen-Macaulay complexes. Our main emphasis will be on explaining the geometric interpretation and combinatorial ideas underlying this numerical characterization. (Received December 05, 2013)

1097-05-43 **Rong Luo*** (rluo@math.wvu.edu), **Zhengke Miao** and **Yue Zhao**. *Vizing's 2-factor conjecture on edge chromatic critical graphs.* Preliminary report.

Vizing conjectured in 1960s that every edge chromatic critical graph has a 2–factor, a 2-regular spanning subgraph. There are not many results on this conjecture. In this talk I will present a new result on this conjecture, namely very critical graph with large maximum degree has a hamiltonian cycle and this has a 2-factor. (Received December 27, 2013)

1097-05-46 **Terry A. McKee*** (terry.mckee@wright.edu). *When All Minimal k-Vertex Separators Induce Complete or Edgeless Subgraphs.*

Define $\mathcal{D}_k$ to be the class of graphs such that, for every independent set $\{v_1, \ldots, v_i\}$ of vertices with $2 \leq i \leq k$, if S is an inclusion-minimal set of vertices whose deletion would leave $v_1, \ldots, v_i$ in i separate connected components, then S induces a complete subgraph; also, let $\mathcal{D} = \bigcap_{k\geq 2} \mathcal{D}_k$.

For instance, $\mathcal{D}_2$ is the class of chordal graphs. Others of these classes—along with some of the modified classes when "complete" is replaced by "edgeless" or by "complete or edgeless"—have been characterized recently.

I shall give unified characterizations of all of these classes. (Received January 02, 2014)

1097-05-82 **Matthias Beck*** (mattbeck@sfsu.edu), **Jessica Delgado** and **Joseph Gubeladze**. *Very ample and Koszul segmental fibrations.*

A lattice polytope $P \subset \mathbf{R}^n$ is the convex hull of finitely many points in $\mathbf{Z}^n$. There is a natural hierarchy of structural sophistication for lattice polytopes, with various concepts motivated from toric geometry and commutative algebra. We will discuss three such concepts in this hierarchy, occupying a point of origin (normality), the bottom (very ampleness), and the top spot (Koszul property). More specifically, we explore a simple construction for lattice polytopes with a twofold aim. On the one hand, we derive an explicit series of very ample 3-dimensional polytopes with arbitrarily large deviation from the normality property, measured via the highest discrepancy degree between the corresponding Hilbert functions and Hilbert polynomials. On the other hand, we describe a large class of Koszul polytopes of arbitrary dimensions, containing many smooth polytopes and extending the previously known class of Nakajima polytopes. (Received January 12, 2014)

1097-05-101 **Linyuan Lu**, **Austin Mohr*** (amohr@nebrwesleyan.edu) and **László Székely**. *Asymptotic Enumeration Using the Lopsided Lovász Local Lemma.* Preliminary report.

The Lovász local lemma is a useful tool for showing that one can avoid a collection of "bad" events in a probability space. A limitation is that it requires most events to be independent. The lopsided version of the lemma relaxes the requirement of independence to that of negative dependence, which is more general but also more difficult to identify. We will familiarize ourselves with the original local lemma by way of hypergraph 2-coloring, then turn our attention to the enumeration of derangements. Remarkably, the original local lemma is wholly inadequate to handle the latter problem, while the lopsided version gives a tight lower bound with relative ease. Finally, we count "high-girth" hypergraphs as a case study in the use of the lopsided local lemma as a tool for asymptotic enumeration. (Received January 14, 2014)

1097-05-104 **Jeremy L. Martin*** (jmartin@math.ku.edu), **Molly Maxwell**, **Victor Reiner** and **Scott O. Wilson**. *Pseudodeterminants and perfect square spanning tree counts.*

Let X be a CW complex. The cellular matrix-tree theorem relates certain weighted counts $\tau_k(X)$ of k-dimensional trees in X to the combinatorial Laplacian operators of X, in particular to their *pseudodeterminants* (products of nonzero eigenvalues). When X is a sphere of dimension $d = 4k+2$ whose antipode map induces a cellular self-duality, Maxwell showed that $\tau_{2k+1}(X)$ is a perfect square, answering a question posed by Kalai and extending a result of Tutte on central reflex graphs. In this talk we consider analogous perfect square phenomena for self-dual spheres of odd dimension. (Received January 14, 2014)

1097-05-105 **Jeremy Aikin*** (jeremy.aikin@maconstate.edu), Department of Mathematics, Middle Georgia State College, Macon, GA 31206, and **Adam Bland**. *Monochromatic sinks in 3-switched tournaments without rainbow triangles.*

Let T be a tournament whose arcs are colored using at most three colors. A cycle C in T is called k-switched if there are at most k vertices in C whose incident arcs in C are two distinct colors. We prove that if every cycle in T of length at least four is 3-switched and every cycle of length three is 2-switched, then T contains a monochromatic sink. (Received January 14, 2014)

1097-05-113 **Bangteng Xu*** (bangteng.xu@eku.edu), Department of Mathematics and Statistics, Eastern Kentucky University, Richmond, KY 40475. *Dual Bent Functions on Finite Groups and C-algebras.*

The dual of a (bent) function on a finite abelian group is a natural concept. In this talk we present the dual bent functions on finite nonabelian groups. A more general algebraic structure of a C-algebra provides a better and natural context for this purpose. We will first discuss Fourier transforms, bent functions, and dual bent functions on C-algebras. Then as an application, we obtain the properties of dual bent functions on finite nonabelian groups. (Received January 15, 2014)

1097-05-116 **N Bradley Fox*** (norman.fox@uky.edu). *A Lattice Path Interpretation of the Diamond Product.*

The diamond product of posets is an operation that corresponds to taking the Cartesian product of polytopes. Through the use of coproducts, recursive formulas have been developed to study the resulting **cd**-index, a polynomial which contains data on the number of chains through particular ranks of a poset, when computing the diamond product of two Eulerian posets. In this talk I will introduce a combinatorial interpretation for the diamond product of two **cd**-words which involves a weighted sum of lattice paths. (Received January 15, 2014)

1097-05-125 **Daniel W. Cranston*** (dcranston@vcu.edu) and **Landon Rabern**. *Graphs with $\chi = \Delta$ have big cliques.*

Brooks' Theorem states that if a graph has maximum degree $\Delta \geq 3$ and clique number $\omega \leq \Delta$, then its chromatic number χ satisfies $\chi \leq \Delta$. Borodin and Kostochka conjectured that if $\Delta \geq 9$ and $\omega \leq \Delta - 1$, then $\chi \leq \Delta - 1$. We show that if $\Delta \geq 13$ and $\omega \leq \Delta - 4$, then $\chi \leq \Delta - 1$. For a graph G, let $\mathcal{H}(G)$ denote the subgraph of G induced by vertices of degree Δ. We also show that if $\omega \leq \Delta - 1$ and $\omega(\mathcal{H}(G)) \leq \Delta - 6$, then $\chi \leq \Delta - 1$. (Received January 16, 2014)

1097-05-132 **Brian Curtin*** (bcurtin@usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 E. Fowler Ave. CMC342, Tampa, FL 33620, and **G R Pourgholi** (pourgholi@ut.ac.ir). *Edge-maximality of power graphs of finite cyclic groups.*

The power graph of a finite group is the undirected graph whose vertices are the group elements and two elements are adjacent if one is a power of the other. We discuss our recent work showing that among all finite groups of any given order, the cyclic group of that order has the maximum number of edges in its power graph. (Received January 17, 2014)

1097-05-138 **M. D. Plummer*** (michael.d.plummer@vanderbilt.edu), Department of Mathematics, Vanderbilt University, Nashville, TN 37240, and **R. Aldred**, **Q. Li**, **D. Ye** and **H. Zhang**. *3-extendable Toroidal Quadrangulations.*

A graph containing a perfect matching is said to be *m-extendable* if $m \leq (|V(G)|-2)/2$ and for every matching M with $|M| = m$, there is a perfect matching F in G such that $M \subseteq F$. Previously, four of the present five authors characterized those quadrangulations of the torus which are 2-extendable. In the present work a characterization of those which are 3-extendable is obtained. Since no quadrangulations of the torus can be m-extendable for any $m \geq 4$, this completes the study of m-extendability for toroidal quadrangulations. Somewhat surprisingly, our result turns out to be a characterization of all 3-extendable toroidal graphs in general. (Received January 17, 2014)

1097-05-148 **Lanzhen Song**, **William Staton** and **Bing Wei*** (bwei@olemiss.edu), Department of Mathematics, University of Mississippi, University, MS 38677. *Independence Polynomials of Some Compound Graphs.*

An independent set of a graph G is a set of pairwise non-adjacent vertices. G is well-covered if all its maximal independent sets have the same size, denoted by $\alpha(G)$. Let $f_s(G)$ for $0 \leq s \leq \alpha(G)$ denote the number of independent sets of s vertices in G. The independence polynomial $I(G;x) = \sum_{i=0}^{\alpha(G)} f_s(G)x^s$ defined first by Gutman and Harary has been the focus of considerable research recently. Motivated by a result of Gutman for some compound graphs, we extend the result for more general compound graphs. In particular, we use our main results to determine the coefficients $f_s(G)$ for some well-covered graphs and present the exact independence polynomials of several well-covered graphs. (Received January 19, 2014)

1097-05-153 **Gagik Amirkhanyan**, **Albert Bush**, **Ernie Croot** and **Chris Pryby*** (cpryby@gatech.edu). *Sets of Rich Lines in General Position.*

The Szemerédi-Trotter theorem implies that the number of lines incident to at least $k > 1$ of n points in $\mathbb{R}^2$ is $O(n^2/k^3 + n/k)$. J. Solymosi conjectured that if one requires the points to be in a grid formation and the lines to be in general position—no two parallel, no three meeting at a point—then one can get a much tighter bound. We prove a slight variant of his conjecture: for every $\varepsilon > 0$ there exists some $\delta > 0$ such that for sufficiently large values of n, every set of lines in general position, each intersecting an $n \times n$ grid of points in at least $n^{1-\delta}$ places, has size at most n^{ε}. This implies a conjecture of Gy. Elekes about the existence of a uniform statistical version of Freiman's theorem for linear functions with small image sets. (Received January 19, 2014)

1097-05-154 **Ben Brubaker** (bbrubake@math.umn.edu) and **Andrew Schultz*** (andrew.c.schultz@gmail.com). *Deformations of the Weyl character formula via ice models.*

By assigning polynomial weights to certain symmetry classes of alternating sign matrices, Okada gave deformations of the Weyl denominator formula in types B, C and D. In this talk we generalize these results by replacing Okada's families of alternating sign matrices with more general families of ice models from statistical mechanics. This allows us to use some local conservation rules — particularly the Yang-Baxter equation — to evaluate the corresponding partition functions. We will see that a certain specialization of these polynomials returns the Weyl character formula. (Received January 27, 2014)

1097-05-156 **Craig Larson*** (clarson@vcu.edu) and **Nico Van Cleemput**. *A Conjecture-making Program for Graph Theorists.*

We will discuss the use of a new open source program that can be used to make conjectures in a variety of mathematical domains, and specific examples of the use of the program in graph theory.

The program is easy to use, easy for users to modify, and could be of significant utility in mathematical investigation. (Received January 22, 2014)

1097-05-179 **Josephine Yu*** (jyu@math.gatech.edu). *Tropicalizing the Positive Semidefinite Cone.* Preliminary report.

We study the tropicalization of the cone of positive semidefinite matrices over the ordered field of real Puiseux series. The tropical PSD matrices form the normal cone of the Newton polytope of the symmetric determinant at the vertex corresponding to the product of diagonal entries. 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 January 21, 2014)

1097-05-185 **Joel Brewster Lewis*** (jblewis@math.umn.edu), **Victor Reiner** and **Dennis Stanton**. *Reflection factorizations of Singer cycles.*

A classical combinatorial problem (with solutions originally due to Hurwitz and Dénes) is to count factorizations of the long cycle as a product of transpositions. In this talk, I will discuss a q-analogue, replacing the symmetric group with $GL(n, q)$, the long cycle with a "Singer cycle", and transpositions with reflections. The pleasant central result is that the number of shortest such factorizations (i.e., with n reflections) is $(q^n - 1)^{n-1}$. I will also mention some generalizations (notably, to factorizations of any length) and open questions. The main tool is the ordinary representation theory of $GL(n, q)$. (Received January 21, 2014)

1097-05-189 **Ronald J. Gould*** (rg@mathcs.emory.edu), Dept. Math and C.S., Atlanta, GA 30322. *More on Chorded Cycles.* Preliminary report.

The study of chorded cycles has seen a recent increase in activity in the past few years. I will review some of this work as well as consider several new results related to classic cycle results. This will include conditions sufficient to imply k independent edges being the chords of k disjoint cycles and k vertices being placed on k disjoint chorded cycles. (Received January 21, 2014)

1097-05-190 **Craig Timmons*** (ctimmons@ucsd.edu) and **Jacques Verstraete**. *Sidon sets and extremal graph theory.*

Let F be any bipartite graph that contains a cycle. Solymosi conjectured that if G is an n-vertex graph in which every edge is in exactly one copy of F, then the number of edges of G is $o(\mathrm{ex}(n, F))$. We construct an infinite family of counterexamples to Solymosi's conjecture using Sidon sets. This is joint work with Jacques Verstraëte. (Received January 21, 2014)

1097-05-218 **Yue Cai*** (yue.cai@uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506, and **Margaret Readdy** (readdy@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Negative q-analogues.* Preliminary report.

Fu, Reiner, Stanton and Thiem introduced the notion of the negative q-binomial coefficient. This has representation-theoretic, cyclic sieving and topological implications. In this talk, we develop the negative q-Stirling number of the second kind, and give its basic properties. (Received January 22, 2014)

1097-05-220 **Sebastian M Cioaba*** (cioaba@math.udel.edu), University of Delaware, Department of Mathematical Sciences, Ewing Hall, Newark, DE 19716-2553. *On the structure of strongly regular and distance-regular graphs: connectivity and matchings.*

In this talk, I will discuss two problems involving the structure of strongly regular and distance-regular graphs. The first problem involves the connectivity of the complement of a ball in a distance-regular graph where we generalize the well-known result that the second subconstituent of a primitive strongly regular graph is connected. This is joint work with Jack Koolen. The second problem deals with the extendability of strongly regular graphs; this is the largest integer t with the property that any matching with t edges can be extended to a perfect matching. This is joint work with my Ph.D. student Weiqiang Li. (Received January 22, 2014)

1097-05-234 **Patricia Hersh*** (plhersh@ncsu.edu) and **Karola Meszaros**. *Posets arising as 1-skeleta of (simple) polytopes.*

We will discuss the topological structure of posets whose Hasse diagrams may be regarded as 1-skeleta of simple polytopes. Familiar examples include the weak Bruhat order and the Tamari lattice, viewed as 1-skeleta of the permutahedron and associahedron, respectively. It seems natural now to ask whether MV polytopes could also be put into this framework. Background in this part of topological combinatorics will not be assumed. (Received January 26, 2014)

1097-05-244 **Xiaofeng Gu*** (xgu@uwsuper.edu), Mathematics and Computer Science Department, University of Wisconsin-Superior, Superior, WI 54880. *Augmenting and preserving partition connectivity of a hypergraph.*

Let k be a positive integer. A hypergraph H is k-partition-connected if for every partition P of $V(H)$, there are at least $k(|P|-1)$ hyperedges intersecting at least two classes of P. We determine the minimum number of hyperedges in a hypergraph whose addition makes the resulting hypergraph k-partition-connected. We also characterize the hyperedges of a k-partition-connected hypergraph whose removal will preserve k-partition-connectedness. This is joint work with Hong-Jian Lai of West Virginia University. (Received January 23, 2014)

1097-05-245 **Paul-Hermann Zieschang*** (zieschang@utb.edu), Department of Mathematics, University of Texas at Brownsville, Brownsville, TX 78520. *Characteristic and curvature of finite association schemes.*

Let X be a finite set, S a scheme on X. We call $\chi(S) := (|X|-1)/(|S|-1)$ the *characteristic* of S. A scheme is thin if and only if its characteristic is 1. - Let R be an algebraically closed field of characteristic 0, let RS (resp. RX) be the free R-module over S (resp. X). Then RS is a semisimple R-algebra and RX is a completely reducible RS-module. Denote by χ_{RS} (resp. χ_{RX}) the character of RS afforded by the RS-module RS (resp. RX), and let $\chi_1, \ldots, \chi_r$ be the irreducible characters of RS with χ_1 being the principal character of RS. Then $\chi_{RS} = \chi_1(1)\chi_1 + \cdots + \chi_r(1)\chi_r$ and there exist positive integers $m_1, \ldots, m_r$ with $\chi_i(1) \le m_i$ for each element i in $\{1, \ldots, r\}$ and $\chi_{RX} = m_1\chi_1 + \cdots + m_r\chi_r$. We define $\alpha(S)$ to be the arithmetic mean of the fractions $m_i/\chi_i(1)$ with $i \in \{2, \ldots, r\}$ and call $\ln(\alpha(S)/\chi(S))$ the *curvature* of S. - The schemes arising from finite generalized polygons have positive curvature, the scheme $HM_{176}(28)$ in Hanaki's and Miyamoto's database of schemes of small valency has negative curvature, thin schemes have curvature 0. (Received January 23, 2014)

1097-05-257 **Sarah K Mason** and **Elizabeth Niese*** (niese@marshall.edu), Marshall University, Huntington, WV 25755. *Quasisymmetric (k,l)-hook Schur functions.*

We introduce a quasisymmetric generalization of Berele and Regev's (k,l)-hook Schur functions. These quasisymmetric hook Schur functions decompose the hook Schur functions in a natural way. The quasisymmetric hook Schur functions can be defined as the generating function for a certain set of composition tableaux on two alphabets. We will look at the combinatorics of the quasisymmetric hook Schur functions, including an analogue of the RSK algorithm and a generalized Cauchy Identity. (Received January 24, 2014)

1097-05-272 **Rui Xu*** (xu@westga.edu), Department of Mathematics, University of West Georgia, and **Dong Ye**, Department of Mathematical Sciences, Middle Tennessee State University. *Cycle double covers and long circuits of graphs.*

The Five Cycle Double Cover Conjecture claims that every bridgeless graph has a cycle double cover which consists of at most 5 cycles. We prove that if a cubic graph has a long circuit, then it has a 5-cycle double cover. Our main theorem partially strengthens some previously known results. (Received January 24, 2014)

1097-05-276 **Kayla R Harville** (kddavis1@olemiss.edu), Department of Mathematics, The University of Mississippi, University, MS 38677, **Talmage James Reid*** (mmreid@gmail.com), Department of Mathematics, University, MS 38677, and **Haidong Wu** (hwu@olemiss.edu), Department of Mathematics, The University of Mississippi, University, MS 38677. *The Matroids without a certain small minor.*

We use the tools of matroid 3-connectivity and internal 4-connectivity to determine classes of binary and regular matroids that do not contain certain minors. These results generalize both classical and recent results from the literature for graphs. Emphasis is placed on the geometric motivation for the decomposition theorems presented in the talk. (Received January 24, 2014)

1097-05-315 **Tim Penttila*** (penttila@math.colostate.edu), **Liz Lane-Harvard** and **Stanley E Payne**. *Strongly regular graphs from large arcs in affine planes.*

Tits constructed generalized quadrangles from ovals in Desarguesian planes in 1968; Ahrens-Szekeres and Hall constructed generalized quadrangles from hyperovals in Desarguesian planes in 1969 and 1971. Payne constructed generalized quadrangles from q-arcs in Desarguesian planes of order q in 1972 and 1985. All of these generalized quadrangles give strongly regular graphs. It is not known if the hypothesis that the plane is Desarguesian is necessary.

Here we show that strongly regular graphs can be constructed from hyperovals and ovals in affine planes, without the hypothesis that the planes be Desarguesian. Thus many new pseudo-geometric strongly regular graphs are constructed. We do not know whether or not any of them are geometric, and this will be the subject of future study. (Received January 26, 2014)

1097-05-321 **Xiangqian Joe Zhou** (xiangqian.zhou@wright.edu), Dept of Math & Stat, Wright State Univeristy, 3640 Col Glenn Hwy, Dayton, OH 45435. *Fat Signed Graphs.* Preliminary report.

A signed graph is a pair (G, Σ) where G is a graph and Σ is a subset of $E(G)$. Edges in Σ are called *odd*. Signed graphs give rise to a very nice subclass of ternary matroids; they are the ternary matroids that can be represented by a ternary matrix with at most two non-zero entries in each column. Unlike the class of graphic matroids, results for signed-graphic matroids are much harder to prove. One reason is that a 3-connected signed-graphic matroid is not uniquely representable by signed graphs. In this talk, we introduce the concept of *fat* signed graphs that can be used as a stabilizer to overcome the difficulty caused by inequivalent representations. (Received January 26, 2014)

1097-05-324 **Jerrold R. Griggs*** (griggs@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Problems in Graph Theory from Set System Conjectures.* Preliminary report.

Our efforts to resolve long-standing problems in extremal set theory lead to graph-theoretic questions that are challenging and interesting in themselves. For instance, it is conjectured that if F is a diamond-free family of subsets of an n-set X, where the subsets are restricted to the three middle sizes $k-1, k, k+1$ with $k = \lfloor n/2 \rfloor$, then $|F|$ is at most $(2+o(1))\binom{n}{\lfloor n/2 \rfloor}$. This leads to investigating the fundamental graph with vertex set $\binom{X}{k}$, two subsets being adjacent if they are at Hamming distance two. Another graph has as vertices $\binom{X}{k-1} \cup \binom{X}{k+1}$ with subsets A, B being adjacent when one strictly contains the other. We share our ideas here in the hope of making further progress on both fronts, the original set system conjectures and the specific graph theory questions. (Received January 26, 2014)

1097-05-330 **Sylvie Corteel**, **Jeremy Lovejoy** and **Carla D Savage*** (savage@ncsu.edu), Department of Computer Science, Box 8206, North Carolina State University, Raleigh, NC 27612. *Ehrhart Theory and Overpartitions.* Preliminary report.

An overpartition of an integer N is a partition of N in which the first copy of each part may be overlined. We show that a recent result of Chen, Sang, and Shi [JTCA 118;4 (2011) 1431-1464] on overpartitions with no non-overlined parts congruent to 0, 1, -1 modulo k can be derived and refined with the help of Ehrhart Theory. This is joint work with Sylvie Corteel and Jeremy Lovejoy. (Received January 26, 2014)

1097-05-332 **Cun-Quan Zhang*** (cqzhang@math.wvu.edu), Morgantown, WV 26506. *Fulkerson conjecture and perfect matching covering.*

Fulkerson conjectured that every bridgeless cubic graph G has a set of six perfect matchings that covers every edge precisely twice. Berge conjectured that every bridgeless cubic graph G has a set of five perfect matchings that covers every edge. This talk will survey some recent results related to these two major conjectures in graph theory. (Received January 26, 2014)

1097-05-334 **John L. Goldwasser*** (jgoldwas@math.wvu.edu) and **Ryan Hansen**. *Maximum fraction of sub-d-cubes of an n-cube containing an exact copy of an induced subgraph of a d-cube.* Preliminary report.

Let K and L be graphs isomorphic to the d-cube, Qd. If G is an induced subgraph of K, and H is an induced subgraph of L, we say that H is an exact d-copy of G if there is a graph isomorphism from V(K) to V(L) whose restriction to V(G) is an isomorphism of G onto H (so G and H are embedded in d-cubes in the same way). We define f(d,G), the d-cube density of G, to be the limit as n goes to infinity of the maximum fraction, over all subsets Jn of V(Qn), of sub-d-cubes of Qn whose intersection with Jn induces an exact d-copy of G. We determine upper and lower bounds, and some exact values, for f(d,G) for various induced subgraphs G of Qd, for small values of d. For example, if C is a 4-cycle, then f(3,C) equals 4/9. There are some connections with Turan densities of hypergraphs. (Received January 26, 2014)

1097-05-335 **Yuqin Sun**, School of Mathematics and Physics, Shanghai University of Electric Power, Shanghai, Shanghai 200090, Peoples Rep of China, and **Xingxing Yu*** (yu@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *On a coloring conjecture of Hajós.*

Hajós conjectured that graphs containing no subdivision of K_5 are 4-colorable. It is shown in [?] that if there is a counterexample to this conjecture then any minimum such counterexample must be 4-connected. We further show that if G is a minimum counterexample to Hajós' conjecture and S is a 4-cut in G then $G-S$ has exactly two components. (Received January 26, 2014)

1097-05-340 **Jie Han** and **Yi Zhao*** (yzhao6@gsu.edu), Dept of Math & Stat, 30 Pryor St, Georgia State University, Atlanta, GA 30303. *Minimum vertex degree threshold for C_4^3-tiling.*

Let C_4^3 be the 3-uniform hypergraph with four vertices and two edges. We prove that the vertex degree threshold for tiling C_4^3 in a 3-uniform hypergraph on $n \in 4\mathbb{N}$ vertices is $\binom{n-1}{2} - \binom{\frac{3}{4}n}{2} + \frac{3}{8}n + c$, where $c = 1$ if $n \in 8\mathbb{N}$ and $c = -\frac{1}{2}$ otherwise. This result is best possible, and is one of the first results on vertex degree conditions for hypergraph tiling. (Received January 26, 2014)

1097-05-349 **Gexin Yu*** (gyu@wm.wdu), 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 January 26, 2014)

1097-05-351 **Guoli Ding**, Department of Mathematics, Louisiana State University, Baton Rouge, LA , and **Haidong Wu*** (hwu@olemiss.edu), Department of Mathematics, University of Mississippi, University, MS. *3-Connected binary matroids with no P_9-minor.* Preliminary report.

Kuratowski's Theorem states that a graph is planar if any only if it has no minor that is isomorphic to $K_{3,3}$ or K_5. Mayhew, Royle and Whittle characterize internally 4-connected binary matroids with no $M(K_{3,3})$-minor. Oxley characterizes 3-connected binary matroids without any P_9- or P_9^*-minor. We first determine internally 4-connected binary matroids with no P_9-minor. Using this we characterize 3-connected binary matroids with no P_9-minor. (Received January 27, 2014)

1097-05-352 **Laura Bradford**, **Meredith Harris**, **Brant Jones**, **Alex Komarinski**, **Caroline Matson** and **Edwin O'Shea*** (osheaem@jmu.edu). *The Refined Lecture Hall Theorem via Abacus Diagrams.*

Bousquet-Mélou & Eriksson's lecture hall theorem generalizes Euler's celebrated distinct-odd partition theorem. We present an elementary and transparent proof of a refined version of the lecture hall theorem using a simple bijection involving abacus diagrams. (Received January 26, 2014)

1097-05-356 **Xi Chen** and **Xiaorui Sun*** (xiaoruisun@cs.columbia.edu), Department of Computer Science, 450 Computer Science Building, 1214 Amsterdam Avenue, Mailcode: 0401, New York, NY 10027, and **Shang-Hua Teng**. *On the order of the automorphism groups of strongly regular graphs.* Preliminary report.

An old conjecture of Babai states that, with known (obvious) exceptions, all strongly regular (SR) graphs have a subexponential number of automorphisms, i.e., $\exp(n^{o(1)})$, where n is the number of vertices. The exceptions are disjoint unions of cliques, line graphs of complete graphs and complete bipartite graphs, and their complements. In 1980 Babai proved an $\exp(\widetilde{O}(n^{1/2})))$ bound (where the Oh-tilde hides poly-logarithmic factors). This bound was reduced to $\exp(\widetilde{O}(n^{1/3}))$ by Spielman in 1996. In this paper we improve this bound to $\exp(\widetilde{O}(n^{9/37}))$.

For the case when the graph satisfies Neumaier's claw bound (1979), our proof extends the basic approach of Babai (1980) and Spielman (1996) by analyzing the standard individualization / refinement heuristic. We show that after individualizing a set of $\widetilde{O}(n^{9/37})$ random vertices, one can build three-level combinatorial structures within the graph, as compared to the one-level and two-level analyses by Babai and Spielman, resp., that are sufficient to distinguish any pair of vertices in the graph. (Received January 26, 2014)

1097-05-366 **Linyuan Lu*** (lu@math.sc.edu), Columbia, SC 29208, and **Shoudong Man**. *Connected Hypergraphs with Small Spectral Radius.*

In 1970 Smith classified all connected graphs with the spectral radius at most 2. Here the spectral radius of a graph is the largest eigenvalue of its adjacency matrix. Recently, the definition of spectral radius has been extended to k-uniform hypergraphs. In this paper, we generalize Smith's theorem to k-uniform hypergraphs. We show that the smallest limit point of the spectral radii of connected k-uniform hypergraphs is $\rho_k = (k-1)!\sqrt[k]{4}$. We classify all connected k-uniform hypergraphs with spectral radius at most ρ_k. (Received January 27, 2014)

1097-05-371 **Laura Sheppardson*** (sheppard@olemiss.edu), Department of Mathematics, 305 Hume Hall, University, MS 38655, and **B Catherine Putnam**. *The Graph Bicycle Spectrum and Bicircular Matroids.*

The cycle spectrum of a graph (the collection of all cycle lengths) has received extensive study. Since graphic matroids are based on the cycles of graphs, results in this field apply immediately to matroids. Motivated by the study of bicircular matroids, we consider the sizes of graph bicycles. That is, connected sets of edges containing exactly two cycles and no leaves. The graphs with bicycles of very few sizes have been well characterized. Here we examine graphs with bicycles of many sizes. In particular, we show that any graph of minimum degree k has bicycles of at least k consecutive sizes. We further explore graph properties which guarantee bicycles of nearly all sizes possible, analogous to pancyclic graphs. (Received January 27, 2014)

1097-05-376 **Stefaan De Winter*** (sgdewint@mtu.edu), 1400 Townsend Drive, Houghton, MI 49931. *Generalizations of a theorem of Benson for generalized quadrangles.* Preliminary report.

In the late 60s Benson obtained a congruence that relates the parameters of a finite generalized quadrangle (GQ), the order of a hypothetical automorphism of this GQ, the number of points fixed by this automorphism and the number of points mapped to a collinear point under this automorphism. In 2005 I showed that this congruence can be generalized to include the so-called partial geometries and applied this in the proof of a characterization of de Van Lint - Schrijver geometry. Later, Temmermans, Thas and Van Maldeghem, obtained further generalizations for various geometries. In this talk I will provide a general approach for strongly regular graphs. I will sketch the proof, and talk about possible applications and further generalizations for distance regular graphs. This is based on joint work with E Kamischke and Z. Wang. (Received January 27, 2014)

1097-05-387 **Blair D. Sullivan*** (blair_sullivan@ncsu.edu). *Evaluating Gromov δ-hyperbolicity in graphs.* Preliminary report.

In this talk, we will define the Gromov δ-hyperbolicity of a graph, a measure of "tree-likeness" on the associated shortest path distance metric, and describe empirical results describing its behavior on a large corpus of real-world networks. We will also give theoretical asymptotic bounds on the hyperbolicity of an important family of random graph models. This is joint work with Aaron Adcock and Michael Mahoney, Stanford University and Nathan Lemons, Los Alamos National Laboratory. (Received January 27, 2014)

1097-05-394 **Steven Klee***, Seattle University, Department of Mathematics, 901 12th Avenue, Seattle, WA 98122, and **Isabella Novik**. *Balanced manifolds and pseudomanifolds.*

A $(d-1)$-dimensional simplicial complex is called balanced if its underlying graph is d-colorable. The property of a given manifold or pseudomanifold triangulation being balanced restricts the combinatorial structure of the triangulation in a significant way. We will present new bounds on the face vectors of balanced manifold triangulations in terms of the dimension and underlying topological structure of the manifold, as well as new constructions of balanced manifolds with few vertices. (Received January 27, 2014)

1097-05-412 **Weiqiang Li*** (weiqiang@udel.edu), UD Department of Mathematical Science, 501 Ewing Hall, Newark, DE 19716. *On the Spectrum of Wenger Graphs.*

Let $q = p^e$, where p is a prime and $e \geq 1$ is an integer. For $m \geq 1$, let P and L be two copies of the $(m+1)$-dimensional vector spaces over the finite field $\mathbb{F}_q$. Consider the bipartite graph $W_m(q)$ with partite sets P and L defined as follows: a point $(p) = (p_1, p_2, \ldots, p_{m+1}) \in P$ is adjacent to a line $[l] = [l_1, l_2, \ldots, l_{m+1}] \in L$ if and only if the following m equalities hold: $l_{i+1} + p_{i+1} = l_i p_1$ for $i = 1, \ldots, m$. We call the graphs $W_m(q)$ Wenger graphs. In this talk we will determine all distinct eigenvalues of the adjacency matrix of $W_m(q)$ and their multiplicities. We also survey results on Wenger graphs.

This talk is based on the joint work with Sebastian M. Cioabă and Felix Lazebnik. (Received January 27, 2014)

1097-05-414 **Shaohui Wang*** (swang4@go.olemiss.edu), 12 County Road 1106, Oxford, MS 38655, and **Bing Wei** (bwei@olemiss.edu), Department of Mathematics, University of Mississippi, University, MS 38677. *Multiplicative Zagreb indices of k-trees.*

Let G be a graph with vetex set $V(G)$ and edge set $E(G)$. The first generalized multiplicative Zagreb index of G is $\prod_{1,c}(G) = \prod_{v\in V(G)} d(v)^c$, for a real number $c > 0$, and the second multiplicative Zagreb index is $\prod_2(G) = \prod_{uv\in E(G)} d(u)d(v)$, where $d(u), d(v)$ are the degrees of the vertices of u, v. The multiplicative Zagreb indices have been the focus of considerable research in computational chemistry dating back to Narumi and Katayama in 1980s. In this paper, we generalize Narumi-Katayama index and the first multicative index, where $c = 1, 2$, respectively, and extend the results of Gutman to the generilized tree, the k-tree, where the results of Gutman are for $k = 1$. Additionally, we characterize the extremal graphs and determine the exact bounds of these indices of k-trees, which attain the lower and upper bounds. (Received January 27, 2014)

1097-05-415 **Tao Jiang**, **Kevin G Milans*** (milans@math.wvu.edu) and **Douglas B West**. *Multicolor degree-Ramsey numbers of cycles.* Preliminary report.

We write $H \xrightarrow{s} G$ if every s-edge-coloring of the *host graph* H contains a monochromatic copy of the *target graph* G. A typical problem in Ramsey theory fixes a target graph and asks for a host graph which is extremal with respect to some graph property; we are interested in host graphs with small maximum degree. The *multicolor degree-Ramsey number* of a graph G, denoted $R_\Delta(G; s)$ is $\min\{\Delta(H)\colon H \xrightarrow{s} G\}$.

We study $R_\Delta(C_n; s)$. It is easy to show that if n is odd, then $R_\Delta(C_n; s)$ is at least exponential in s, but if n is even, then $R_\Delta(C_n; s) \leq f(n)s^2$ for some function f. From below, we approximately extend a multicolor Ramsey result of Li and Lih to show that for each $\varepsilon > 0$, there exists a constant c_ε such that $R_\Delta(C_4; s) \geq c_\varepsilon s^{2-\varepsilon}$ and $R_\Delta(C_6; s) \geq c_\varepsilon s^{3/2-\varepsilon}$. These results are nearly sharp.

This is joint work with Tao Jiang and Douglas B. West. (Received January 27, 2014)

1097-05-425 **Laszlo Babai** and **John Wilmes***, Department of Mathematics, University of Chicago, 5734 S. University Avenue, Chicago, IL 60637. *Automorphisms of Steiner designs.*

Let X be a Steiner 2-design on v points with lines of length $k \geq 3$. We show that $|\mathrm{Aut}(X)| \leq v^{O(\log v)}$. (The implied constant is absolute, does not depend on k.) The best previous bound was $\exp(O(v^{1/2}\log^2 v))$ (Babai–Pyber 1994, Spielman 1996). The result extends to Steiner t-designs.

The proof is a combinatorial analysis of the individualization/refinement heuristic for colored designs. One of our tools is an *addressing scheme* based on a random tower of iterated cones. The scheme enables tracking the propogation of color information. It produces growing families of uniformly distributed, pairwise independent points, allowing us to apply the second moment method.

The line-graph of a Steiner 2-design is strongly regular (SR). We give bounds on the number of reconstructions of a Steiner 2-design from its line graph, and consequently show that such graphs have at most $\exp(O(n^{1/6}\log^2 n))$ automorphisms where n is the number of vertices. We discuss the significance of these results for the more general problem of bounding the number of automorphisms of SR graphs.

Our main result, the $v^{O(\log v)}$ bound, was also proved simultaneously and independently by Xi Chen, Xiaorui Sun, and Shang-Hua Teng. (Received January 27, 2014)

1097-05-426 **Stan Dziobiak*** (smdziobi@olemiss.edu), Department of Mathematics, University of Mississippi, Hume Hall 305, University, MS 38677-1848, and **Guoli Ding** (ding@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918. *Obstructions for Apex-Series-Parallel Graphs.* Preliminary report.

The famous Graph Minor Theorem of Robertson and Seymour states that every minor-closed class $\mathcal{C}$ of graphs can be characterized by a *finite* list of minor-minimal non-members, called *obstructions* of $\mathcal{C}$, and denoted by $\mathbf{ob}(\mathcal{C})$. Given a minor-closed class of graphs $\mathcal{C}$ and its obstruction set $\mathbf{ob}(\mathcal{C})$, the problem of determining $\mathbf{ob}(\mathcal{C}^*)$ (where $\mathcal{C}^*$ denotes the class of graphs that contain a vertex whose deletion leaves a graph in $\mathcal{C}$) is already very hard if $\mathcal{C}$ is the class of planar graphs, has only been solved (completely) for a few non-trivial minor-closed classes of graphs $\mathcal{C}$. In this talk, we report on the progress towards the solution for series-parallel graphs. (Received January 27, 2014)

1097-05-427 **Brian G. Kronenthal*** (kronenthal@kutztown.edu). *Generalized Quadrangles and Algebraically Defined Graphs.* Preliminary report.

In this talk, we will study generalized quadrangles from the perspective of their point-line incidence graphs. In particular, the incidence graphs of classical generalized quadrangles of odd prime power order q contain induced bipartite subgraphs that may be defined algebraically; indeed, defining partite sets $P = \mathbb{F}_q^3 = L$, we say vertices $(a_1, a_2, a_3) \in P$ and $[x_1, x_2, x_3] \in L$ are adjacent if and only if $a_2 + x_2 = a_1x_1$ and $a_3 + x_3 = a_1x_1^2$. This subgraph has girth eight. Of particular interest is whether it is possible to alter these equations to create a nonisomorphic girth eight graph. Success could illuminate a strategy for constructing new generalized quadrangles. (Received January 27, 2014)

1097-05-432 **William Graham** and **Victor Kreiman*** (kreiman@uwp.edu). *Excited Young diagrams, equivariant K-theory, and Schubert varieties.*

We give combinatorial descriptions of the restrictions to T-fixed points of the classes of structure sheaves of Schubert varieties in the T-equivariant K-theory of Grassmannians and of maximal isotropic Grassmannians of orthogonal and symplectic types. We also give formulas, based on these descriptions, for the Hilbert series and Hilbert polynomials at T-fixed points of the corresponding Schubert varieties. These descriptions and formulas are given in terms of two equivalent combinatorial models: excited Young diagrams and set-valued tableaux. In types A_n and C_n the restriction formulas had been proved earlier by Kreiman by a different method. In type A_n, the formula for the Hilbert series had been proved earlier by Li and Yong. The method we discuss, which relies on a restriction formula of Graham and Willems, is based on the method used by Ikeda and Naruse to obtain the analogous formulas in equivariant cohomology. We also give Hilbert series and Hilbert polynomial formulas which are valid for Schubert varieties in any cominuscule flag variety, in terms of the 0-Hecke algebra. (Received January 27, 2014)

1097-05-435 **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *On Spanning Halin Subgraphs.* Preliminary report.

A Halin graph is a plane graph $H = T \cup C$ such that T is a spanning tree of H with no vertices of degree 2 where —$T| \geq 4$ and C is a cycle whose vertex set is the set of leaves of T. Clearly, Halin graphs are edge-minimal planar 3-connected graphs. Various sufficient conditions for graphs containing a spanning Halin subgraph will be presented. (Received January 27, 2014)

1097-05-441 **Kenneth W Johnson*** (kwj1@psu.edu), Math Department, Penn State Abington, 1600 Woodland Road, Abington, PA 18901. *Fissioning the classes of an association scheme.* Preliminary report.

Harmonic analysis on a finite group G often involves the association scheme coming from the class algebra of the group, or more generally the centralizer ring obtained from a permutation group action. The analysis is effective if the ring is commutative. In the case of the class algebra of a group, recent work has shown that the classes of a group can be split into subclasses which also generate a commutative subalgebra of the group algebra. This is said to be a "fission" of G. An upper bound for such a fission is $s(G)$, the degree of the total character τ of G which is the sum of the degrees of the irreducible characters. It seems that $s(G)$ has other interesting interpretations, for example it is the number of involutions in a symmetric group, or the number of symmetric matrices in $Gl(n, q)$. It appears to be common that this upper bound is attained, but not always.

The questions which will be addressed include:

Given an arbitrary association scheme, what is the dimension of the largest commutative algebra obtained from fissioning its classes?

For an arbitrary association scheme is there any way of obtaining an upper bound on the largest such dimension? (Received January 27, 2014)

1097-05-448 **Richard Ehrenborg*** (jrge@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Cyclically consecutive permutation avoidance.*

We give an explicit formula for the number of permutations avoiding cyclically a consecutive pattern in terms of the spectrum of the associated operator of the consecutive pattern. As an example, the number of cyclically consecutive 123-avoiding permutations in $\mathfrak{S}_n$ is given by $n!$ times the convergent series $\sum_{k=-\infty}^{\infty} \left(\frac{\sqrt{3}}{2\pi(k+1/3)}\right)^n$ for $n \geq 2$. (Received January 27, 2014)

1097-05-449 **Mark Ellingham*** (mark.ellingham@vanderbilt.edu), **Kenta Noguchi** and **Xiaoya Zha**. *Partial duality, bouquets, and genus.* Preliminary report.

In 2009 Chmutov introduced a partial duality operation, using only a subset of the edges, for graph embeddings. The topological consequences of this operation have not yet been intensively investigated. We discuss bounds on the genus of partial duals, and and determine conditions under which a partial dual is a *bouquet* (1-vertex embedding). (Received January 27, 2014)

1097-05-455 **Alyssa Sankey*** (alyssa.unb@sankey.ca), Department of Mathematics and Statistics, University of New Brunswick, Fredericton, NB E3B 5A3, Canada. *Weighted association schemes, fusions, and minimal coherent closures.* Preliminary report.

A weighted association scheme is a scheme with an edge weight function, which for our purposes will take values ± 1. When the scheme has a coherent fusion – a merging of classes resulting in another association scheme – the edge weights on the fusion scheme are inherited. The reverse process involves the *coherent closure* of a weighted scheme: the smallest coherent algebra containing the weighted adjacency matrices. The weight function applied to this closure is necessarily constant on the classes of the associated configuration.

In this talk we present two main objects of study: minimal rank coherent closures of strongly regular graphs with regular weights, with emphasis on closures of rank 4; and regular weights on strongly regular graphs obtained as fusions of association schemes with trivial regular weights. Both of these extend work of Taylor on regular two-graphs and their interactions with strongly regular graphs. (Received January 27, 2014)

1097-05-467 **John Shareshian** and **Russ Woodroofe*** (rwoodroofe@math.msstate.edu). *Why coset lattices involving A_{15} are non-contractible.*

Ken Brown has asked whether any finite group has a contractible coset lattice. In previous work, we have shown that if G is a finite group with no composition factor isomorphic to an alternating group, then the coset lattice of G is non-contractible.

If G has alternating group composition factors, then the situation is more complicated. We have a divisibility conjecture that would imply many groups with alternating composition factors are non-contractible. Unfortunately, the stronger statement that we need to prove the answer to Brown's question to be "no" for all groups is not true for certain A_n, with the first failure at $n = 15$.

In this talk, I'll discuss how to extend our techniques to many more alternating groups, including A_{15}.

This is joint work with John Shareshian. (Received January 28, 2014)

1097-05-484 **Daniel J Poole*** (poole@math.osu.edu), 231 W 18th Ave, Columbus, OH 43210. *Asymptotic distribution of the numbers of vertices and arcs of the giant strong component in sparse random digraphs.*

For $D(n, \text{Prob(arc)} = p)$, Karp (1990) and Łuczak (1990) proved that for $p = c/n, c > 1$, with probability tending to 1, there is an unique giant strong component of size $(\theta^2 + o(1))n$, where $\theta = \theta(c)$, is the unique root of $1 - \theta = e^{-c\theta}$. We prove that in either random digraph model, $D(n, p = c/n)$ or $D(n, m = cn)$, $c > 1$, the joint distribution of the number of vertices and number of arcs in the giant strong component is asymptotically Gaussian with mean $n(\theta^2, c\theta^2)$ and 2×2 covariance matrix linear in n. We introduce a greedy deletion process which terminates with the directed $(1,1)$-core, the maximal digraph with minimum in-degree and out-degree at least 1. This $(1,1)$-core contains all non-trivial components; however, we show that the likely numbers of residual vertices and arcs inside the $(1,1)$-core but outside the largest strong component have order at most polynomial in $\ln n$, which is dwarfed by the anticipated order of their fluctuations, $n^{1/2}$. By approximating the likely realization of the deletion process with a deterministic trajectory, we show, via Fourier-based techniques, that the number of vertices and arcs in the $(1,1)$-core have jointly an asymptotic Gaussian distribution. Joint work with Boris Pittel. (Received January 28, 2014)

1097-05-497 **G Eric Moorhouse*** (moorhous@uwyo.edu), 1000 E Univ Ave, Dept 3036, University of Wyoming, Laramie, WY 82071. *Two-graphs and finite geometries.* Preliminary report.

Two-graphs arising from combinatorial substructures (ovoids, spreads, etc.) of finite geometries have long been useful as isomorphism invariants or, in the most highly symmetric cases, as objects of interest in their own right. We will discuss some new examples of the latter description (highly symmetric two-graphs) arising from dual polar graphs. (Received January 28, 2014)

1097-05-513 **Francesco Fumagalli** (fumagalli@math.unifi.it), Firenze, Italy, and **John Shareshian*** (shareshi@math.wustl.edu), St. Louis, MO. *Truncated Quillen complexes of p-groups.*

Let G be a group and let p be a prime. Starting with the seminal papers of K. S. Brown and D. Quillen, relations between the algebraic structure of G and the topological structure of the order complex of the poset of its nontrivial elementary abelian p-subgroups have been studied. Say G is a finite p-group. Then this order complex is contractible and thus provides little information. However, S. Bouc and J. Thévenaz showed that if one removes from the poset all subgroups of order p, the complex becomes more interesting. Here we show show that determining the topology of this truncated complex is equivalent to counting certain extraspecial subgroups of G. This allows us to give a negative answer to a question raised by Bouc and Thévenaz. (Received January 28, 2014)

1097-05-514 **Sarah R. Bockting-Conrad*** (bockting@math.wisc.edu). *Tridiagonal pairs of q-Racah type, the double lowering operator ψ, and the quantum algebra $U_q(\mathfrak{sl}_2)$.*

Let $\mathbb{K}$ denote an algebraically closed field and let V denote a vector space over $\mathbb{K}$ with finite positive dimension. Let A, A^* denote a tridiagonal pair of q-Racah type with diameter $d \geq 1$. Let $\{V_i\}_{i=0}^d$ (resp. $\{V_i^*\}_{i=0}^d$) denote a standard ordering of the eigenspaces of A (resp. A^*). In an earlier paper, we associated with A, A^* a linear transformation $\psi : V \to V$ such that $\psi V_i \subseteq V_{i-1} + V_i + V_{i+1}$ and $\psi V_i^* \subseteq V_0^* + V_1^* + \cdots + V_{i-1}^*$ for $0 \leq i \leq d$. One of the relations involving ψ was reminiscent of a defining relation for the quantized enveloping algebra $U_q(\mathfrak{sl}_2)$. We explore this connection further. In doing so, we will give two natural $U_q(\mathfrak{sl}_2)$-module structures for V and discuss how they are related. This leads to a number of interesting relations involving the operator ψ and other operators associated with A, A^*. (Received January 28, 2014)

1097-05-518 **Jason S Williford*** (jwillif1@uwyo.edu), 1000 E. University Ave., Laramie, WY 82071. *Constructions of Q-polynomial schemes.*

An association scheme is called Q-polynomial if, after suitably reordering the idempotents, the idempotent E_i is a degree i polynomial of E_1, where multiplication is done using the Schur product. The notion of Q-polynomial schemes is formally dual to schemes generated by distance-regular graphs. However, the theory of Q-polynomial schemes is much less understood than its dual counterpart. In this talk, we will discuss the known Q-polynomial schemes, including some new examples. (Received January 28, 2014)

06 ► Order, lattices, ordered algebraic structures

1097-06-97 **John D. LaGrange*** (lagrangej@lindsey.edu), Lindsey Wilson College, Division of Natural and Behavioral Sciences, Columbia, KY 42728. *The lattice of annihilators in a simple graph.* Preliminary report.

Let R be a reduced commutative ring with $1 \neq 0$. It is well known that $\mathcal{A}(R) = \{\text{ann}(X) \mid \emptyset \neq X \subseteq R\}$ is a complete Boolean algebra, and $\mathcal{A}_1(R) = \{\text{ann}(r) \mid r \in R\}$ is a join-semilattice (both under inclusion). Given a set X of vertices of a simple graph G, let $\mathbf{c}(X)$ be the set of vertices v of G such that v is adjacent to every element of X. The set $\mathbf{c}(X)$ can be regarded as a graph-theoretic analogue of the ring-theoretic annihilator. In this talk, the sets $\mathcal{L}(G) = \{\mathbf{c}(X) \mid X \subseteq G\}$ and $\mathcal{L}_1(G) = \{\mathbf{c}(x) \mid x \in G\} \cup \{\emptyset, G\}$ are examined in order to exploit the underlying combinatorial attributes that dictate the properties of $\mathcal{A}(R)$ and $\mathcal{A}_1(R)$. (Received January 13, 2014)

1097-06-98 **Jonathan D.H. Smith***, Department of Mathematics, Iowa State University, Ames, IA 50011. *Poset loops.* Preliminary report.

Given a ring and a locally finite poset, an *incidence loop* or *poset loop* is obtained from a new and natural extended convolution product on the set of functions mapping intervals of the poset to elements of the ring. The original motivation comes from *algebra loops*, whose character theory fuses the characters of groups of unipotent matrices to a less drastic extent than the fusion leading to supercharacters. Algebra loops are the incidence loops of finite chains.

The focus lies on the interplay between properties of the ring, the poset, and the loop. The annihilation structure of the ring and extremal elements of the poset determine commutative and associative properties of elements of the loop. Nilpotence of the ring and height restrictions on the poset force the loop to become associative, or even commutative. Constraints on the appearance of nilpotent groups of class 2 as poset loops are given. The main result shows that the incidence loop of a poset of finite height is nilpotent, of nilpotence class bounded in terms of the height of the poset. (Received January 13, 2014)

11 ► Number theory

1097-11-3 **Suresh Venapally***, Emory University. *Quadratic forms and Galois cohomology.*

Let K be a field of characteristic not equal to 2. The u-invariant of K is defined as the maximum of dimensions of anisotropic quadratic form over. It is well known that the u-invariant of finite field is 2 and the u-invariant of a p-adic field is 4. The famous Hasse-Minkowski theorem asserts that the u-invariant of a totally imaginary number field is 4. Let K be a complete discrete valued field with residue field κ and F the function field of a curve over K. If $char(\kappa) \neq 2$ and the u-invariants of the function fields of curves over κ are uniformly bounded, then Harbater, Hartman and Krashen computed the u-invariatn of F, extending the results of Parimala-Suresh for K a P-adic field, $p \neq 2$.

A theorem of Saltmans brings out the equivalence of the finiteness of the u-invariant of a field and the finiteness of the symbol length in Galois cohomology. Using a recent result of Krashen, one can show that the finiteness of the u-invariant follows from "uniform boundedness" for the 2-torsion in the Brauer group. Function fields of curves over complete discrete valued fields with residue fields of characteristic 2 and finite 2-rank have uniform boundedness for the Brauer group. This leads to the finiteness of the u-invariant of such fields. (Joint work with Parimala.) (Received April 30, 2013)

1097-11-12 **Tony Shaska*** (shaska@oakland.edu). *Minimal equations of curves over their minimal field of definition.*

For a given genus $g \geq 2$ the field of moduli of algebraic curves is not necessary a field of definition. Work of Weil, Shimura and others give conditions when this is true, however an algorithmic approach to determine the field of moduli and the minimal field of definition for a given algebraic curve C is still not known. If such minimal field of definition F is known for a given C, then an interesting question becomes if there is a "minimal model" of C defined over F. We will discuss such questions and give some results for some special families of curves. (Received January 28, 2014)

1097-11-19 **Mustafa Hajij*** (mhajij1@lsu.edu), Louisiana State University, Dept of Mathematics, Baton Rouge LA, LA 70802. *The tail of the quantum spin networks and Andrews-Gordon-type identities.*

We use the skein theory associated with Kauffman bracket to prove the Andrews-Gordon-type identity for the theta function and a corresponding identity for the false theta function. Furthermore, we show that other natural q-series show up in the study of the tail of quantum spin networks. (Received January 21, 2014)

1097-11-22 **Kit Ho Mak*** (kmak6@math.gatech.edu), 686 Cherry Street, Atlanta, GA 30332. *Class field towers and lower bounds for the Ihara constants $A(2)$ and $A(3)$.*

Let C be a curve over a finite fi eld $\mathbb{F}_q$. It is well-known that the Weil bound is not sharp when the genus of C is large compared to q. The Ihara constant $A(q)$ is a measure of the asymptotic behaviour of the number of rational points on curves over $\mathbb{F}_q$ when the genus becomes large.

In this talk, we will give a survey of our current knowledge about the Ihara constants, and give a construction of class field towers that improves the lower bounds for $A(2)$ and $A(3)$. This is joint work with Iwan Duursma. (Received December 03, 2013)

1097-11-25 **Zhengyao Wu*** (zwu22@emory.edu), 400 Dowman Dr., W401, Atlanta, GA 30322. *A Hasse principle for hermitian forms.*

Let F be a function field of one variable over a complete discrete valued field with residue characteristic $\neq 2$. For each discrete valuation v on F, let F_v be the completion of F at v. Let D be a finite-dimensional central division F-algebra with involution σ of the first kind. Suppose h is a hermitian or skew-hermitian form of rank $n \geq 3$ on D. This article shows that h is isotropic if and only if there is a fixed integer $r > 0$ and for each v there exists an isotropic vector x_v of h such that $x_v(D \otimes_F F_v)$ has reduced dimension r. (Received December 10, 2013)

1097-11-28 **Ricardo Conceicao*** (rconcei@emory.edu), 100 Hamill st, Oxford, GA 30054, and **Chris Hall** and **Douglas Ulmer**. *Explicit point on elliptic curves over function fields.*

Let E be the elliptic curve $y^2 = x(x+1)(x+t)$ over the field $\mathbb{F}_p(t)$ where p is an odd prime. In this talk, we discuss the arithmetic of E over extensions $K_d = \mathbb{F}_q(t^{1/d})$ where q is a power of p and d is an integer prime to p. In particular, we present a formula for the rank r_d of $E(K_d)$ given in terms of an elementary property of the subgroup of $(\mathbb{Z}/d\mathbb{Z})^\times$ generated by p. It turns out that r_d is large for many values of d and that for two families of values of d we are able to exhibit explicit points generating a subgroup of $E(K_d)$ of finite index. This talk is based on a joint work with C. Hall and D. Ulmer. (Received December 11, 2013)

1097-11-30 **Andrew V. Sutherland*** (drew@math.mit.edu). *Sato-Tate distributions of low genus curves.* Preliminary report.

The original Sato-Tate conjecture is concerned with the statistical distribution of the number of points on the reductions modulo primes of a fixed elliptic curve defined over the rational numbers. It predicts that this distribution can be explained in terms of a random matrix model, using the Haar measure on the special unitary group SU(2). Thanks to recent work by Richard Taylor and others, this conjecture is now a theorem.

The Sato-Tate conjecture generalizes naturally to abelian varieties of dimension g, including the Jacobian of a genus g curve, where it associates to each abelian variety a compact subgroup of the unitary symplectic group $\mathrm{USp}(2g)$ whose Haar measure governs the distribution of arithmetic data attached to the abelian variety. While the Sato-Tate conjecture remains open for all g greater than 1, the Sato-Tate groups that arise in genus 2 have been completely classified.

I will report on current work-in-progress in genus 3. (Received December 13, 2013)

1097-11-89 **Nicolas Bergeron**, (Paris VI, France), **Mehmet Haluk Sengun***, (Warwick, UK), and **Akshay Venkatesh**, (Stanford, USA). *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 January 13, 2014)

1097-11-99 **Nivedita Bhaskhar*** (nbhaskh@emory.edu). *More examples of non-rational adjoint groups.*

A k-variety is said to be rational if its function field is purely transcendental over k. The first example of a non-rational adjoint k-group $\mathrm{PSO}(q)$ was given by Merkurjev as a consequence of his computations of R-equivalence classes of adjoint classical groups. The quadratic form in question has non-trivial discriminant which property is used crucially in the proof. Gille provided the first example of a quadratic form of trivial discriminant whose associated adjoint group is non-rational. In this talk we give a recursive construction to produce examples of k_n-quadratic forms q_n in the n-th power of the fundamental ideal in the Witt ring whose corresponding adjoint groups are not (stably) rational. (Received January 15, 2014)

1097-11-102 **Ivan Horozov*** (horozov@math.wustl.edu), Washington University in St. Louis, Department of Mathematics, One Brookings Dr, Campus Box 1146, Saint Louis, MO 63130. *Non-commutative Hilbert modular symbol.*

I am going to present a construction of non-commutative Hilbert modular symbol, which is a generalization of Manin's non-commutative modular symbol to the case of Hilbert modular groups. I use a new method based on generalization of iterated path integrals to higher dimensions, which I call iterated integrals over membranes. (Iterated integrals were used by K.-T. Chen to give de Rham structure on a loop space of a manifold.)

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. I will present 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 over membranes.

Manin's non-commutative modular symbol is a non-commutative 1-cocycle. Similarly, the non-commutative Hilbert modular symbol is a non-commutative 2-cocycle. (Received January 14, 2014)

1097-11-109 **Matthew Ward*** (wardm4@math.washington.edu). *Moduli of Vector Bundles on Genus 1 Curves.*

Moduli of stable vector bundles on elliptic curves over separably closed fields were classified by Atiyah. All such moduli spaces are isomorphic to the elliptic curve itself. We use methods from derived categories to show that when the Weil-Châtelet group of the Jacobian of a genus 1 curve is sufficiently large there are more examples. This is joint work with Ben Antieau and Daniel Krashen. (Received January 14, 2014)

1097-11-145 **Wade M Hindes*** (whindes@math.brown.edu), Department of Mathematics, Brown University, 151 Thayer St., Providence, RI 02912. *Arithmetic properties of curves related to dynamical Galois theory.*

The Galois theory of the iterates of a quadratic polynomial f can be parametrized by certain points on the curves $y^2 = f^n(x)$ and their quadratic twists. In this talk, we study the geometry and arithmetic of such curves (and related ones) over global and finite fields. As an application, we classify certain Galois phenomena by studying rational points. Additionally, we construct families of curves using PCF polynomials that have some interesting arithmetic: complex multiplication, large rank, and completely determined rational points. (Received January 18, 2014)

1097-11-207 **David M Zureick-Brown***, 400 Dowman Dr, Atlanta, GA 30322, and **Eric Katz**.
Rational points on curves and chip firing.

Let X be a curve over $\mathbb{Q}$ with genus $g \geq 2$, $p > 2r$ a prime, J the Jacobian of X, $r = \text{rank } J(K)$, and $\mathcal{X}$ a regular proper model of X at p. Suppose $r < g$. We prove that $\#X(\mathbb{Q}) \leq \#\mathcal{X}(\mathbb{F}_p) + 2r$, extending the refined version of the Chabauty-Coleman bound to the case of bad reduction.

In this talk I'll review the setup of Chabauty-Coleman and explain a new technical insight from tropical geometry which generalizes the classical rank of a divisor on a curve to a notion better suited for singular curves and which satisfies Clifford's theorem. (Received January 22, 2014)

1097-11-208 **Alvaro Lozano-Robledo*** (alvaro.lozano-robledo@uconn.edu), Department of Mathematics, University of Connecticut, 196 Auditorium Road, U-3009, Storrs, CT 06269.
Uniform boundedness in terms of ramification.

Let $d \geq 1$ be fixed. Let F be a number field of degree d, and let E/F be an elliptic curve. Let $E(F)_{\text{tors}}$ be the torsion subgroup of $E(F)$. In 1996, Merel proved the uniform boundedness conjecture, i.e., there is a constant $B(d)$, which depends on d but not on the chosen field F or on the curve E/F, such that the size of $E(F)_{\text{tors}}$ is bounded by $B(d)$. Moreover, Merel gave a bound (exponential in d) for the largest prime that may be a divisor of the order of $E(F)_{\text{tors}}$. In 1996, Parent proved a bound (also exponential in d) for the largest p-power order of a torsion point that may appear in $E(F)_{\text{tors}}$. It has been conjectured, however, that there is a bound for the size of $E(F)_{\text{tors}}$ that is polynomial in d. In this talk we discuss that under certain hypotheses there is a linear bound for the largest p-power order of a torsion point defined over F, which in fact is linear in the maximum ramification index of a prime ideal of the ring of integers F over (p). (Received January 22, 2014)

1097-11-263 **Pere Menal-Ferrer*** (pmf3@math.gatech.edu). *Torsion in Homology for Hyperbolic 3-Manifolds of Finite Volume.*

In this talk, I will present some results about the amount of torsion in the homology groups of a hyperbolic 3-manifold. I will start with the seminal work by N. Bergeron and A. Venkatesh for the compact case, and then I will discuss what is known in the finite-volume setting. (Received January 24, 2014)

1097-11-346 **David B. Leep***, Department of Mathematics, 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506-0027. *The u-invariant of a rational function field over a field having cohomological dimension* 1. Preliminary report.

We discuss the u-invariant of a rational function field $k(t)$ over a field k when k has cohomological dimension 1. After stating some general results, we focus on the case when the absolute Galois group of k is a pro-cyclic group and obtain some partial results for this case. (Received January 26, 2014)

1097-11-465 **Michael Filaseta*** (filaseta@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *The genus behind Hilbert's Irreducibility Theorem.* Preliminary report.

This talk is more of a question than a discussion of new results. We will present a partial argument for showing how Hilbert's Irreducibility Theorem can be viewed in a certain way as following from Siegel's Theorem on integral points on curves of genus > 0. Since the deduction of Hilbert's Irreducibility Theorem from Siegel's Theorem is not new, the emphasis is on the particular rather simple approach. We give some details on how the simple approach can be shown to work in special cases. The question then is whether the approach works in general. (Received January 28, 2014)

1097-11-469 **Ali Dagdeviren*** (m.a.dagdeviren@gmail.com), Yildiz Technical University, Department of Mathematics, Davutpasa Campus, 34210 Istanbul, Turkey, and **Salim Yuce**, Yildiz Technical University, Department of Mathematics, Davutpasa Campus. *Dual Matrices with Lorentzian Matrix Multiplication.*

In this study, we will define Lorentzian Matrix Multiplication over Dual Matrices. In addition, we give some property about this topic. (Received January 28, 2014)

1097-11-496 **Matthew Boylan*** (boylan@math.sc.edu), Mathematics Department, University of South Carolina, 1523 Greene Street, Columbia, SC 29223, and **Kenny Brown**. *The Shimura Correspondence on certain subspaces of half-integral weights.* Preliminary report.

We give explicit formulas for the Shimura Correspondence on certain Hecke invariant subspaces of half-integral weight modular forms. (Received January 28, 2014)

1097-11-521 **Carl Libis*** (clibis@lanecollege.edu). *Solving the recursive problem* $a_{n-1}^2 - a_n \cdot a_{n-2} + 4 = 0$. Preliminary report.

We will show how to convert the recursive problem

$$a_{n-1}^2 - a_n \cdot a_{n-2} + 4 = 0$$

into a standard three-term recursion. We also show some properties that the recursion satisfies.
(Received January 28, 2014)

12 ► Field theory and polynomials

1097-12-2 **Daniel Krashen*** (dkrashen@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Algebraic structures, topology, and the arithmetic of fields.*

The study of vector bundles and related structures has played an important role in our understanding of the topology and geometry of manifolds. In this talk I will describe a few of the ways in which the study of algebraic structures such as quadratic forms, division algebras have played a closely analogous role in our understanding of the arithmetic of fields, and how new ways of importing techniques from topology to has led to important new advances in our understanding of these structures. (Received January 27, 2014)

1097-12-391 **Hernando Bermudez** and **Anthony Ruozzi*** (anthony@mathcs.emory.edu), Dept. of Math & CS, Emory University, 400 Dowman Dr. W401, Atlanta, GA 30322. *Classifying Forms of Simple Groups via Their Invariants.*

Let G be a simple linear algebraic group over a field F, and V an absolutely irreducible representation of G. We show that under some mild hypotheses there exists an invariant homogeneous polynomial f for the action of G on V defined over F, such that twisted forms of f up to a scalar multiple classify twisted forms of G over F.
(Received January 27, 2014)

1097-12-444 **Sunil Chebolu**, **Jan Minac** and **Andrew Schultz*** (andrew.c.schultz@gmail.com). *Solving embedding problems from a module-theoretic perspective.*

When K/F is an extension whose Galois group is a cyclic p-group, we show that the classical parameterizing space of elementary p-abelian extensions of K — viewed as an $\mathbb{F}_p[\mathrm{Gal}(K/F)]$-module — is the universal parameterizing space for a wide class of embedding problems for K/F. With this methodology we are able to answer a number of explicit enumeration problems for Galois groups. We explore one such application that connects the number of H_{p^3}-extensions of a field to the number of M_{p^3} extensions of that field, where H_{p^3} and M_{p^3} are the two nonabelian groups of order p^3. (Received January 27, 2014)

13 ► Commutative rings and algebras

1097-13-26 **S. Kabbaj*** (kabbaj@kfupm.edu.sa), Department of Mathematics and Statistics, King Fahd University of Petroleum & Minerals, Dhahran, 31261, Saudi Arabia, and **K. Louartiti** and **M. Tamekkante**. *A preliminary on bi-amalgamated algebras.*

Let $f : A \to B$ and $g : A \to C$ be two commutative ring homomorphisms and let J and J' be two ideals of B and C, respectively, such that $f^{-1}(J) = g^{-1}(J')$. This is a preliminary study of ring-theoretic properties in a new construction called the "*bi-amalgamation of A with (B, C) along (J, J') with respect to (f, g)*" and arising as a pullback. It capitalizes on previous works carried on various settings of pullbacks and amalgamations to develop a unified study on bi-amalgamations. This study should both compare and contrast with recent studies in the literature on amalgamated algebras and Nagata's idealizations as well as yield original examples which arise naturally as bi-amalgamations subject to various ring conditions. (Received December 11, 2013)

1097-13-34 **Marco Fontana*** (fontana@mat.uniroma3.it), Dipartimento di Matematica e Fisica, 1, Largo San Leonardo Murialdo, Università degli Studi "Roma Tre", 00146 Rome, Italy. *Going ... Back: recent developments in the theory of Zariski-Riemann spaces of valuation domains, originated by joint works with David Dobbs published in 1986-1987.*

In this talk, I will present some recent results concerning the Zariski-Riemann spaces of valuation domains, endowed with various topologies such as the ultrafilter topology and the inverse topology, with applications to the theory of star and semistar operations. (Received December 19, 2013)

1097-13-44 **Dan D. Anderson*** (dan-anderson@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242, and **Sangmin Chun**, Department of Mathematics, Seoul National University, Seoul, 151-747, South Korea. *Unions of Submodules.*

We consider when a subset of a module (ring) is a union of submodules (ideals). Special attention to paid to irredundant unions and unions of incomparable submodules, especially in the case where the submodules (ideals) in question are cyclic or prime. (Received December 30, 2013)

1097-13-45 **Michael Axtell**, **Nicholas Baeth** and **Joe Stickles*** (jstickles@millikin.edu). *Graphical Representations of Factorizations in Commutative Rings.*

We survey the recent and active area of irreducible divisor graphs of commutative rings. Notable algebraic and graphical results are given, and alternate constructions for irreducible divisor graphs and higher dimensional analogs are explored. (Received December 31, 2013)

1097-13-52 **Shane P Redmond*** (shane.redmond@eku.edu), **S Pirzada** and **Rameez Raja**. *Locating Numbers and Zero-Divisor Graphs of Commutative Rings.* Preliminary report.

Given a connected graph G and an ordered subset W of the vertex set of G, we define the locating code of a vertex v of G to be the vector representing the distances from v to the vertices of W. The set W is called a locating set if distinct vertices have distinct codes. The minimum cardinality for a locating set of G is called the locating number of G, denoted $loc(G)$. Locating sets and locating numbers for general classes of graphs are discussed. Then locating sets and locating numbers for zero-divisor graphs of commutative rings are examined, with an eye towards identifying relationships between locating numbers and ring properties. Finally, these ideas are extended to other graphs on commutative rings. (Received January 04, 2014)

1097-13-66 **Ela Celikbas**, **Christina Eubanks-Turner** and **Sylvia M Wiegand*** (swiegand@math.unl.edu), Math. Dept., UNL, Lincoln, NE 68588-0130. *Prime ideals in two-dimensional polynomial-power series domains.* Preliminary report.

We describe Spec B, the partially ordered sets of prime ideals of the ring $B = R[[x]][y]/Q$ or $B = R[y][[x]]/Q$, where x and y are indeterminates over a one-dimensional Noetherian domain and Q is a height-one prime ideal of the appropriate ring. Our focus is on the partially ordered sets that arise as Spec B when $R = \mathbb{Z}$, the ring of integers. (Received January 09, 2014)

1097-13-80 **M Axtell*** (axte2004@stthomas.edu), University of St. Thomas, OSS201, 2115 Summit Ave, St. Paul, MN 55105, and **N. Baeth** and **J Stickles**. *Cut Structures in Zero-Divisor Graphs of Commutative Rings.*

Zero-divisor graphs, and more recently, compressed zero-divisor graphs are well-represented in the commutative ring literature. In this work, we consider various cut structures, sets of edges or vertices whose removal disconnects the graph, in both compressed and non-compressed zero-divisor graphs. In doing so we connect these graph-theoretic concepts with algebraic notions and provide realization theorems of zero-divisor graphs for commutative rings with identity. (Received January 11, 2014)

1097-13-84 **Christop P. Mooney*** (cpmooney@viterbo.edu), 900 Viterbo Dr, Reinhart Center, Viterbo University, La Crosse, WI 54601. *On Irreducible Divisor Graphs.*

In this talk, we construct several different associated irreducible divisor graphs of a commutative ring with unity using various choices for the definition of irreducible and atomic in the literature. We continue pursuing the program initiated by I. Beck of exploiting the interaction between algebraic structures and associated graphs to further our understanding of both objects. Factorization in rings with zero-divisors is considerably more complicated than integral domains; however, we find that many of the same techniques can be extended to rings with zero-divisors. This allows us to use graph theoretic properties to help characterize finite factorization properties of commutative rings, and conversely. (Received January 12, 2014)

1097-13-91 **Ayman R Badawi*** (abadawi@aus.edu), American University of Sharjah, Department of Mathematics, Sharjah, 26666, United Arab Emirates, and **Unsal Tekir** and **Ece Yetkin**. *On 2-absorbing primary ideals in commutative rings.* Preliminary report.

Let R be a commutative ring with $1 \neq 0$. In this paper, we introduce the concept of 2-absorbing primary ideal which is a generalization of primary ideal. A proper ideal I of R is called a *2-absorbing primary ideal* of R if whenever $a, b, c \in R$ and $abc \in I$, then $ab \in I$ or $ac \in \sqrt{I}$ or $bc \in \sqrt{I}$. It is shown that if I is a 2-absorbing primary ideal of R, then $\sqrt{I}$ is a 2-absorbing ideal. It is shown that a proper ideal I of R is a 2-absorbing primary ideal if and only if whenever $I_1I_2I_3 \subseteq I$ for some ideals I_1, I_2, I_3 of R, then $I_1I_2 \subseteq I$ or $I_1I_3 \subseteq \sqrt{I}$ or $I_2I_3 \subseteq \sqrt{I}$. It is shown that if I_1 is a P_1-primary ideal of R for some prime ideal P_1 of R and I_2 is a P_2-primary ideal of R for some prime ideal P_2 of R, then $I_1 I_2$ and $I_1 \cap I_2$ are 2-absorbing primary ideals of R. It is shown that a Noetherian domain R is a Dedekind domain if and only if a nonzero 2-absorbing primary ideal of R is either M^k for some maximal ideal M of R and some positive integer $k \geq 1$ or $M_1^k M_2^n$ for some distinct maximal ideals M_1, M_2 of R and some positive integers $k, n \geq 1$. (Received January 13, 2014)

1097-13-106 **Shashikant Mulay*** (mulay@math.utk.edu). *Automorphism groups of Power-series rings.*
The talk will expose some recent results on torsion subgroups of the automorphism group of a (several variables) power-series ring. (Received January 14, 2014)

1097-13-126 **Sarah Glaz*** (sarah.glaz@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269. *Prüfer properties of localizations of polynomial rings.* Preliminary report.
Let \$R\$ be a commutative ring, and let \$f\$ be a polynomial with coefficients in \$R\$. Denote by \$c(f)\$, the content of \$f\$, the ideal of \$R\$ generated by the coefficients of \$f\$. A ring \$R\$ is called a Gaussian ring if \$c(f)c(g) = c(fg)\$ for any two polynomials \$f\$ and \$g\$ with coefficients in \$R\$. Gaussian rings were defined by Tsang in 1965, and became an active topic of investigation due to their connection to Kaplansky's conjecture, which was solved between 1997 and 2005. The focus of these investigations lied in the comparison between the Gaussian property and several related ring theoretic and homological properties, all of which coincide with the condition of being a Prüfer ring, when the ring is an integral domains. This talk will discuss the behavior of six Prüfer properties in several localizations of polynomial rings. In particular, we will consider some recent results and counterexamples to questions of ascent and descent of these properties among the rings involved, and the remaining open problems. (Received January 16, 2014)

1097-13-134 **Lee Klingler**, **Warren McGovern** and **Madhav P Sharma*** (msharma2@fau.edu), Florida Atlantic University, Department of Mathematical Sciences, 777 Glades Rd, Boca Raton, FL 33431. *Gaussian Property of the rings $R(X)$ and $R\langle X\rangle$.* Preliminary report.
The content of a polynomial f over a commutative ring R is the ideal $c(f)$ of R generated by the coefficients of f. A commutative ring R is said to be Gaussian if $c(fg) = c(f)c(g)$ for all polynomials f and g over R. A number of authors have formulated necessary and sufficient conditions for $R(X)$ (respectively $R\langle X\rangle$) to be semihereditary, w. dim ≤ 1, Arithmetical, and Prüfer. An open problem has been for the Gaussian Property. We give a necessary and sufficient condition for $R(X)$ and $R\langle X\rangle$ to be Gaussian for a commutative ring R whose the square of the nilradical is zero. (Received January 17, 2014)

1097-13-176 **Gabriel Picavet*** (gabriel.picavet@math.univ-bpclermont.fr) and **Martine Picavet-L'Hermitte** (martine.picavet@math.univ-bpclermont.fr). *More results on Prüfer hulls of FCP ring extensions.* Preliminary report.
Let $R \subset S$ be a (ring) extension of commutative rings, $[R, S]$ the set of all R-subalgebras of S and $\overline{R}$ the integral closure of R in S. We say that the extension $R \subset S$ has FCP if each chain in $[R, S]$ is finite. An extension $R \subseteq S$ is called Prüfer if each of its subextensions $R \subseteq T$ is a flat epimorphism. An arbitrary extension $R \subset S$ has a greatest Prüfer subextension $R \subseteq \widetilde{R}$, called the Prüfer hull of R in S. For an FCP extension $R \subset S$, we show that $\widetilde{R}$ is a large quotient ring of R in S with respect to a multiplicatively closed subset linked to the conductor of $R \subseteq \overline{R}$. We also show that $|[R, \widetilde{R}]| = |[\overline{R}, \widetilde{\overline{R}}]|$ and $|[R, \overline{R}]| = |[\widetilde{R}, \overline{\widetilde{R}}]|$. Moreover, we prove that the supports of $\overline{R}/R$ and $S/\overline{R}$ do not meet if and only if $S = \overline{R}\widetilde{R}$. This last condition is equivalent to many others such as $\widetilde{R} \subseteq S$ is integral. In that case $\widetilde{R}$ is equal to the Morita hull of R in S. (Received January 21, 2014)

1097-13-177 **Martine Picavet-L'Hermitte*** (martine.picavet@math.univ-bpclermont.fr) and **Gabriel Picavet**. *Idealizations which are FCP or FIP extensions.* Preliminary report.
Let $R \subseteq S$ be a (ring) extension of commutative rings and $[R, S]$ the set of all R-subalgebras of S. We say that the extension $R \subseteq S$ has FIP (resp. FCP) if $[R, S]$ (resp. each chain in $[R, S]$) is finite. In a previous paper, D. Dobbs and ourselves characterized arbitrary FCP and FIP extensions. Let M be an R-module, and consider the ring extension $R \subseteq R(+)M$, where $R(+)M$ is the idealization of M. In this talk, we consider the FCP and FIP properties of the extension $R \subseteq R(+)M$. We show that this extension has FCP if and only if the length of the R-module M is finite, and has FIP if and only if M has finitely many submodules. As a by-product, we get that an R-module M, with $C := (0 : M)$, has finitely many submodules if and only if the three following conditions are satisfied: (1) M is finitely generated, (2) R/C has finitely many ideals and (3) M_P is cyclic for any prime ideal P of R containing C such that R/P is infinite. (Received January 21, 2014)

1097-13-193 **Tim S. Long*** (tlong1@gmu.edu). *Going-Down, Epimorphisms, and Integrality in Amalgamated Duplications.* Preliminary report.

We consider extensions of the ring construction $R \bowtie I$, the amalgamated duplication of a ring along an ideal. Specifically, if $R \subset T$ are rings with ideals $I \subseteq J$, respectively, then we examine the ring extension $R \bowtie I \subset T \bowtie J$. We give necessary and sufficient conditions for this extension to satisfy going-down, and for $T \bowtie J$ to be a flat epimorphism of $R \bowtie I$. We also determine the integral closure of $R \bowtie I$ in $T \bowtie J$, and use this to derive conclusions about when $(R \bowtie I, T \bowtie J)$ is a normal pair (that is, when S is integrally closed in $T \bowtie J$ for every intermediate ring $R \bowtie I \subseteq S \subseteq T \bowtie J$). (Received January 22, 2014)

1097-13-238 **Jesse Gerald Smith***, Department of Mathematics, The University of Tennessee, 1403 Circle Drive, Knoxville, TN 37996-1320. *Classification of Finite Planar Nontrivial Ideal-based Zero-divisor Graphs for Commutative Rings.* Preliminary report.

Let R be a commutative ring with nonzero identity and I a proper ideal of R. Define the *ideal-based zero-divisor graph* of R with respect to the ideal I, denoted $\Gamma_I(R)$, to be the graph on vertices $\{x \in R \setminus I \mid xy \in I$ for some $y \in R \setminus I\}$, where distinct vertices x and y are adjacent if and only if $xy \in I$. We say that $\Gamma_I(R)$ is nontrivial if it is nonempty and distinct from the zero-divisor graph $\Gamma(R)$ (i.e., I is not prime and $I \neq \{0\}$). We will give a classification of all commutative rings that admit a finite planar nontrivial $\Gamma_I(R)$. (Received January 23, 2014)

1097-13-246 **Evan Houston*** (eghousto@uncc.edu) and **Muhammad Zafrullah**. *Integral domains in which any two v-coprime elements are comaximal.*

Domains in which the star operations d and w coincide have received a good deal of attention recently. These are exactly the domains D in which $I = D$ whenever I is a finitely generated ideal of D with $I^v = D$. In this work, we study what happens when "finitely generated" is replaced by "two-generated." It turns out that these are precisely the domains in which $d = F$, where F is a certain star operation closely connected to, but more complicated than, the w-operation. (Received January 23, 2014)

1097-13-264 **Hannah Robbins*** (robbins@roanoke.edu), 2415 Fairway Dr SW, Roanoke, VA 24015. *Ring extensions preserving the finiteness of associated primes.* Preliminary report.

Let R and S be commutative Noetherian rings and M a finitely generated R-module. If $R \to S$ is flat, then $S \otimes M$ has only finitely many associated primes whenever $\mathrm{Ass}_R M$ is finite. In this talk we generalize flat extensions to a new type of ring extension, called calm, which also preserves finiteness of the associated primes when we move from a module to its extension. We will discuss properties of calm extensions and give some examples of rings which have only calm extensions. (Received January 24, 2014)

1097-13-274 **Paul-Jean Cahen**, **David E Dobbs** and **Thomas G Lucas*** (tglucas@uncc.edu). *Valuative Pairs of Rings.*

An integral domain D is valuative if for each $x \in qf(D)\backslash\{0\}$, at least one of $D \subseteq D[x]$ and $D \subseteq D[1/x]$ has no proper intermediate rings. We extend this notion to pairs of commutative rings $R \subseteq T$ with a common nonzero identity: the ring R is T-valuative if for each $t \in T\backslash\{0\}$, at least one of $R \subseteq R[t]$ and $R \subseteq R[(R :_T t)]$ has no proper intermediate rings. There are weak and strong versions as well: R is weakly T-valuative if for each $t \in T$, either $R \subseteq R[t]$ has no proper intermediate rings or $R \subseteq R[s]$ has no proper intermediate rings for each $s \in (R :_T t)$; R is strongly T-valuative if for each $t \in T$, at least one of $R \subseteq R[(R :_T (R :_T t))]$ and $R \subseteq R[(R :_T t)]$ has no proper intermediate rings. In general, the following implications are not reversible: strongly T-valuative $\Rightarrow$ T-valuative $\Rightarrow$ weakly T-valuative (even when T is the total quotient ring of R). However if R is integrally closed in T, then all three are equivalent. Unlike valuative domains (which have at most three maximal ideals), (strongly) [weakly] T-valuative rings can have infinitely many maximal ideals. (Received January 24, 2014)

1097-13-307 **Jim Coykendall*** (jcoyken@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634, and **Saba el-Kaseasbeh**. *Ideal graphs.*

Recently there has been much research that has been focused on the interplay between graph theory and commutative ring theory. In this talk we will present a graphical approach to the study of ideal relations in commutative rings. Highlighted will be the graphical structure induced under various assumptions made on the edge definitions. (Received January 25, 2014)

1097-13-316 **Moshe Roitman*** (mroitman@math.haifa.ac.il), University of Haifa, Mount Carmel, 31905 Haifa, Israel. *On the elementary divisor problem.*

In this talk we will discuss some aspects of the elementary divisor problem: is a Bézout domain necessarily an elementary divisor ring? (Received January 26, 2014)

1097-13-355 **K Alan Loper*** (loper.4@osu.edu), Ohio State University, 1179 University Drive, Newark, OH 43055, and **Nick Werner** (nwerner@newark.osu.edu), Ohio State University, 1179 University Drive, Newark, OH 43055. *Pseudo-convergent sequences and Prufer domains of integer-valued polynomials.*

Let V be a one-dimensional, non-discrete valuation domain. For a subset S of V we show that if S is a pseudo-convergent sequence such that V does not contain a pseudo-limit of S then the ring Int(S,V) is a Prufer domain. This extends what was known because the set S need not be pre-compact. (Received January 26, 2014)

1097-13-369 **Takayuki Hibi**, **Akihiro Higashitani**, **Kyouko Kimura** and **Augustine B. O'Keefe*** (abok222@uky.edu). *Edge ideals of Cameron-Walker graphs.*

In 2005 Cameron and Walker classified all finite simple graphs G such that the matching number of G, $m(G)$, is equal to the induced matching number of G, $i(G)$. We call such graphs Cameron-Walker graphs. This class of graphs is of particular interest to algebraists as these graph theoretic invariants provide upper and lower bounds for the Castelnuovo-Mumford regularity of the ring $R/I(G)$, where R is the polynomial ring in $|V(G)|$ variables and $I(G)$ is the edge ideal of G. Here we explore other properties of the edge ideals of Cameron-Walker graphs such as (sequentially) Cohen-Macaulayness, (pure) shellability, and (pure) vertex decomposability. (Received January 27, 2014)

1097-13-375 **Bruce Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88011. *On pullback decompositions of quasilocal rings.* Preliminary report.

It is a standard observation that a quasilocal ring R has a principal maximal ideal generated by a nonzerodivisor if and only if R is a pullback of a PID A and a flat overring of R whose residue field is the quotient field of A. Thus a single property of the maximal ideal has a strong influence on the overall structure of the ring. In this talk we seek to pinpoint what properties of the maximal ideal of a quasilocal ring R enable a decomposition into a pullback of a one-dimensional ring A (possibly with zero divisors) and a flat overring of R that map surjectively onto the total quotient ring of A. As one application, we give a decomposition theorem for quasilocal rings having a maximal ideal whose square is two-generated. (Easy examples show that no such decomposition may be possible if it is assumed only that the maximal ideal itself is two-generated.) In this case rather than a PID, the decomposition involves a one-dimensional Cohen-Macaulay ring of multiplicity ≤ 2. David Dobbs' notion of a divided prime ideal plays a motivating role throughout. (Received January 27, 2014)

1097-13-398 **David Cook II*** (dcook8@nd.edu), Department of Mathematics, 255 Hurley Building, University of Notre Dame, Notre Dame, IN 46556-4618. *Betti tables of non-squarefree ideals associated to simplicial complexes.*

We introduce a non-squarefree monomial ideal, called the uniform face ideal, of a simplicial complex with respect to a given ordered proper vertex colouring. When the colouring satisfies a certain nesting property, the resolution of the ideal is linear. In this case, we fully describe the Betti table of the ideal by means of the f-vector of the simplicial complex. (Received January 27, 2014)

14 ► Algebraic geometry

1097-14-74 **Laurentiu G Maxim*** (laurentiu.maxim@gmail.com), 480 Lincoln Drive, Madison, WI 53706, and **Nero Budur** and **Markus Banagl**. *Intersection spaces, perverse sheaves and type IIB string theory.*

The method of intersection spaces associates rational Poincare complexes to singular stratified spaces. For a complex projective hypersurface with only isolated singularities, we show that the cohomology of the associated intersection space is the hypercohomology of a perverse sheaf, the intersection space complex, on the hypersurface. We will discuss properties of the intersection space complex, such as self-duality, its betti numbers and mixed Hodge structures on its hypercohomology groups. This is joint work with Banagl and Budur. (Received January 10, 2014)

1097-14-79 **Washington Taylor***, 6-317, CTP, MIT, 77 Massachusetts Ave., Cambridge, MA 02139. *Classifying and enumerating elliptically fibered Calabi-Yau threefolds and associated singularities.*

Motivated by the physics of F-theory, a systematic classification is given of the set of smooth complex surfaces that can act as bases for an elliptically fibered Calabi-Yau threefold with section. This classification enables a systematic analysis of such Calabi-Yau threefolds with large Hodge numbers, which is illuminated by the close correspondence between geometry and the physics of six-dimensional supergravity theories. A complete enumeration of all elliptically fibered Calabi-Yau threefolds with section requires a systematic understanding of codimension two singularities associated with singular elliptic fibrations. The study of such singularities suggests a mysterious formula relating the arithmetic genus of certain singular curves to the representation theory of Lie algebras. This talk describes a number of results and open questions, including work carried out with Sam Johnson, Vijay Kumar, David Morrison, and Daniel Park. (Received January 11, 2014)

1097-14-95 **Anatoly Libgober*** (libgober@uic.edu), Department of Mathematics, 851 S.Morgan Str., Chicago, IL. *Calabi-Yau threefolds from plane singular curves.* Preliminary report.

We shall describe a construction of isotrivial elliptically fibered Calabi-Yau threefolds having positive Mordell-Weil rank associated with plane curves with mild singularities. The rank of such threefolds is related to the rank of abelianization of commutator of the fundamental group of the complement to the curve. I also will discuss methods for calculation of Mordell-Weil ranks for elliptic threefolds corresponding to curves with large number of ordinary cusps. (Received January 13, 2014)

1097-14-108 **Kirill Zainoulline*** (kirill@uottawa.ca), Dept. of Mathematics and Statistics, University of Ottawa, 585 King Edward, Ottawa, Ontario K1N6N5, Canada, and **Alexander Merkurjev** and **Alexander Neshitov**. *Invariants of degree 3 and torsion in the Chow group of a versal flag.*

We prove that the group of normalized cohomological invariants of degree 3 modulo the subgroup of semidecomposable invariants of a semisimple split linear algebraic group G is isomorphic to the torsion part of the Chow group of codimension 2 cycles of the respective versal G-flag. In particular, if G is simple, we show that this factor group is isomorphic to the group of indecomposable invariants of G. As an application, we construct nontrivial cohomological classes for indecomposable central simple algebras. (Received January 14, 2014)

1097-14-115 **Milagros Izquierdo*** (milagros.izquierdo@liu.se), Department of Mathematics, Linköping University, 58183 Linköping, Sweden, and **Antonio F Costa** and **Hugo Parlier**. *On the Connectivity of the Compactification of Moduli Space.*

Consider the moduli space M_g of Riemann surfaces of genus $g \geq 2$ and its Deligne-Munford compactification $\overline{M}_g$. We are interested in the branch locus B_g for $g > 2$, i.e., the subset of M_g consisting of surfaces with automorphisms. It is well-known that the set of hyperelliptic surfaces (the hyperelliptic locus) is connected in M_g but the set of (cyclic) trigonal surfaces is not. By contrast, we show that for $g \geq 5$ the set of (cyclic) trigonal surfaces is connected in $\overline{M}_g$. To do so we exhibit an explicit nodal surface that lies in the completion of every equisymmetric set of 3-gonal Riemann surfaces. For $p > 3$ the connectivity of the p-gonal loci becomes more involved. We show that for $p \geq 11$ prime and genus $g = p - 1$ there are one-dimensional strata of cyclic p-gonal surfaces that are completely isolated in the completion $\overline{B}_g$ of the branch locus in $\overline{M}_g$. (Received January 15, 2014)

1097-14-146 **I Biswas**, **A Dhillon*** (adhill3@uwo.ca) and **N Hoffmann**. *Essential Dimension of Coherent Sheaves.*

Some recent results on essential dimension of coherent sheaves on projective varieties will be discussed. In the special case of a smooth projective curve, we obtain a kind of genericity theorem for the essential dimension of the moduli stack of vector bundles over the curve. (Received January 18, 2014)

1097-14-178 **Lara B. Anderson*** (lara.anderson@vt.edu), Department of Physics, Virginia Tech, 850 West Campus Drive, Blacksburg, VA 24060. *Geometric Constraints in Heterotic/F-theory Duality.* Preliminary report.

We systematically analyze a broad class of dual heterotic and F-theory models that give four-dimensional supergravity theories, and compare the geometric constraints on the two sides of the duality. In this talk I will show that F-theory gives new insight into the conditions under which heterotic vector bundles can be constructed. We show that in many cases the F-theory geometry imposes a constraint on the extent to which the gauge group can be enhanced, corresponding to limits on the way in which the heterotic bundle can decompose. We explicitly construct all dual F-theory/heterotic pairs in the class under consideration where the common twofold base surface is toric, and give both toric and non-toric examples of the general results. (Received January 21, 2014)

1097-14-195 **Antonella Grassi*** (grassi@math.upenn.edu), **Jim Halverson** and **Julius L Shaneson**. *Deformations and Resolutions.*

We utilize the deformation theory of algebraic singularities to study charged matter in compactifications of M-theory, F-theory, and type IIa string theory on elliptically fibered Calabi-Yau manifolds. (Received January 21, 2014)

1097-14-203 **Alexander Rhys Duncan*** (arduncan@umich.edu), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48109. *Forms of toric varieties.*

A Severi-Brauer variety is a twisted form of projective space. I consider twisted forms of toric varieties as a natural generalization of Severi-Brauer varieties. In particular, one can consider a natural notion of a "Brauer class" in this setting. (Received January 22, 2014)

1097-14-226 **Jese Leo Kass***, Department of Mathematics, University of South Carolina, 1523 Greene Street, Columbia, SC 29208. *An explicit semi-factorial model of the Néron model.* Preliminary report.

In recent work Cédric Pépin proved that the Néron model of an abelian variety admits a semi-factorial model, a compactification well-suited to studying the Néron pairing. I will prove that an explicit semi-factorial model of a jacobian variety is given by a moduli space — the compactified jacobian. The proof is an application of the autoduality theorem of Arinkin–Esteves–Gagné–Kleiman. (Received January 22, 2014)

1097-14-232 **David R Morrison*** (drm@math.ucsb.edu). *Canonical singularities and superconformal field theories.*

To every isolated canonical singularity which can occur on an elliptically fibered complex algebraic threefold, there is an associated six-dimensional superconformal field theory. We will explain this correspondence, and outline a classification program for the singularities and the field theories. This talk is based in part on joint work with Jonathan Heckman and Cumrun Vafa. (Received January 23, 2014)

1097-14-270 **Mirjam Cvetic*** (cvetic@physics.upenn.edu), Department of Physics and Astronomy, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104-6396. *Elliptic fibrations with higher rank Mordell-Weil Group: F-theory compactifications with higher rank Abelian Gauge Symmetry.*

The construction of Abelian gauge symmetries in F-theory compactifications on elliptically fibered Calabi-Yau manifolds has been more elusive than the well studied non-Abelian cases. We present a systematic approach to engineer Abelian gauge factors in F-theory, by explicitly constructing general elliptic curves with rank two and three Mordell-Weil groups and their Calabi-Yau elliptic fibrations. Compactifications of F-theory on such Calabi-Yau spaces lead to U(1)xU(1) and U(1)xU(1)xU(1) Abelian gauge symmetry, respectively. We determine the full massless matter spectrum both in six and four dimensions and also in the presence of additional SU(5) Grand Unified Symmetry, by an explicit study of the co-dimension two singularities. We also obtain closed expressions for the four-dimensional chiral indices of matter representations in four-dimensions by formulating conditions on chirality-inducing G4-flux of dual M-theory compactifications. (Received January 24, 2014)

1097-14-278 **Martha E Precup*** (martha_precup@baylor.edu), Department of Mathematics, One Bear Place #97328, Waco, TX 76798-7328. *Connectedness Properties of Hessenberg Varieties.*

In this talk, we consider certain closed subvarieties of the flag variety, known as Hessenberg varieties. We show that nilpotent Hessenberg varieties are rationally connected. We give a connectedness criterion for semisimple Hessenberg varieties generalizing a criterion given by Anderson and Tymoczko in the regular semisimple case. (Received January 24, 2014)

1097-14-311 **Qile Chen**, Rm 628, MC 4421, 2990 Broadway, New York, NY 10027, and **Yi Zhu*** (yzhu@math.utah.edu), 155 S 1400 E ROOM 233, Salt Lake City, UT 84112. *Arithmetics of semisimple groups over function fields.*

A complex affine variety is $\mathbb{A}^1$-connected if a general pair of points can be connected by the image of a map from the affine line. The typical examples are affine spaces. In this talk, I will report the recent progress on $\mathbb{A}^1$-connected varieties, which include all semisimple groups. I will also survey their arithmetic applications over function fields, e.g., strong approximation problem. (Received January 25, 2014)

1097-14-401 **Darren B Glass***, dglass@gettysburg.edu. *Genera and non-genera of curves with prescribed automorphisms.*

In this talk, we consider which integers g and σ can occur respectively as the genus and p-rank of a curve defined over a field of odd characteristics p which admit certain automorphism groups. This will lead us to discuss a question in combinatorial number theory related to the number of components of certain moduli spaces. (Received January 27, 2014)

1097-14-422 **Mahir Bilen Can*** (mcan@tulane.edu), 6823 St. Charles Ave., Tulane University, Mathematics Department, New Orleans, LA 70118, and **Soumya Banerjee** (soumya.banerjee@yale.edu), Yale University Mathematics Dept., 442 Dunham Lab, 10 Hillhouse Ave., New Haven, CT 06511. *Equivariant K-theory of spherical varieties.* Preliminary report.

In this talk we present our work on equivariant K-theory of smooth complete spherical varieties. After explaining our general result, a description of the equivariant K-rings, we present its applications to wonderful compactifications of minimal rank symmetric varieties. This is a joint work with Soumya Banerjee. (Received January 27, 2014)

1097-14-447 **Caroline Junkins*** (cjunk084@uottawa.ca). *Triality and the gamma-filtration.*

For a linear algebraic group G, the gamma-filtration on the Grothendieck group of a projective homogeneous G-variety has a presentation which is highly dependent on the Tits algebras of G. It has recently been shown that there is a correspondence between torsion elements in the gamma-filtration and cohomological invariants of G. In the case that G is of inner type D4, we show that such a torsion element detects splitting of the Tits algebras, and acts as an invariant of the associated trialitarian triple. We discuss applications to decomposability and hyperbolicity of the associated algebras with orthogonal involution. (Received January 27, 2014)

1097-14-466 **Asher Auel*** (asher.auel@yale.edu), Yale University, 10 Hillhouse Ave, New Haven, CT 06511. *Curves and Brauer classes on K3 surfaces associated with cubic fourfolds.* Preliminary report.

We study K3 surfaces associated with cubic fourfolds containing special cycles over number fields. These can give rise to prime period Brauer classes on isogenous K3 surfaces, as well as families of algebraic curves that have applications to the arithmetic of moduli spaces of curves. (Received January 28, 2014)

1097-14-495 **Drake M Harmon*** (dharmon2@fau.edu). *A class of rational surfaces with a non-rational singularity explicitly given by a single equation.*

The family of surfaces X defined by the equation $z^n = (y - a_1x)\cdots(y - a_nx)(x - 1)$ over an algebraically closed field k of characteristic 0, $a_i \in k$ distinct, is studied. It is shown that these are rational surfaces containing a non-rational singularity at the origin. The exact sequence of Chase-Harrison-Rosenberg on the open complement of the ramification locus $X \to \mathbb{A}^2$ and terms of the exact sequence in Galois cohomology of Rim are computed, as well as a closer look at the Brauer group.

The resolution of the non-rational singularity is explored, and facts about the blown-up surface are used to prove properties about the original surface X. (Received January 28, 2014)

1097-14-503 **Alan Thompson*** (amthomps@ualberta.ca), Dept of Mathematical and Statistical Sciences, 632 Central Academic Building, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *The arithmetic/thin dichotomy for Calabi-Yau threefolds and families of lattice polarized K3 surfaces.*

Recently there has been a great deal of interest in studying one-parameter families of Calabi-Yau threefolds with small Hodge numbers, motivated by the discovery of the arithmetic/thin dichotomy by Brav and Thomas. However, it remains an open problem to explain the geometric origins of this dichotomy. I will present an interesting observation relating this problem to the behaviour of fibrations of these Calabi-Yau threefolds by lattice polarized K3 surfaces of high rank. Such fibrations are characterized by a map from the projective line into the appropriate moduli space of lattice polarized K3 surfaces. As we shall see, there appears to be a close link between the ramification behaviour of this map and the arithmetic/thin dichotomy for the corresponding threefold. (Received January 28, 2014)

1097-14-505 **Atoshi Chowdhury*** (atoshi@berkeley.edu). *Stability of line bundles on reducible surfaces.*

Suppose X is a family of algebraic varieties with smooth generic fiber and reducible central fiber. Then the relative Picard stack of X (the moduli space of line bundles on X) is naturally non-separated: line bundles on the generic fiber will have infinitely many limits over the central fiber. I'll discuss a stability condition that can be imposed on line bundles to rectify this non-separatedness. In particular, I'll give some results on the separatedness of the moduli space of semistable line bundles over certain degenerations of algebraic surfaces. (Received January 28, 2014)

1097-14-507 **Ursula Whitcher*** (whitchua@uwec.edu). *Lattice-polarized K3 surfaces, curves, and moduli.*

We describe particular families of K3 surfaces with a natural geometric correspondence to abelian surfaces. We use the Picard-Fuchs equations of the families to characterize modular curves, Shimura curves, and Humbert surfaces. (Received January 28, 2014)

1097-14-508 **Fred Thompson*** (jthomps17.jt@gmail.com), Royal Oak, MI 48067. *Bielliptic curves of genus 3 in the hyperelliptic moduli.*

In this paper we study bielliptic curves of genus 3 defined over an algebraically closed field k and the intersection of the moduli space $\mathcal{M}_3^b$ of such curves with the hyperelliptic moduli $\mathcal{H}_3$. Such intersection $\mathcal{S}$ is an irreducible, 3-dimensional, rational algebraic variety. We determine the equation of this space in terms of the $Gl(2,k)$-invariants of binary octavics and find a birational parametrization of $\mathcal{S}$. We also compute all possible subloci of curves for all possible automorphism group G. Moreover, for every rational moduli point $\mathfrak{p} \in \mathcal{S}$, such that $|\operatorname{Aut}(\mathfrak{p})| > 4$, we give explicitly a rational model of the corresponding curve over its field of moduli in terms of the $Gl(2,k)$-invariants. (Received January 28, 2014)

1097-14-511 **Anthony Várilly-Alvarado*** (av15@rice.edu), Department of Mathematics MS 136, Rice University, 6100 S. Main St., Houston, TX 77005, and **Bianca Viray**. *Arithmetic of del Pezzo surfaces of degree 4 and vertical Brauer groups.*

Del Pezzo surfaces X of degree 4 are smooth (complete) intersections of two quadrics in four-dimensional projective space. They are some of the simplest surfaces for which there can be cohomological obstructions to the existence of rational points, mediated by the Brauer group BrX of the surface. I will explain how to construct, for every non-trivial, non-constant element A of BrX, a rational genus-one fibration $X \dashrightarrow \mathbb{P}^1$ such that A is "vertical" for this map. This implies, for example, that if there is a cohomological obstruction to the existence of a point on X, then there is a genus-one fibration $X \dashrightarrow \mathbb{P}^1$ where none of the fibers are locally soluble, giving a concrete, geometric way of "seeing" a Brauer-Manin obstruction. The construction also gives a fast, practical algorithm for computing the Brauer group of X. Conjecturally, this gives a mechanical way of testing for the existence of rational points on these surfaces. This is joint work with Bianca Viray. (Received January 28, 2014)

1097-14-512 **Caleb Shor*** (cshor@wne.edu), Department of Mathematics, Western New England University, 1215 Wilbraham Rd, Springfield, MA 01027. *On q-Weierstrass points of hyperelliptic curves with extra automorphisms.*

In this talk, we will consider the problem of calculating the q-Weierstrass points of hyperelliptic curves. In particular, we will focus on genus 3 hyperelliptic curves with extra automorphisms. Given such a curve C, we fix a group G which acts as a full automorphism group on C and then classify its 2-Weierstrass points accordingly. (Received January 28, 2014)

1097-14-533 **David J Swinarski*** (dswinarski@fordham.edu), 113 W 60th St Room 813, New York, NY 10023. *Equations of curves with automorphisms.* Preliminary report.

Curves with automorphisms have been studied for over a century, but there is still no general algorithm for writing equations for their canonical models. I will discuss work in progress toward producing equations for curves of low genus. (Received January 31, 2014)

15 ► Linear and multilinear algebra; matrix theory

1097-15-1 **Ilse C.F. Ipsen*** (ipsen@ncsu.edu), North Carolina State University, Department of Mathematics, SAS Hall, Raleigh, NC 27695. *Introduction to Randomized Matrix Algorithms.*

The emergence of massive data sets, over the past fifteen or so years, has lead to the development of a new class of matrix algorithms, so-called randomized algorithms. They are being designed for matrix multiplication, solution of least squares problems, canonical correlations, and low-rank approximations. Randomized algorithms have been used effectively in applications like machine learning, population genomics, astronomy and nuclear engineering. We give a flavour of randomized algorithms, and along the way illustrate key concepts from numerical analysis (conditioning and pre-conditioning) and statistics (sampling, coherence and leverage scores). (Received January 11, 2014)

1097-15-18 **Nakhila Mistry*** (nmistry@elon.edu), 5732 Campus Box, Elon, NC 27244, and **Crista Arangala**. *Music Genomics: Applying Seriation Algorithms to Billboard #1 Hits.*

Music plays a prominent role in society and companies have even started studying its aspects for commercial purposes. It is only natural to ask what are the characteristics that make certain songs appealing. While much research has been conducted on the mathematical principles of sound, there has been less focus on analyzing the structure of popular songs from a mathematical perspective. One mathematical tool that researchers have used to study this is seriation, or ordering. Seriation algorithms are frequently used for companies with an online presence, including Google, Facebook, Amazon, and Pandora, to understand the traits of what users like in order to attract more consumers. We will use these types of seriation algorithms to conduct a mathematical analysis of the structural qualities of music. We will test whether the same structural traits appear in an artist's songs as the songs of the artists that they cite as musical influences. In order to musically link the chosen artists, we will use applied linear algebra methods. Results show that an artist's songs have a higher quantitatively measured connection with the artists they cite as influences rather than the artists who they never mention as musical influences. (Received November 25, 2013)

1097-15-81 **Jaedeok Kim*** (jkim@jsu.edu), 711 Hampton Dr SE, Jacksonville, AL 36265, and **Youngmi Kim** (ykim@jsu.edu), 711 Hampton Dr SW, Jacksonville, AL 36265. *Principal Angles and Numerical Ranges of Operators Involving two Orthogonal Projections.*

We show that two pairs of subspaces (M, N) and $(M^{\perp}, N^{\perp})$ are unitarily equivalent if M and N are subspaces of $\mathbb{C}^n$ in generic position by constructing a unitary operator. The relationships between two sets of the principal angles, the principal angles between M and N and the principal angles between $M^{\perp}$ and $N^{\perp}$, are established. We use the relationships to prove inequalities that are associated with numerical ranges of operators involving two orthogonal projections. (Received January 11, 2014)

1097-15-129 **Yun Fan*** (yfan@mail.ccnu.edu.cn), Dept of Mahematics, Central China Normal University, Wuhan, Hubei 430079, Peoples Rep of China. *Permutation-like Matrix Groups with a Maximal Cycle of Prime Square Length.*

A matrix group is said to be permutation-like if any matrix of the group is similar to a permutation matrix. G. Cigler proved that, if a permutation-like matrix group contains a normal cyclic subgroup which is generated by a maximal cycle and the matrix dimension is a prime, then the group is similar to a permutation matrix group. This paper extends the result to the case where the matrix dimension is a square of a prime. (Received January 25, 2014)

1097-15-433 **Miroslav Fiedler**, **Frank J. Hall** and **Mikhail Stroev*** (mstroev1@gsu.edu), Atlanta, GA 30303. *Dense Alternating Sign Matrices and Extensions.*

An *alternating sign matrix*, henceforth abbreviated ASM, is an $n \times n$ $(0, +1, -1)$-matrix without zero rows and columns, such that the $+1$s and -1s alternate in each row and column, beginning and ending with a $+1$. The substantial interest in ASMs in the mathematics community originated from the alternating sign matrix conjecture of Mills et al. in 1983 and has continued in several combinatorial directions. In this talk, some connections of alternating sign matrices with total unimodularity, combined matrices, and generalized complementary basic matrices are explored. In particular, it is shown that every "dense" ASM is a network matrix, and hence is totally unimodular. (Received January 27, 2014)

1097-15-452 **Young Jo Kwak*** (kwaky@colorado.edu). *Intermediate report: Orthogonal groups O(n) as automorphisms of the Lie algebras in characteristic two.*

We show that orthogonal groups O(n) hold one to one correspondence to the automorphisms of the associate Lie algebras in characteristic two. We explain it on an example by using the combinatorial algebra equipped with the combinatorial basis. This is an extending version of the recent paper "Orthogonal groups O(n) over GF(2) as automorphisms" by Kwak in Comm Algebra, Vol 42, Iss 5, (2014) to characteristic two in general. (Received January 27, 2014)

1097-15-474 **Rachid Marsli*** (rmarsli1@student.gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, and **Frank J Hall** (fhall@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *Geometric Multiplicities and Gersgorin Discs.*

We show that if A is an $n \times n$ complex matrix and λ is an eigenvalue of A with geometric multiplicity k, then λ is in at least k of the n Gersgorin discs of A. (Received January 28, 2014)

16 ► Associative rings and algebras

1097-16-487 **Kelly McKinnie*** (kelly.mckinnie@mso.umt.edu). *Lattices associated to the Brauer group of a K3-surface.* Preliminary report.

Let X be a complex, projective K3 surface with cyclic Néron-Severi Group. In a 2005 paper van Geemen classified the isomorphism types of sublattices of index 2 in T_X, the transcendental lattice of X. In the index 2 case these sublattices correspond to Brauer classes in ${}_2\mathrm{Br}(X)$. For each isomorphism type an auxiliary variety was constructed along with a geometric construction that recovers the original K3 surface together with a Brauer-Severi bundle over X corresponding to the Brauer class. In joint work with Justin Sawon, Sho Tanimoto, and Anthony Várilly-Alvarado this classification is extended to lattices of odd index. (Received January 28, 2014)

1097-16-523 **R. Parimala*** (parimala@mathcs.emory.edu), Dept. of Mathematics and Computer Science, Emory University, Atlanta, GA 30322. *Variations on a theme of Harbater-Hartmann-Krashen.*

Let K be a complete discrete valued field with residue field k and F the function field in one variable over K. Using patching techniques, Harbater-Hartmann-Krashen prove a Hasse principle for torsors under connected linear algebraic groups which are F-rational. It remained open whether the rationality assumption on the group is necessary for the Hasse principle to hold. We shall explain via an example of a nonrational torus, that the rationality assumption on G cannot be dispensed with.

This is joint work with J.-L. Colliot-Thélène and V. Suresh. (Received January 28, 2014)

1097-16-524 **David J. Saltman*** (saltman@idaccr.org). *Maximal subfields and division algebras.*

I intend to report on progress on the following general question. Namely, to what extent is a division algebra determined by its maximal subfields. This is a project with Rapinchuk, Rowen, Krashen, and others. (Received January 28, 2014)

17 ► Nonassociative rings and algebras

1097-17-96 **Jonathan Kujawa*** (kujawa@math.ou.edu), Dept. of Mathematics, University of Oklahoma, Norman, OK 73019. *Representations of classical Lie superalgebras.*

I will discuss recent results obtained by myself and coauthors on the finite dimensional representations of classical Lie superalgebras. (Received January 13, 2014)

1097-17-217 **Andrew J. Talian***, Department of Mathematics, University of Georgia, Athens, GA 30602. *Endotrivial Modules for Type I Lie Superalgebras.*

A supermodule M for a Lie superalgebra $\mathfrak{g}$ (over a field k) is called endotrivial if $\mathrm{End}_k(M) \cong k \oplus P$ for some projective supermodule P. The set of such modules for a Lie superalgebra $\mathfrak{g}$ form a group under the tensor product, denoted $T(\mathfrak{g})$. In this talk, we classify the group of endotrivial modules for certain Lie superalgebras of particular interest called detecting subalgebras, and use these results to classify the group of endotrivial modules for some Type I Lie superalgebras. (Received January 22, 2014)

1097-17-328 **Huanchen Bao*** (hb4tb@virginia.edu) and **Weiqiang Wang** (ww9c@virginia.edu). *Schur duality and Kazhdan-Lusztig theory.*

A quantized Schur duality between the quantum group of type A and the Hecke algebra of type A has been discovered by Jimbo in 1986. In this talk we describe a generalization of Schur-Jimbo duality to a duality between a coideal subalgebra of the quantum group of type A and the Hecke algebra of type B. A new theory of canonical basis arising from such a coideal subalgebra is developed which allows a new formulation of Kazhdan-Luszitg theory of type B. As a main application we provide a formulation of Kazhdan-Lusztig theory for the category O of the ortho-symplectic Lie superalgebras for the first time. This is joint work with Weiqiang Wang. (Received January 26, 2014)

20 ► Group theory and generalizations

1097-20-73 **Scott T. Chapman*** (scott.chapman@shsu.edu). *On the Catenary Degree of a Numerical Monoid.*

Let S be a numerical monoid (i.e., a submonoid under addition of the nonnegative integers). It follows that S has a unique minimal set of generators, which we denote by $S = \langle n_1, n_2, \ldots, n_k \rangle$ where $n_1, n_2, \ldots, n_k$ are positive integers. If $x \in S$, then an irreducible factorization of x is a representation of x as a linear combination over the nonnegative integers of the minimal generators. We study these factorizations using the catenary degree from the theory of non-unique factorizations. The catenary degree uses a metric like function to measure the distance between given factorizations of a particular element in S. Much literature is dedicated to this function. We prove two main results. 1) If the generators of S form an arithmetic sequence, then we can exactly determine the set of values attained by the catenary degree. 2) For any numerical monoid, the sequence of catenary values is eventually periodic. (Received January 10, 2014)

1097-20-162 **Spencer Dowdall*** (dowdall@illinois.edu), Department of Mathematics, 1409 W Green Street, Urbana, IL 61801, and **Ilya Kapovich** and **Christopher J. Leininger**. *Fibrations and polynomial invariants for free-by-cyclic groups.*

The beautiful theory developed by Thurston, Fried and McMullen provides a near complete picture of the various ways a hyperbolic 3–manifold M can fiber over the circle. Namely, there are distinguished convex cones in the first cohomology $H^1(M;\mathbb{R})$ whose integral points all correspond to fibrations of M, and the dynamical features of these fibrations are all encoded by McMullen's "Teichmüller polynomial."

This talk will describe recent work developing aspects of this picture in the setting of a free-by-cyclic group G. Specifically, I will introduce a polynomial invariant that determines a convex polygonal cone $\mathcal{C}$ in the first cohomology of G whose integral points all correspond to algebraically interesting splittings of G. The polynomial invariant additionally provides a wealth of dynamical information about these splittings. This is joint work with Ilya Kapovich and Christopher J. Leininger. (Received January 20, 2014)

1097-20-188 **Harvey I. Blau*** (blau@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115. *Quotient Structures and Partial Wreath Products in Algebras and Association Schemes.* Preliminary report.

A quotient subset, originally defined as the pre-image of the identity under a (commutative) C-algebra homomorphism, is shown to generalize to the context of (not necessarily commutative) reality-based algebras. Quotient subsets connect in a natural way to extensions of wreath products. Characterizations in terms of irreducible characters are obtained, and applications are made to association schemes. Several known results follow as corollaries. (Received January 21, 2014)

1097-20-215 **Christopher P. Bendel** and **Brian D. Boe***, Department of Mathematics, University of Georgia, Athens, GA 30602, and **Christopher M. Drupieski**, **Daniel K. Nakano**, **Brian J. Parshall**, **Cornelius Pillen** and **Caroline B. Wright**. *Bounding the dimensions of rational cohomology groups.*

Let k be an algebraically closed field of characteristic $p > 0$, and let G be a simple simply-connected algebraic group over k that is defined and split over the prime field $\mathbb{F}_p$. In this talk we investigate situations where the dimension of a rational cohomology group for G can be bounded by a constant times the dimension of the coefficient module. As an application, we use our results to obtain effective bounds on the first cohomology of the symmetric group. We also show how, for finite Chevalley groups, our methods permit significant improvements over previous estimates for the dimensions of second cohomology groups. (Received January 22, 2014)

1097-20-267 **Tobias Kildetoft**, Department of Mathematics, Aarhus University, DK-8000, Aarhus, Denmark, and **Daniel K. Nakano***, Department of Mathematics, University of Georgia, Athens, GA 30602. *On good (p, r)-filtrations for rational G-modules.*

In this talk we will investigate the problem of when the tensor product between the Steinberg module and a simple module has a good filtration, with certain requirements on the highest weight of the simple module. This problem will be discussed in relation to Donkin's Conjecture on (p, r)-filtrations. (Received January 24, 2014)

1097-20-275 **Matt Clay**, **Max Forester** and **Joel Louwsma*** (jlouwsma@ou.edu), Department of Mathematics, The University of Oklahoma, Norman, OK 73019. *Stable commutator length in Baumslag–Solitar groups.*

We obtain results both about computing stable commutator length in Baumslag–Solitar groups and about the spectrum of values it takes. In the first direction, we show that, for a certain class of elements, stable commutator length is computable and takes only rational values. We also determine exactly which elements of this class admit extremal surfaces. Our techniques additionally give lower bounds on the stable commutator length of all elements. In the second direction, we show that there is a uniform gap in the stable commutator length spectrum: no element of a Baumslag–Solitar group has stable commutator length between 0 and 1/12. Some of the techniques we use to show this apply more generally to other groups acting on trees. (Received January 24, 2014)

1097-20-288 **Wanshun Wong***, University of Ottawa, Department of Mathematics and Statistics, 585 King Edward, Ottawa, ON K1N 6N5, Canada. *Periods of generic torsors of groups of multiplicative type.*

If G is a commutative linear algebraic group, the first Galois cohomology $H^1(K, G)$ is an abelian group, and the period of a G-torsor over K is defined to be the order of the corresponding element in $H^1(K, G)$. In this talk I will present a formula for the period of a generic G-torsor (also called versal torsor) in terms of coflasque resolutions of G, where G is a group of multiplicative type. (Received January 25, 2014)

1097-20-295 **J. Matthew Douglass*** (douglass@unt.edu) and **Gerhard Roehrle**. *Equivariant K-theory of generalized Steinberg varieties.*

In this talk I will describe the equivariant K-groups of two families of generalized Steinberg varieties. These varieties interpolate between the Steinberg variety of a reductive algebraic group and its nilpotent cone. The description is in terms of the extended affine Hecke algebra. For one family, which roughly speaking corresponds to the closure of the regular nilpotent orbit, the K-groups can be concisely described in terms Kazhdan-Lusztig theory. For the other family, which roughly speaking corresponds to the closure of the zero nilpotent orbit, the K-groups are not well-understood and seem to be much more subtle, even in the most degenerate case. This work is joint with Gerhard Röhrle. (Received January 25, 2014)

1097-20-325 **Brian J. Parshall*** (bjp8w@virginia.edu), Dept. of Mathematics, University of Virginia, Charlottesville, VA 22903. *Q-Koszul algebras.* Preliminary report.

Q-Koszul algebras are positively graded algebras which have strong homological and structural properties. They arise naturally in the modular representation theory of semisimple algebraic groups. This is true if the characteristic is very large, but (remarkably) seems also to hold in some cases when the characteristic is small. This talk will define Q-Koszul algebras and discuss some recent work on them. It is joint work with L. Scott. (Received January 26, 2014)

1097-20-333 **Jon F. Carlson*** (jfc@math.uga.edu), **Nadia Mazza** and **Daniel K. Nakano**. *Endotrivial modules for the general linear group in a nondefining characteristic.*

This paper is part of a series of efforts to classify the endotrivial kG-modules in the case that G is a finite group and k is a field of characteristic $p > 0$ dividing the order of G. The endotrivial modules form an important part of the Picard group of self-equivalences of the stable category of all finitely generated kG-modules modulo projective modules. In this paper we consider the general linear group $GL(n, q)$ where p does not divide q. We classify endotrivial modules in the case that the Sylow p-subgroup is abelian. Of particular intersest is the application of a new method for detecting endotrivial modules introduced by Balmer. (Received January 26, 2014)

1097-20-343 **Theresa Brons*** (tbrons@math.uga.edu). *Extensions of First Line-bundle Cohomology over the Flag Variety G/B.* Preliminary report.

Let G be a simple, connected, reductive algebraic group over a field of characteristic p, and let $B \subset G$ be a Borel subgroup. From an algebraic perspective, line-bundle cohomologies over the flag variety G/B are the right-derived functors of $\text{ext}\,\text{ind}_B^G-$ applied to one-dimensional B-modules. When $p = 0$, semi-simplicity of the category of finite dimentional G-modules implies that $H^i(G, \mathcal{H}^j(\lambda)) = 0$. In general this is not the case, and the many questions about $H^i(G, \mathcal{H}^j(\lambda))$ remain unanswered. During this talk I will discuss an interesting result on $H^1(G, \mathcal{H}^1(\lambda))$ obtained using some results on B-cohomology by Bendel, Pillen, and Nakano and by Wright. (Received January 28, 2014)

1097-20-379 **Christopher P French*** (frenchc@grinnell.edu), Noyce Science Center, 1116 8th Ave, Grinnell, IA 50112. *Noncommutative imprimitive association schemes of rank 6.*

Just as in the case of group theory, association schemes of rank less than 6 are commutative. Before the current research, we knew of three classes of noncommutative imprimitive association schemes of rank 6; the intersection of any two of these classes consisted only of a thin scheme corresponding to the symmetric group S_3. In recent work with Ben Drabkin, we have found a new class of noncommutative imprimitive association schemes of rank 6 which do not fit into any of the three previously known classes. In this talk, we will describe how we found these new association schemes and discuss some of their properties. (Received January 27, 2014)

1097-20-386 **Craig Guilbault**, WI , and **Christopher P Mooney*** (cpmooney@bradley.edu), 332 E Hazelwood St, Morton, IL 61550. *Non-rigid CAT(0) groups with cell-like equivalent boundaries.*

Recently there has been a surge of interest in "coarse invariants" of groups. This has led geometric group theorists to return to the classical notions of shape equivalence and similar invariants. It has been shown by Bestvina and Geoghegan that all CAT(0) boundaries of a group are shape equivalent, and Bestvina has asked if they all satisfy the stronger notion of cell-like equivalence. In a joint work with Craig Guilbault, we have shown that the answer is "Yes" for an interesting family of groups introduced by Croke and Kleiner. This family includes many of the known examples of groups with multiple boundaries. (Received January 27, 2014)

1097-20-472 **Christopher P Bendel**, **Daniel K Nakano** and **Cornelius Pillen*** (pillen@southalabama.edu), Department of Mathematics and Statistics, University of South Alabama, Mobile, AL 36688. *A new look at rational and generic cohomology.*

Let G be a connected reductive algebraic group and B be a Borel subgroup defined over an algebraically closed field of characteristic $p > 0$. In this talk new results on the vanishing of G and B-cohomology groups are presented. As an application we give a new proof of the seminal work by Cline, Parshall, Scott and van der Kallen on rational and generic cohomology. Furthermore, vanishing ranges for the associated finite group cohomology of $G(\mathbb{F}_{p^r})$ are established which generalizes earlier work of Hiller. (Received January 28, 2014)

22 ► Topological groups, Lie groups

1097-22-50 **William Graham** and **Wenjing Li*** (wli@ccal.edu). *The smooth locus of spiral Schubert varieties of type $\tilde{A}_2$.*

One interesting problem in the study of Schubert varieties is to determine the set of points where the Schubert variety is smooth. In previous work, we studied the Bruhat order for the affine Weyl group W of type $\tilde{A}_2$, related the Bruhat order to the W action on $\mathbb{R}^2$, and gave a description of the locus of non-rationally smooth points of an interesting family of Schubert varieties called spiral Schubert varieties. Although rational smoothness is determined by the Weyl group with its Bruhat order, to determine smoothness one needs to use the root system. In this work we describe the smooth locus of spiral Schubert varieties in the case of $\tilde{A}_2$. We do this by using our previous results, as well as some root system facts, to calculate equivariant multiplicities of spiral Schubert varieties at certain rationally smooth points. (Received January 03, 2014)

1097-22-130 **David M Freeman*** (david.freeman@uc.edu), Blue Ash College, University of Cincinnati, 9555 Plainfield Rd, Cincinnati, OH 45236. *Invertible Carnot Groups.* Preliminary report.

We will discuss a characterization of Iwasawa N-groups of real rank one non-compact simple Lie groups in terms of certain metric inversions. We will highlight connections between this characterization and the property of inversion invariant bi-Lipschitz homogeneity. (Received January 17, 2014)

1097-22-151 **Matthew Stover***, Department of Mathematics, Temple University, 1805 N. Broad Street, Philadelphia, PA 19122. *Cusped hyperbolic n-manifolds.*

While there are many simple topological constructions of one-cusped (finite volume, complete) hyperbolic 2- and 3- manifolds, building higher-dimensional examples has proven much more difficult. In fact, only last year Kolpakov and Martelli constructed the first one-cusped hyperbolic 4-manifolds. I will explain why, for each $k > 0$, there is a constant n_k such that none of the known methods of building hyperbolic manifolds can produce a k-cusped hyperbolic n-manifold for any $n \geq n_k$. For example, for $k = 1$ we can take $n_k = 30$. I will also describe some more recent work relating the geometry of anisotropic integral quadratic lattices to cusp shapes of arithmetic hyperbolic n-manifolds. (Received January 19, 2014)

1097-22-301 **James Keesling*** (kees@ufl.edu), Department of Mahematics, University of Florida, Gainesville, FL 32611-8105, and **James Maissen** and **David Wilson**. *A New Approach to the Hilbert-Smith Conjecture.* Preliminary report.

The Hilbert-Smith Conjecture states that if G is a compact group acting effectively on a compact manifold M^n, then G is a Lie group. The conjecture is equivalent to stating that there is no effective action of a $p-$adic group Δ_p on a compact manifold M^n. The conjecture is known to be true for $n = 1$ and $n = 2$ by classical results. It is known to be true for $n = 3$ by a recent result of John Pardon.

Most of the classical work done on the subject focuses on the quotient space of the action. The present authors have approached the problem focusing on properties of the $p-$adic action assuming that one exists. There are many new results that have been obtained. (Received January 25, 2014)

1097-22-380 **Brandon Samples*** (brandon.samples@gcsu.edu), Georgia College & State University, Department of Mathematics, Campus Box 017, Milledgeville, GA 31061. *Components of Springer fibers for exceptional groups.*

Let G be the complex connected simply connected simple Lie group of type G_2 or F_4. Let K denote the fixed point subgroup relative to an involution of G that is lifted from a Cartan involution. This talk gives a description of certain components of Springer fibers associated to closed K-orbits contained in the flag variety of G. These components allow us to describe certain multiplicity polynomials associated to discrete series representations of the real form G_2^2 of G_2 and the two real forms F_4^4 and F_4^{-20} of F_4. These goals are motivated by the descriptions of Springer fiber components and the associated multiplicity polynomials for several classical types described by Barchini, Zierau and Graham. A discussion of the progress with regards to E_6 will be provided if time permits. (Received January 27, 2014)

1097-22-413 **Leticia I Barchini*** (leticia@math.okstate.edu), 403 Mathematical Sciences, OSU, Stillwater, OK 74078. *Invariants of Harish-Chandra modules.*

We start with a special nilpotent orbit and the trivial character of the corresponding component group. The Springer correspondence attaches to such pair an irreducible representation of the Weyl group. This representation admits two bases of W-harminic polynomials. The first basis is parametrized by a family of primitive ideals. The second is parametrized by orbital varieties (certain irreducible components of the intersection of the closure of the orbit and the nilradical of a Borel subalgebra) McGovern defined a combinatorial order on orbital varieties and one on primitive ideals showing that in such order the change of bases matrix is upper triangular. Trapa, using geometry attached to HC-modules of a real group defined various orders on orbital varieties and also showed triangularity results for such orders. In the context of the indefinite symplectic group we investigate the relation between the various orders and derive consequences relevant to the computation of invariants of HC-modules. In particular we address a question posted by Trapa on the shape of such modules. (Received January 27, 2014)

1097-22-421 **Markus Hunziker** (markus_hunziker@baylor.edu), Department of Mathematics, One Bear Place #97328, Waco, TX 76798, **Mark Sepanski*** (mark_sepanski@baylor.edu), Department of Mathematics, One Bear Place #97328, Waco, TX 76798, and **Ronald Stanke**, Department of Mathematics, One Bear Place #97328, Waco, TX 76798. *A new Schrödinger model for unitary highest weight representations.*

It follows from the classification of unitary highest weight representations and the work of Kashiwara-Vergne that every unitary reduction point of the metaplectic group $Mp(n,\mathbb{R})$ can be embedded in $L^2(M_{n,k})$ for some $k < n$, where $M_{n,k}$ denotes the space of real $n \times k$ matrices. Furthermore, every reduction point can be embedded in a space of sections of a holomorphic vector bundle on the Segal upper halfplane or—via boundary values—in a degenerate principal series representation. In this paper, we give a new realization of unitary highest weight representations in the kernel of a system of Schrödinger equations on the space $M_{n,k} \times Sym_k$, where Sym_k denotes the space of symmetric real $k \times k$ matrices. Our realization has simple intertwining maps to the previously known realizations mentioned above. (Received January 27, 2014)

1097-22-430 **Myron Minn-Thu-Aye*** (myron.minn-thu-aye@uconn.edu). *Perverse coherent sheaves, properly stratified categories, and multiplicity computations.* Preliminary report.

Let G be a complex reductive algbraic group, and $\mathcal{N}$ the nilpotent cone of its Lie algebra. The category of perverse coherent sheaves on $\mathcal{N}$ possesses the structure of a properly stratified category, which closely resembles the structure of category $\mathcal{O}$. By studying this structure, together with an equivalence between coherent sheaves on $\mathcal{N}$ and constructible sheaves on the affine Grassmannian, we develop an effective algorithm to compute multiplicities of simple objects in perverse coherent sheaves. (Received January 27, 2014)

1097-22-437 **Jordan Alexander**, **Markus Hunziker*** (markus_hunziker@baylor.edu) and **Jeb F. Willenbring**. *Hilbert series of determinantal varieties and strongly orthogonal roots.* Preliminary report.

The coordinate rings of the classical determinantal varieties (and their analogs for symmetric and skew-symmetric matrices) carry the structure of a unitary highest weight representation. By modifying the Enright-Willenbring correspondence between Wallach representations and certain finite dimensional representations, we are able to give a uniform formula for the numerator polynomials of the Hilbert series of all determinantal varieties in terms of strongly orthogonal roots. (Received January 27, 2014)

1097-22-460 **Roger Zierau*** (zierau@math.okstate.edu). *Leading Term Cycles of Highest Weight Harish-Chandra Modules.* Preliminary report.

It is a difficult problem in representation theory to compute the characteristic cycle of a Harish-Chandra module. The part of the the characteristic cycle that contributes to the associated variety (in the sense that the moment map image is an irreducible component of the associated variety) is called the leading term cycle. This lecture will discuss some examples of the computation of leading term cycles of highest weight Harish-Chandra modules. (Received January 27, 2014)

26 ► Real functions

1097-26-10 **Dinh Thanh Duc*** (dinhthanhduc@qnu.edu.vn), Department of Mathematics, Quy Nhon University, 170 An Duong Vuong Street, Quy Nhon, Binh Dinh 53000, Vietnam, and **Nguyen Du Vi Nhan** (ndvynhan@gmail.com), Department of Mathematics, Quy Nhon University, 170 An Duong Vuong Street, Quy Nhon, Binh Dinh 53000, Vietnam.
Inequalities for differences and their applications. Preliminary report.

The paper deals with various weighted inequalities for the forward difference operator acting on products of compositions and convolutions of functions on $\mathbb{Z}$. A discrete version of Saitoh's inequality in the Sobolev spaces and some generalizations of discrete Opial-type inequalities are also considered. Several applications to the zeta functions and difference equations are also given. (Received October 09, 2013)

28 ► Measure and integration

1097-28-463 **Stephen David Lewis*** (stedalew@uw.edu), University of Washington, Dept of Mathematics, Box 354350, Seattle, WA 98195. *Local Set Approximation.*

In many areas of geometric measure theory, it is useful to study the interplay between the geometry of a closed set $A \subseteq \mathbb{R}^n$ and the geometry of a collection of closed sets $\mathcal{S} \subset \mathcal{P}(\mathbb{R}^n)$ which approximate A locally uniformly on small scales (in a Hausdorff distance sense). This includes several Plateau problems, harmonic analysis, and regularity of measures. In this talk we introduce a general framework for such studies. Included, we will discuss a result about the connectedness at infinity of the cone of tangent sets.

This is joint work with Matt Badger. (Received January 28, 2014)

30 ► Functions of a complex variable

1097-30-39 **Costel P Peligrad*** (peligrc@ucmail.uc.edu), University of Cincinnati, Department of Mathematical Sciences, P.O. Box 45221-0025, Cincinnati, OH 45221-0025. *Reflexive operator algebras on non commutative Hardy spaces.* Preliminary report.

We consider a non trivial action of the circle group, $\boldsymbol{T}$ on a von Neumann algebra M such that the Arveson spectrum is finite or, if the spectrum is infinite, the spectral subspace corresponding to the least positive element contains an unitary element. Similarly to the case when $M = L^{\infty}(\boldsymbol{T})$ is acted upon by translations, we define the generalized Hardy space $H_{+} \subset H$ where H is the Hilbert space of the standard representation of M and the subalgebra M_{+} of analytic elements of M with respect to the action. We prove that $M_{+} \subset B(H_{+})$ is a reflexive algebra of operators, that is, it is completely determined by its invariant subspaces. Examples include the algebra of analytic Toeplitz operators, w^*-crossed products, reduced w^*-semicrossed products and some reflexive nest subalgebras of von Neumann algebras. (Received December 23, 2013)

1097-30-55 **Pekka Pankka*** (pekka.pankka@jyu.fi), Department of Mathematics and Statistics, P.O.Box (MaD), FI-40014 University of Jyväskylä, Jyväskylä, Finland. *Sharpness of Rickman's Picard theorem in all dimensions.*

In the late 1960's and early 1970's, results of Reshetnyak and Martio-Rickman-Väisälä showed that mappings of bounded distortion, also called as quasiregular mappings, can be viewed as a counterpart for holomorphic mappings in quasiconformal geometry. One of the natural goals from the very beginning in this theory was obtain Picard-type results. In 1980, Rickman showed that a non-constant quasiregular mapping from the Euclidean n-space to the n-sphere omits only finitely many points, where the number depends only on the dimension and distortion. The sharpness of Rickman's theorem was not as simple issue as in the classical Picard theorem. In

1984, Rickman showed by a surprising and elaborate construction that given any finite set in the 3-sphere there exists a quasiregular from the Euclidean 3-space into the 3-sphere omitting exactly that set.

In this talk, I will discuss joint work with David Drasin on the sharpness of Rickman's Picard theorem in all dimensions. Especially, I will discuss the role of bilipschitz geometry in the proof which leads to a stronger stament on the metric properties of the map and is a crucial ingredient in dimensions $n \geq 4$. (Received January 06, 2014)

1097-30-63 **Daniel Seco*** (d.seco@warwick.ac.uk), 2 Warwick Street, Earlsdon, Coventry, CV5 6ET, United Kingdom. *Cyclic functions in Hilbert spaces of analytic functions on the disk.*

We study forward shift cyclicity from an optimizational viewpoint introduced by Bènèteau-Condori-Liaw-Seco-Sola. First we present this optimizational viewpoint and then, we use it to characterize the cyclicity of functions holomorphic across the boundary of the unit disk in a large and natural class of reproducing kernel Hilbert spaces, which includes Dirichlet-type spaces, as done in recent work by Fricain-Mashreghi-Seco. (Received January 08, 2014)

1097-30-68 **Javad Mashreghi*** (javad.mashreghi@mat.ulaval.ca), 1070 Pav. Vachon, Quebec, QC G1V 0A6, Canada. *A group structure on $\mathbb{D}$ and its application on model spaces.*

We present a group structure on $\mathbb{D}$ via the automorphisms which fix the point 1. Then, through the induced group action, each point of $\mathbb{D}$ produces an equivalence class which turns out to be a Blaschke sequence. Moreover, the corresponding Blaschke products are minimal solutions of the functional equation $\psi \circ \varphi = \lambda\psi$, where λ is a unimodular contant and φ is an automorphism of the unit disc which fixes the point 1. We also characterize all Blaschke products which satisfy this equation and study its application in the theory of composition operators on model spaces K_Θ. (Received January 10, 2014)

1097-30-76 **Stephen J. Gardiner** (stephen.gardiner@ucd.ie), University College, Dublin, Ireland, and **Dima Khavinson*** (dkhavins@usf.edu), University of South Florida. *Boundary behaviour of universal power series.*

A power series that converges on the unit disc $\mathbb{D}$ is called *universal* if its partial sums approximate arbitrary polynomials on arbitrary compacta in $\mathbb{C}\backslash\mathbb{D}$ that have connected complement. In this talk we will show that such series grow strongly and possess a Picard-type property near each boundary point. (Received January 11, 2014)

1097-30-93 **Thomas Ransford*** (ransford@mat.ulaval.ca). *Shift-invariant subspaces and cyclicity in the Dirichlet space.*

In this expository talk, I shall attempt to give an overview of the progress made on the problem of classifying the closed, shift-invariant subspaces of the Dirichlet space, and on the related problem of characterizing the functions that are cyclic for the Dirichlet space. (Received January 13, 2014)

1097-30-127 **Shuaibing Luo*** (luo@math.utk.edu) and **Stefan Richter**. *Index of invariant subspaces in the space of weak products of Dirichlet functions.*

The space of weak products of Dirichlet functions denoted by $D \odot D$ has has many nice properties, we can think of it as the analogue of H^1 space. The dual of $D \odot D$ has been characterized by Arcozzi, Rochberg, Sawyer, and Wick in 2010. In this talk, we first identify the Cauchy dual of $D \odot D$ by using the dual of $D \odot D$, then we establish the existence of pseudocontinuations of the functions in some subspaces in the Cauchy dual of $D \odot D$, and from this we conclude that the index for any M_z-invariant subspaces in $D \odot D$ is 1. (Received January 16, 2014)

1097-30-231 **Vyron S. Vellis*** (vellis1@illinois.edu), 1409 West Green Street, Urbana, IL 61801, and **Jang-Mei Wu**. *Sets of Constant distance from a Jordan curve.*

We study the ϵ-level sets of the signed distance function to a planar Jordan curve Γ, and ask what properties of Γ ensure that the ϵ-level sets are Jordan curves, or uniform quasicircles, or uniform chord-arc curves for *all* sufficiently small ϵ. Sufficient conditions are given in term of a scaled invariant parameter for measuring the local deviation of subarcs from their chords. The chordal conditions given are sharp.

As an application, we will present concrete examples of quasisymmetric spheres constructed over quasidisks. (Received January 23, 2014)

1097-30-262 **Rishika Rupam*** (rishika@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77840, and **Mishko Mitkovski** (mmitkov@clemson.edu), Department of Mathematics, Clemson University, Clemson, SC 29632. *The Toeplitz kernel approach in inverse spectral theory of differential operators.*

When does the spectrum of an operator determine the operator uniquely? This question and its many versions have been studied extensively in the field of inverse spectral theory for differential operators. Several notable mathematicians have worked in this area. Among others, there are important contributions by Borg, Levinson, Hochstadt, Liebermann; and more recently by Simon, Gesztezy, del Rio and Horvath, which have further fueled these studies by relating the completeness problems of families of functions to the inverse problems of the Schrödinger operator. In this talk, we discuss the role played by the Toeplitz kernel approach in answering some of these questions, as described by Makarov and Poltoratski. We will also describe some new results using this approach. (Received January 24, 2014)

1097-30-269 **Ariel E Barton*** (bartonae@missouri.edu) and **Lesley A Ward**. *A new class of harmonic measure distribution functions.*

Let Ω be a planar domain containing 0. Let $h_\Omega(r)$ be the harmonic measure at 0 in Ω of the part of the boundary of Ω within distance r of 0. The function h_Ω is called the harmonic measure distribution function of Ω.

In this talk we address the inverse problem by discussing several sets of sufficient conditions on a function f for f to arise as a harmonic measure distribution function.

In particular, earlier work of Snipes and Ward shows that for each function f that increases from zero to one, there is a sequence of multiply connected domains X_n such that h_{X_n} converges to f pointwise almost everywhere. We show that if f satisfies our sufficient conditions, then $f = h_\Omega$, where Ω is a subsequential limit of bounded simply connected domains that approximate the domains X_n. Further, the limit domain is unique in a class of suitably symmetric domains. Thus $f = h_\Omega$ for a unique symmetric bounded simply connected domain Ω. (Received January 24, 2014)

1097-30-287 **Mishko Mitkovski*** (mmitkov@clemson.edu). *Basis properties of complex exponentials.*

Questions about various types of basis properties of the sequence of complex exponentials have a very long history, with origins in the work of Paley, Wiener, and Levinson. In this talk I will present a characterization of all of the fundamental basis properties of this sequence in terms of the invertibility properties of naturally associated Toeplitz operators. In addition, I will present a unified approach toward the density characterization of all of these basis properties. (Received January 24, 2014)

1097-30-461 **Huy Tran*** (tranvohuy@gmail.com), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98105, and **Steffen Rohde** and **Michel Zinsmeister**. *The Loewner equation and Lipschitz graphs.* Preliminary report.

The proofs of continuity of Loewner traces in the stochastic [Rohde&Schramm] and in the deterministic settings [Marshall&Rohde], [Lind] employ different techniques. In the former setting of the Schramm-Loewner evolution SLE, Hölder continuity of the conformal maps is shown by estimating the derivatives, whereas the latter setting uses the theory of quasiconformal mapping. In this talk, we will adopt the former method to the deterministic setting and present a new and elementary proof that Hölder-1/2 driving functions with norm less than 4 generate simple arcs. We will also present a sufficient condition for driving functions to generate curves that are graphs of Lipschitz functions. (Received January 27, 2014)

1097-30-462 **Joel Barnes*** (joel@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98103. *Distributional limits of random conformally balanced trees.* Preliminary report.

A conformally balanced tree is an embedding of a given planar map into the plane with constraints on the harmonic measure of its edges such that the resulting set is unique up to scale and rotation. Bishop (2011) showed that there exists a conformal map from the exterior of the disc to the complement of such a tree, and that conformally balanced trees approximate any compact, continuous set in the plane. The preimage of the tree under the map is a conformal welding map which induces a lamination of the unit circle that corresponds exactly to the encoding of the tree as an excursion. We consider the distributional limits of the maps for the uniform measure on random walk excursions as the number of steps goes to infinity, normalized by conformal radius, and we show that subsequential limits are almost surely nontrivial. (Received January 28, 2014)

31 ► Potential theory

1097-31-47 **Nageswari Shanmugalingam*** (shanmun@uc.edu), Department of Mathematical Sciences, P.O. Box 210025, Cincinnati, OH 45221-0025, and **Xining Li**, University of Cincinnati, Department of Mathematical Sciences, P.O.Box 210025, Cincinnati, OH 45221-0025.
Preservation of bounded geometry under sphericalization and flattening of a metric measure space.

A metric measure space whose measure is doubling and supports a p-Poincaré inequality is said to be of bounded geometry. A more complete theory of quasiconformal mappings and potential theory can be developed for such spaces, as demonstrated for example by the work of Heinonen, Koskela, Shanmugalingam, and Tyson. We will discuss how the procedures of sphericalization and flattening of a metric measure space with bounded geometry in turn yields a metric measure space with bounded geometry. (Received January 02, 2014)

1097-31-94 **Stamatis Pouliasis*** (stamatis.pouliasis.1@ulaval.ca) and **Javad Mashreghi**.
Condenser capacity, exponential Blaschke products and universal covering maps.

First we shall present some basic facts about condenser capacity, Green functions and their relation with complex analysis. Then we will examine the asymptotic behavior of the capacity of the inverse image of a condenser under exponential Blaschke products and universal covering maps. (Received January 13, 2014)

1097-31-454 **Dewey Estep*** (estepdy@mail.uc.edu), 344 Shiloh St Apt #202, Cincinnati, OH 45220, and **Nageswari Shanmugalingam**. *Geometry of the Prime End Boundary and the Dirichlet Problem for bounded domains in metric measure spaces.*

First introduced in the complex plane by Caratheodory, Prime Ends provide a way to define the boundary of a bounded domain such that its closure retains many properties intrinsic to the structure of the domain itself rather than its ambient space. For example, the Prime End closure of the Slit Disk in $\mathbb{C}$ retains the structure imposed by the 'slit,' while the normal metric closure ignores it. Using the definition given by Shanmugalingam, Bjorn, Bjorn and Adamowicz, we may speak of Prime Ends in more general metric spaces. Here we define and study the Dirichlet Problem with Prime End Boundary data on bounded domains, showing that under certain assumptions we may construct solutions using the Perron Method. (Received January 27, 2014)

1097-31-458 **Marcos D Lopez*** (lopezms@mail.uc.edu), 470 Lakeview Drive, 310, Wilder, KY 41071, and **James Gill**. *Discretized Metric Measure Spaces of Controlled Geometry.*

In this talk, I will provide a background on Gromov Hausdorff convergence including its measured version, including some important results due to Cheeger and Koskela. I only consider metric spaces with doubling measures that support a Poincaré type inequality, which form an essential class of metric spaces in the study of Sobolev spaces. A method to approximate such a space by a graph will be presented. This method uses maximal epsilon nets, and ensures the persistence of a doubling measure and Poincaré equality on the approximated space. These results are a joint work with James Gill. (Received January 27, 2014)

32 ► Several complex variables and analytic spaces

1097-32-61 **C. Bénéteau**, **A. A. Condori**, **C. Liaw**, **D. Seco** and **A. A. Sola*** (a.sola@statslab.cam.ac.uk), Center for Mathematical Sciences, University of Cambridge, Cambridge, CB3 0WB, United Kingdom. *Cyclicity in Dirichlet-type spaces on the bidisk via extremal polynomials.*

Extending recent work by the authors on Dirichlet-type spaces in the unit disk to the two-dimensional setting, we study functions that are cyclic with respect to the operators induced by multiplication by the coordinate functions. For certain subclasses of functions in such spaces, we identify near-optimal approximating polynomials, determine sharp rates of cyclicity, and study simple cyclic and non-cyclic examples in detail. (Received January 08, 2014)

33 ► Special functions

1097-33-429 **Paul M Terwilliger*** (terwilli@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706. *Leonard pairs and the q-Tetrahedron algebra.*

A Leonard pair is a pair of diagonalizable linear transformations of a finite-dimensional vector space, each of which acts in an irreducible tridiagonal fashion on an eigenbasis for the other one. The Leonard pairs are classified up to isomorphism, and correspond to the orthogonal polynomials from the terminating branch of the Askey scheme. The most general polynomials in this branch are the q-Racah polynomials. The q-Tetrahedron algebra was introduced in 2006. In this talk we show that each Leonard pair of q-Racah type gives a module for the q-Tetrahedron algebra. We discuss how this module illuminates the structure of the Leonard pair. This is joint work with Tatsuro Ito and Hjalmar Rosengren. (Received January 27, 2014)

34 ► Ordinary differential equations

1097-34-41 **K. Renee Fister*** (kfister@murraystate.edu), 6C-5 Faculty Hall, Dept. of Mathematics and Statistics, Murray, KY 42071, and **Bryce Norris**, **Glenna Buford**, **Holly Gaff**, **Elsa Schaefer** and **Suzanne Lenhart**. *Optimal Control of an age-structured Cholera Model.*

We analyze cholera dynamics through a variation on an SIR epidemiological model in which two separate age classes are considered in a population. We discuss R_0, estimated using parameters from Bangladesh. We then construct the necessary conditions for an optimal protection control minimizing infected classes and societal costs. Subsequently, we provide some numerical examples for our model with optimal control denoting that a protection control be implemented at the end of the monsoon season. (Received December 24, 2013)

1097-34-211 **Rudi Weikard*** (rudi@math.uab.edu), Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294-1170. *Spectral theory for left-definite problems.*

In this talk we consider spectral, inverse spectral and inverse scattering for the differential equation

$$-u'' + qu = \lambda wu$$

where $q \geq 0$ but where w is only required to be real and locally integrable but not positive.

Applications include solving the Cauchy problem for the Camassa-Holm equation. (Received January 22, 2014)

1097-34-360 **Stephen Clark*** (sclark@mst.edu), Missouri University of Science and Technology, Department of Mathematics & Statistics, Rolla, MO 65409, **Fritz Gesztesy** (gesztesyf@missouri.edu), University of Missouri, Department of Mathematics, Columbia, MO 65211, and **Roger Nichols** (roger-nichols@utc.edu), University of Tennessee-Chattanooga, Department of Mathematics, Chattanooga, TN 37403. *Principal Solutions Revisited.*

In this talk, we discuss the identification of principal solutions associated with Sturm–Liouville operators on arbitrary open intervals, $(a, b) \subseteq \mathbb{R}$, as introduced by Leighton and Morse in the scalar context in 1936 and by Hartman in the matrix-valued situation in 1957, with Weyl–Titchmarsh solutions, as long as the underlying Sturm–Liouville differential expression is nonoscillatory (resp., disconjugate or bounded from below near an endpoint) and in the limit point case at the endpoint in question. An explicit formula is presented for Weyl–Titchmarsh functions in this case which appears to be new in the matrix-valued context. (Received January 27, 2014)

35 ► Partial differential equations

1097-35-6 **Peter A. Perry*** (peteraperry@gmail.com), Department of Mathematics, 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506-0027. *Determinants in Two-Dimensional Inverse Scattering.*

This talk concerns inverse scattering in two space dimensions and its application to solving completely integrable, dispersive nonlinear PDE's.

In the 1960's, Faddeev introduced Complex Geometric Optics (CGO) solutions: scattering solutions at fixed energy with asymptotic behavior parameterized by a complex parameter k. The CGO solutions determine the *scattering transform*, which linearizes completely integrable flows associated with the Schrodinger or Dirac-type problem.

For given k, the CGO solutions need not be unique. The set of k for which non-uniqueness occurs is called the *exceptional set* and corresponds to those k for which a certain Fredholm operator is not invertible.

A nonempty exceptional set leads to singularities in the scattering transform and such phenomena as rational solitons or blow-up in finite time for the solutions to the corresponding completely integrable PDE's. In this talk we will apply the Banach-space renormalized determinant developed by Gohberg, Goldberg, and Krupnik in the 1990's to constrain the exceptional set and prove that completely integrable flows for the Davey-Stewartson II and Novikov-Veselov equations at zero energy are isospectral. This work is in part joint with Russell Brown and Michael Music. (Received August 31, 2013)

1097-35-54 **Alain Miranville***, miranv@math.univ-poitiers.fr. *Asymptotic behavior of variants of the Cahn-Hilliard equation.*

Our aim in this talk is to discuss the qualitative behavior (existence of finite-dimensional attractors and blow up in finite time) of variants of the Cahn-Hilliard equation. Such equations arise in the context of image inpainting and biology. (Received January 06, 2014)

1097-35-60 **Leonid Parnovski** and **Roman Shterenberg*** (shterenb@math.uab.edu), Department of Mathematics, University of Alabama at Birmingham, 1300 University Blvd., Birmingham, AL 35294. *Complete asymptotic expansion of the spectral function of multidimensional almost-periodic Schrodinger operators.*

We prove the complete asymptotic expansion of the spectral function (the integral kernel of the spectral projection) of a Schrodinger operator $H = -\Delta + b$ acting in R^d when the potential b is real and either smooth periodic, or generic quasi-periodic (finite linear combination of exponentials), or belongs to a wide class of almost-periodic functions. (Received January 08, 2014)

1097-35-62 **Qi Wang*** (qwang@math.sc.edu), 1523 Greene Street, room 411, Columbia, SC 29208, and **Jia Zhao** (zhao62@email.sc.edu), 1523 Greene Street, Room 411, Columbia, SC 29208. *3D Hydrodynamic phase-field Models and Simulations for Biofilms.*

Bacteria are ubiquitous. Instead of living individually, bacteria appear to live in a society called bio lm, which is a microorganism with glue-like extra-cellular polysaccharide substance. Significant attentions have been attracted into biofilm research, as biofilms are responsible for many chronic disease .

In this talk, a three dimensional hydrodynamic model has been derived, by phase-field approach. The hydrodynamical effects on biofilm formation and functioning have been analyzed. Later, by distinguishing various types of bacteria, the quorum sensing and antimicrobial effects in biofilm has been investigated. The biofilm formation accounting for cell motility issue has been studied as well. (Received January 19, 2014)

1097-35-64 **Yuan Lou*** (lou@math.ohio-state.edu), Department of Mathematics, Columbus, OH 43210. *Finding ESS in Spatial Models.*

From habitat degradation and climate change to spatial spread of invasive species, dispersal plays a central role in determining how organisms cope with a changing environment. How should organisms disperse "optimally" in heterogeneous environments? I will discuss some recent development on the evolution of dispersal, focusing on finding evolutionarily stable strategies (ESS) for dispersal. This talk is mostly based upon joint works with Steve Cantrell, Chris Cosner and King-Yeung (Adrian) Lam. (Received January 08, 2014)

1097-35-71 **Michael Shearer*** (shearer@ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695, and **Melissa Strait**, Department of Mathematics, North Carolina State University, Raleigh, NC 27695. *Two fluid flow in a capillary tube.* Preliminary report.

A phase field model for two-phase flow in a capillary tube, developed by Cueto-Felgueroso and Juanes, results in a PDE with higher-order terms. We find traveling wave solutions of the PDE and determine a bound on parameters to obtain physically relevant solutions. We observe that the traveling wave height decreases monotonically with capillary number. Finite difference simulations of the injection of a gas finger into water show a traveling wave advancing ahead of a rarefaction, leaving a plateau region of fluid adjacent to the tube wall. The residual thickness of this region was measured in experiments by G.I. Taylor in his famous 1961 paper. We find agreement between the traveling wave heights and the plateaus seen in the PDE simulations, and the results also compare favorably with the residual fluid thickness observed in the experiments. (Received January 10, 2014)

1097-35-78 **Kazuo Yamazaki*** (kyamazaki@math.okstate.edu), 401 Mathematical Sciences Building, Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Global regularity of the logarithmically supercritical MHD system with zero diffusivity.*

We review recent developments concerning the global regularity issue of the generalized magnetohydrodynamics system with fractional Laplacians such as the logarithmically supercritical case in N-dimension and special case when dimensional is two. We discuss further open problems elaborate on similar systems of equations. (Received January 11, 2014)

1097-35-92 **Geng Chen*** (gchen73@math.gatech.edu), Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332. *Uniqueness of Conservative Solutions to the Camassa-Holm Equation.*

In this talk, we discuss a recent paper on the uniqueness of energy conservative solutions to the Camassa-Holm Equation. This is a joint work with Alberto Bressan and Qingtian Zhang. (Received January 28, 2014)

1097-35-100 **Ronghua Pan** and **Kun Zhao*** (kzhao@tulane.edu). *Non-isentropic compressible gas flows through porous media.*

The motion of compressible gas flows through porous media can be modeled by the Euler equations with frictional damping, which is a 2 by 2 system of hyperbolic balance laws. The damped Euler equations are also known due to its close connection with the Darcy's Law and porous medium equation(PME). Indeed, the Darcy's Law and PME can be derived from the damped Euler equations by either applying the so-called "quasi static approximation" (singular convergence of solutions), or taking the limit of solutions as time goes to infinity. Because of its strong physical background and significant mathematical challenge, the damped Euler equations have attracted considerable attention in recent years. Mathematical theory of the "isentropic" system (the case of constant entropy) has been fully developed during the past two decades. However, the "non-isentropic" case (a 3 by 3 system) is under-developed. Rigorous analysis of the non-isentropic model in the Eulerian coordinates is very limited. In this talk, I will report some recent progress in this direction. (Received January 13, 2014)

1097-35-103 **Mathew A. Johnson*** (matjohn@math.ku.edu), Department of Mathematics, 405 Snow Hall, 1460 Jayhawk Blvd., Lawrence, KS 66045. *Modulational Instability in the Whitham Equation for Water Waves.*

In Whitham's 1974 book, he introduced a model equation for the unidirectional propagation of finite-depth surface water water waves with small amplitude. This model is completely fake, in the sense that it is not derived from any known water wave model. Rather, it is constructed by combining the full unidirectional linear dispersion relation coming from the Euler equations with a canonical shallow water nonlinearity. Whitham formally demonstrated that the resulting pseudo-differential equation, which has affectionately been termed "Whitham's equation", describes many short-wave phenomena present in the full Euler system which are outside the scope of the commonly studied "long-wave" theories (like KdV and Boussinesq theories), such as breaking. In this talk, I will discuss recent joint work with Vera Mikyoung Hur (Urbana-Champaign) in which we demonstrate that the Whitham equation contains enough information from the full Euler equations to bear out the famous Benjamin-Feir instability of Stokes waves. That is, we demonstrate that small-amplitude periodic traveling wave solutions of Whitham's equation are modulationally unstable provided their wavelength is sufficiently large, and are spectrally stable otherwise. (Received January 14, 2014)

1097-35-110 **Sebastian Herr** and **Jeremy L Marzuola*** (marzuola@math.unc.edu), Department of Mathematics, CB#3250, Chapel Hill, NC 27599. *On discrete rarefaction in an NLS model for weak turbulence.*

With Jim Colliander, Tadahiro Oh and Gideon Simpson, we explored numerically and analytically some solutions that arise from a dynamical systems model introduced by Colliander-Keel-Staffilani-Takaoka-Tao (2010) to study the interaction of resonant frequencies in the cubic, defocusing NLS equation on the torus. This dynamical system gives a rich class of solutions, some of which we can prove exist, some of which we study probabilistically and some of which we show exist in approximate models, including a discrete Burger's equation. The goal is to present solutions that have cascades towards large frequency. We will discuss how the toy model fits into the study of the NLS equation and what information can be gained towards the idea of "weak turbulence." We will also discuss some of the perturbative techniques developed with Sebastian Herr towards reconciling the toy model with in particular the Burger's equation model. (Received January 14, 2014)

1097-35-112 **Michael Renardy*** (mrenardy@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123, and **Shirshendu Chowdhury**, **Debanjana Mitra** and **Mythily Ramaswamy**. *Null controllability of the linearized compressible Navier-Stokes system in one dimension.*

We consider the one dimensional compressible Navier-Stokes equations linearized around a steady state of constant density and constant nonzero velocity, with periodic boundary conditions. We explore the controllability of this linearized system using a control only for the velocity equation. We prove that the linearized system with homogeneous periodic boundary conditions is null controllable in an appropriate Sobolev space by a localized interior control when time is sufficiently large. The proof is based on an observability inequality obtained with the help of two types of Ingham inequality.

We also consider the analogous problem with Dirichlet boundary conditions rather than periodicity. For this case, we show approximate controllability and null controllability in the case of creeping flow. (Received January 15, 2014)

1097-35-114 **Yuri Latushkin*** (latushkiny@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65203. *The Morse and Maslov indices for periodic and for multidimensional differential operators.*

In this talk we discuss some recent results on connections between the Maslov and the Morse indices for differential operators. The Morse index is a spectral quantity defined as the number of negative eigenvalues counting multiplicities while the Maslov index is a geometric characteristic defined as the signed number of intersections of a path in the space of Lagrangian planes with the train of a given plane. The problem of relating these two quantities is rooted in Sturm's Theory and has a long history going back to the classical work by Arnold, Bott, Duistermaat, Smale, and to a more recent paper by Deng and Jones. Two situations will be addressed: First, the case when the differential operator is a Schroedinger operator equipped with theta-periodic boundary conditions, and second, when the Schroedinger operators are acting on a family of multidimensional domains obtained by shrinking a star-shaped domain to a point and are equipped with either Dirichlet or quite general Robbin boundary conditions.

This is a joint work with G. Cox, C. Jones, R. Marangell, A. Sukhtayev, and S. Sukhtaiev. (Received January 15, 2014)

1097-35-117 **Avner Friedman** and **King-Yeung Lam***, lam.184@osu.edu. *On the Stability of Steady States in a Granuloma Model.*

We consider a free boundary problem for a system of two semilinear parabolic equations. The system represents a simple model of granuloma, a collection of immune cells and bacteria filling a 3-dimensional domain $\Omega(t)$ which varies in time. We prove the existence of stationary spherical solutions and study their linear asymptotic stability as time increases to infinity. (Received January 15, 2014)

1097-35-133 **Junxiong Jia*** (jjx425@gmail.com), 686 Cherry Street, Skies building, Atlanta, GA 30332, and **Ronghua Pan** (panrh@math.gatech.edu), 686 Cherry Street, Skies building, Atlanta, GA 30332. *Well-posedness and decay for full Navier-Stokes equations with temperature dependent coefficients.*

In this talk, firstly, we study the local and global well-posedness for full Navier-Stokes equations with temperature dependent coefficients in the framework of Besov space. We generalized R. Danchin's results for constant transport coefficients to obtain the local and global well-posedness for the initial with low regularity in almost critical Besov space. Secondly, we give a time decay rate results of the global solution in the Besov space framework which is not investigated before. Due to the low regularity assumption, we find that the high frequency part is also important for us to get the time decay. (Received January 17, 2014)

1097-35-135 **Ana L. Vivas-Barber*** (alvivasbarber@nsu.edu), Norfolk State University, Department of mathemtics, 700 Park Avenue, Norfolk, VA 23504, and **Sunmi Lee**. *Inclusion of Asymptomatic Individuals for an Age-Structure Influenza Model.* Preliminary report.

Age- structure models have been developed for different epidemiological models over the last few decades. Not many standard epidemiological models for Influenza do include asymptomatic individuals as part of the population; we observe that the dynamics of the system changes when we include asymptomatic individuals. An integro-differential system for an age-structure influenza model is proposed; the steady state solution depending on the age distribution is found; the basic reproduction number is evaluated; and numerical simulations with influenza parameters are presented. (Received January 17, 2014)

1097-35-140 **Ciprian G. Gal** and **Joseph L. Shomberg*** (jshomber@providence.edu). *Dynamic Boundary Conditions with Memory: Attractors of the Coleman-Gurtin Equation.* Preliminary report.

We report some recent advances concerning the asymptotic behavior and stability of the Coleman-Gurtin equation possessing a singularly perturbed memory kernel and equipped with dynamic boundary conditions with memory. We obtain a family of global attractors, with optimal regularity, which is upper-semicontinuous as the perturbation parameter vanishes. In addition, we obtain a robust (Hölder continuous) family of exponential attractors; hence, proving the global attractors are finite dimensional, uniform with respect to the perturbation parameter. We assume nonlinear terms are defined on the interior of the domain and on the boundary, subject to a balance condition in the sense of A. Rodríguez-Bernal and A. Tajdine, JDE **169** (2001). (Received January 17, 2014)

1097-35-150 **John L Lewis*** (johnl@uky.edu), Mathematics Department, 7th Floor Patterson Office Tower, University of Kentucky, Lexington, KY 40506-0027, and **Kaj Nystrom** (kaj.nystrom@math.uu.se), Department of Mathematics, Uppsala University, S-751 06 Uppsala, Sweden. *Operators of p - Laplace Type: Estimates for Solutions Vanishing on Lower Dimensional Sets.* Preliminary report.

We discuss boundary Harnack inequalities and the Martin boundary problem for operators of p - Laplace type on lower dimensional Reifenberg sets. Our work extends earlier work of the authors for positive solutions to operators of p - Laplace type vanishing on a portion of a domain whose boundary is locally n - 1 Reifenberg flat. (Received January 19, 2014)

1097-35-152 **Christian Seis*** (cseis@math.toronto.edu), University of Toronto, Department of Mathematics, 40 St. George Street, Toronto, Ontario M5S 2E4, Canada. *On the long-time asymptotics of solutions to the porous medium and thin film equation.*

We consider the porous medium equation and the thin film equation in $\mathbb{R}^N$. It is well-known that the long-time behavior of solutions to these equations is described by its self-similar solutions, the so-called Barenblatt or Smyth-Hill solution, respectivly. In recent work (partially joint with R. McCann), we study the higher order asymptotics by computing the complete spectrum of the operators that are obtained by linearizing the equation around the self-similar solutions. The knowledge of the spectrum and the corresponding eigenfunctions provides information not only on the slowest rates of convergence to the self-similar solution; it also allows us to extract further information on characteristic geometric pathologies to all orders. (Received January 19, 2014)

1097-35-155 **R. M. Brown*** (russell.brown@uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506, and **S Kim** and **K. A. Ott**. *The Green function for the mixed problem for the linear Stokes system in domains in the plane.*

We give conditions which allow us to construct a Green function for the linear Stokes system in domains in the plane. We show that the velocity field has a logarithmic singularity and is Hölder continuous away from the pole. The argument follows an idea of D. Mitrea and I. Mitrea to work in the Lorentz space, $L^{2,\infty}$ i.e. in weak L^2. (Received January 19, 2014)

1097-35-158 **Barbara Prinari*** (bprinari@uccs.edu), Department of Mathematics, University of Colorado Colorado Springs, 1420 Austin Bluffs Pkwy, Colorado Springs, CO 80918. *Inverse Scattering Transform for the focusing NLS equation with fully asymmetric boundary conditions.*

We present the inverse scattering transform (IST) for the focusing nonlinear Schrödinger equation: $iq_t = q_{xx} + 2|q|^2q$, with non-zero boundary conditions $q(x,t) \sim q_{l/r}(t) = A_{l/r}e^{i\theta_{l/r}(t)}$ as $x \to \mp\infty$ in the fully asymmetric case.

The direct problem is shown to be well-posed for NLS solutions $q(x,t)$ such that $q(x,t) - q_{l/r}(t) \in L^{1,1}(\mathbb{R}^{\mp})$ with respect to x for all $t \geq 0$, for which analyticity properties of eigenfunctions and scattering data are established. The inverse scattering problem is formulated both via (left and right) Marchenko integral equations, and as a Riemann-Hilbert problem on a single sheet of the scattering variables $\lambda_{l/r} = \sqrt{k^2 + A_{l/r}^2}$, where k is the usual complex scattering parameter in the IST. The time evolution of the scattering coefficients is then derived, showing that, unlike the case of solutions with the same amplitude as $x \to \pm\infty$, here both reflection and transmission coefficients have a nontrivial time dependence.

[Joint work with F. Demontis and C. van der Mee, University of Cagliari, Italy, and Federica Vitale, University of Salento, Italy] (Received January 20, 2014)

1097-35-159 **Geng Chen**, **Tao Huang*** (txh35@psu.edu) and **Chun Liu**. *Eulerian Description of Variational Wave Equation and Singularity Formation.*

We study the formation of finite time singularities in the form of super norm blowup for a spatially inhomogeneous hyperbolic system. The system is related to the variational wave equations as those in [**?**]. The system possesses a unique C^1 solution before the emergence of vacuum in finite time, for given initial data that are smooth enough, bounded and uniformly away from vacuum. At the occurrence of blowup, the density becomes zero, while the momentum stays finite, however the velocity and the density of the energy are both infinity. (Received January 20, 2014)

1097-35-160 **Dat Tien Cao*** (dtcznb@mail.missouri.edu), Mathematics Department, University of Missouri-Columbia, Columbia, MO 65211. *Finite energy solutions of quasilinear elliptic equations with sub-natural growth terms.*

We study finite energy solutions to quasilinear elliptic equations of the type

$$-\Delta_p u = \sigma\, u^q \quad \text{in } \mathbb{R}^n,$$

where Δ_p is the p-Laplacian, $p > 1$, and σ is a nonnegative function (or measure) on $\mathbb{R}^n$, in the case $0 < q < p-1$ (below the "natural growth" rate $q = p-1$). We give explicit necessary and sufficient conditions on σ which ensure that there exists a solution u in the homogeneous Sobolev space $L_0^{1,p}(\mathbb{R}^n)$, and prove its uniqueness. Among our main tools are integral inequalities closely associated with this problem, and Wolff potential estimates used to obtain sharp bounds of solutions. More general quasilinear equations with $\mathrm{div}\mathcal{A}(x, \nabla u)$ in place of $\Delta_p u$ are considered as well. This is joint work with Igor E. Verbitsky. (Received January 20, 2014)

1097-35-171 **Murat Akman*** (murat.akman@uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40508, and **John L Lewis** and **Andrew L Vogel**. *Hausdorff Dimension of a measure associated with a positive weak solution of generalized p-laplace equation.* Preliminary report.

In this talk I will discuss Hausdorff dimension of a measure related to a positive weak solution of a certain partial differential equation in a simply connected domain. This work generalizes work of Lewis and coauthors when the measure is p-harmonic and also for p = 2, the well known theorem of Makarov regarding the Hausdorff dimension of harmonic measure relative to a point in a simply connected domain.

I will also explain a possible generalization of this result when the domain is an open subset of $\mathbb{R}^n$ and describe construction of an example with the Hausdorff dimension of the corresponding measure is $< n-1$ when $p \geq n$. (Received January 20, 2014)

1097-35-197 **Chris Curtis***, San Diego State University, Department of Mathematics and Statistics, 5500 Campanile Drive, GMCS 415, San Diego, CA 92182. *Tight-Binding Approximations and Edge States in Honeycomb Optical Lattices.*

Over the last several years, a great deal of interest has emerged over honeycomb optical lattices, which are modeled by a Gross-Pitaevskii (GP) equation with a periodic, two-dimensional potential. Using a tight-binding approximation in the semi-classical limit, a two-dimensional nonlinear discrete system has been derived as an approximation to the GP equation. We present results that establish the validity of this approximation on asymptotically long time scales.

By introducing an edge into the discrete system, we then present results on the propagation of modes localized along the edge, or edge modes. Ignoring nonlinearity, one can find a plethora of linear edge modes, but a central question is what is the impact of nonlinearity on these problems. In the case of weak nonlinearity, we have developed a rigorously justified approximation describing the impact of nonlinearity on the linear modes. The most important result from this is that the nonlinearity does not cause delocalization away from the edge. In the case of strong nonlinearity, we present numerical results which show the nonlinearity does not cause delocalization, and thus edge modes should be a stable feature for optical lattices with edges. (Received January 21, 2014)

1097-35-199 **Peter D. Miller*** (millerpd@umich.edu). *Modulational stability properties of periodic traveling waves in Klein-Gordon equations.*

For a wide class of potentials modeled on the sine-Gordon potential $V(u) = -\cos(u)$, the nonlinear Klein-Gordon equation $u_{tt} - u_{xx} + V'(u) = 0$ admits four types of periodic traveling wave solutions: they can propagate at subluminal or superluminal speeds and they can be waves of librational or rotational type. We consider the linearized stability of such waves, paying particular attention to the possibility of unstable spectrum near the origin, the hallmark of so-called modulational instability. We describe an index detecting modulational instability, and we relate it to other notions of modulational instability arising from Whitham's fully nonlinear wave modulation theory as well as the weakly nonlinear theory of slowly-varying wave envelopes described by a cubic nonlinear Schödinger equation. This is joint work with Chris Jones, Robert Marangell, and Ramón Plaza. (Received January 22, 2014)

1097-35-205 **Dat Tien Cao** and **Igor E. Verbitsky*** (verbitskyi@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Quasilinear elliptic equations and weighted norm inequalities in the "upper triangle" case.*

We study positive solutions to the homogeneous quasilinear equation $-\triangle_p u - \sigma\, u^q = 0$ on $\mathbf{R^n}$ in the case $0 < q < p-1$ (below the natural growth rate $q = p-1$), where $\triangle_p$ is the p-Laplacian and $\sigma \in L^1_{loc}$ is an arbitrary nonnegative function (or measure).

We will associate with this problem certain integral inequalities involving nonlinear Wolff's potentials, and give necessary and sufficient conditions for the existence of a positive solution, along with pointwise estimates of minimal solutions, and discuss regularity and uniqueness questions. (Received January 22, 2014)

1097-35-216 **Yannis Angelopoulos*** (yannis@math.toronto.edu), Department of Mathematics, University of Toronto, Bahen Centre, 40 St. George St., Room 6290, Toronto, ON M5S 2E4, Canada. *Well-posedness and ill-posedness issues for the Novikov-Veselov equation.*

In this talk I will describe some recent work on the Novikov-Veselov equation. Using the Fourier restriction method, I will talk about some well-posedness and ill-posedness results for this equation in certain Sobolev spaces. Finally I will discuss some similar results that apply to some related models. (Received January 22, 2014)

1097-35-223 **Matthias L. Youngs*** (youngsml@iupuc.edu), 4601 Central Ave, Columbus, IN 47203, and **Anthony C. K. Suen**. *Analysis of Free Boundary Problems for Compressible Flows.*

We discuss models that track the support of a compressible fluid density. Initially, the analysis used considers free boundary problems associated to an individual fluid packet evolving in time. A suitable existence theory for weak solutions preserving desired physical properties such as local momentum conservation is developed. Weak compactness arguments are made to handle the possibility for infinitely many collisions of fluid packets at a possibly dense set of collision times. Past results of David Hoff and Matthias Youngs are presented as well as current progress in higher dimensions done by Youngs ad Anthony C. K. Suen. (Received January 22, 2014)

1097-35-228 **Michael E Music*** (michael.music@uky.edu). *The nonlinear Fourier transform for two-dimensional subcritical potentials.*

We study the inverse scattering method for the Novikov-Veselov equation for a larger class of Schrödinger potentials than could be handled previously. Previous work concerns so-called conductivity type potentials, which have a bounded positive solution at zero energy and are a nowhere dense set of potentials. We relax this assumption to include logarithmically growing positive solutions at zero energy. These potentials are stable under perturbations. For this sufficiently smooth data of this type, we prove that the associated scattering transform can be inverted, and the original potential is recovered from the scattering data. (Received January 23, 2014)

1097-35-241 **Catherine Sulem*** (sulem@math.toronto.edu), 40 St George Street, Toronto, Ontario M5S2E4, Canada. *Lower bound for the rate of blow-up of singular solutions of the three dimensional Zakharov system.*

The Zakharov system describes the propagation of Langmuir waves in a non-magnetized plasma. It was derived by V.E. Zakharov in 1972 in the form of a coupled system governing the electric field complex amplitude and the density fluctuations of ions. Heuristic arguments and numerical simulations show that solutions may blow-up in a finite time both in two and three dimensions.

In two dimensions, there exist exact self-similar blowing-up solutions. In addition, Merle (1996) established a lower bound for the rate of blow-up of singular solutions in the energy space. This rate is optimal. In three dimensions, there are no known explicit blowing-up solutions. Self-similar solutions exist only asymptotically close to collapse. In the present work, we assume that the solution blows up in a finite time and we establish a lower bound for the blow-up rates of some Sobolev norms of the solution.

This is a joint work with Jim Colliander and Magda Czubak. (Received January 23, 2014)

1097-35-250 **Ronghua Pan** (panrh@math.gatech.edu), Room 008, Skiles buliding, 686 Cherry street, Atlanta, GA 30332, **Yachun Li** (ycli@sjtu.edu.cn), Room 1304, Department of Mathematics, No.800, Dongchuan Road, Shanghai, Shanghai 200240, Peoples Rep of China, and **Shengguo Zhu*** (zhushengguo@sjtu.edu.cn), Room 140, Skiles Building, 686 Cherry Street, Atlanta, GA 30332. *Existence of strong solutions to 2D Shallow Water equations with vacuum far fields.* Preliminary report.

We identify sufficient conditions on initial data to ensure the existence of a unique strong solution to the Cauchy problem to 2D Shallow Water equations (viscous Saint-Venants model)when the far fields of initial data allow vacuum. This is a recent work joint with Yachun Li and Ronghua Pan. (Received January 23, 2014)

1097-35-252 **V F. Vasseur**, Mathematics Department, Austin, TX 78712, and **C Yu*** (yucheng@math.utexas.edu), Mathematics Department, Austin, TX 78712. *Existence of the global weak solutions to compressible Navier-Stokes equations with density dependent viscosity.* Preliminary report.

The existence of global weak solutions for the isentropic compressible Navier-Stokes equations with density dependent coefficients vanishing on vacuum regions has been a long standing open problem. The primary focus of this talk is the recent result concerning existences of global in time weak solutions in three dimensional space for any $\gamma > 1$ with large initial data vanishing on vacuum regions. It should be remarked that our result naturally holds in two dimensional space with $\gamma = 2$. Thus, we resolved Lions' open problem concerning weak solutions of the viscous shallow water equations. This is joint work with Alexis F. Vasseur. (Received January 23, 2014)

1097-35-265 **Gianluca Mola*** (gianluca.mola@polimi.it), Politecnico di Milano. *Recovering the reaction and the diffusion coefficients in a linear parabolic equation.*

Let H be a real separable Hilbert space and $A : \mathcal{D}(A) \to H$ be a positive and self-adjoint (unbounded) operator. We consider the identification problem consisting in searching for a H-valued function u and a couple of real numbers λ and μ, the first one being positive, that fulfill the initial-value problem

$$u'(t) + \lambda\, Au(t) = \mu\, u(t), \quad t \in (0,T), \quad u(0) = u_0,$$

and the additional constraints

$$\|A^{r/2}u(T)\|^2 = \varphi \quad \text{and} \quad \|A^{s/2}u(T)\|^2 = \psi,$$

for some time-instant $T > 0$, where we denote by A^s and A^r the powers of A with exponents $r < s$. Provided that the given data u_0 and φ, $\psi > 0$ satisfy proper *a priori* limitations, using a Faedo-Galerkin approximation scheme we construct a unique solution (u, λ, μ) on the whole interval $[0, T]$, and exhibit an explicit continuous dependence estimate-of Lipschitz-type-with respect to the data. Also, we provide specific applications to second and fourth-order parabolic initial-boundary value problems. The results are obtained in collaboration with A. Lorenzi. (Received January 24, 2014)

1097-35-268 **Tao Luo*** (tl48@georgetown.edu), St. Mary's Hall, Washington, DC 20057, and **Zhouping Xin** and **Huihui Zeng**. *On the evolution of vacuum boundaries of compressible fluids with self-gravitation.*

The vacuum free boundary problems of compressible fluids with self-gravitation will be discussed, in particular on the regularity and uniqueness, for the 3-d spherically symmetric motion, both in short and large time. (Received January 24, 2014)

1097-35-277 **Gino Biondini*** (biondini@buffalo.edu), Buffalo, 14260, and **Emily Fagerstrom**, Buffalo, NY 14260. *The Benjamin-Feir instability revisited.*

The modulational instability (MI), also known as Benjamin-Feir instability in the context of water waves, is one of the most widespread phenomena in nonlinear science. In many cases, the underlying dynamics is governed by the nonlinear Schrodinger (NLS) equation. The initial stage of MI can therefore be described by linearizing the NLS equation around a constant background. Once the perturbations have grown, however, the linearization ceases to be valid. On the other hand, the NLS equation is a completely integrable infinite-dimensional Hamiltonian system, and the initial-value problem is therefore amenable to solution via the inverse scattering transform (IST). In this talk I will describe how the recently-developed IST for the focusing NLS equation with non-zero boundary conditions can be used to elucidate the nonlinear stage of the MI. (Received January 24, 2014)

1097-35-281 **Gideon Simpson*** (simpson@math.drexel.edu), Department of Mathematics, Drexel University, Korman Center - Room 206, 33rd and Market Streets, Philadelphia, PA 19104, and **David M Ambrose**. *Well-Posedness Results for a Derivative Nonlinear Schrödinger Equation.*

In this talk, recent results on the existence and uniqueness of solutions to a generalized derivative nonlinear Schrödingier equation will be presented. This equation, with nonlinearity $i|u|^{2\sigma}u_x$, has recently been given attention for its solitary wave solutions and blow up dynamics. However, there are relevant values of σ, including $1 < \sigma < 2$, for which well-posedness results are needed. Open problems will be highlighted. (Received January 24, 2014)

1097-35-282 **Alexis F. Vasseur*** (vasseur@math.utexas.edu). *Relative entropy applied to shocks for Conservation Laws and applications.*

We develop a theory based on relative entropy to study the stability and contraction properties of extremal shocks of conservation laws. We will present first application of the theory to the study of asymptotic limits. (Received January 24, 2014)

1097-35-285 **Dhanapati Adhikari*** (dadhikari@marywood.edu), Department of Mathematics, Marywood University, 2300 Adams Avenue, Scranton, PA 18509. *Damped two-dimensional Boussinesq equations.*

We examine the damped 2D Boussinesq equations and study how damping affects the regularity of solutions. Since the damping effect is insufficient in overcoming the difficulty due to the "vortex stretching", we seek unique global small solutions. By positioning the solutions in a suitable functional setting, we are able to obtain a unique global solution under a minimal smallness assumption. This is a joint work with C. Cao, J. Wu and X. Xu. (Received January 24, 2014)

1097-35-291 **Karthik Adimurthi**, **Tadele Mengesha** and **Phuc Cong Nguyen*** (pcnguyen@math.lsu.edu). *Nonlinear weighted norm inequalities and quasilinear Riccati type equations.*

We discuss certain nonlinear versions of weighted norm inequalities for fractional and singular integrals. These inequalities provide bounds of Muckenhoupt-Wheeden, Calderón-Zygmund, or Adams type for gradients of solutions to a wide class of quasilinear equations with measure or distributional data. As an application, the existence of solutions to a quasilinear Riccati type equation is obtained in the framework of Morrey spaces. This talk is based on joint work with Tadele Mengesha and Karthik Adimurthi. (Received January 25, 2014)

1097-35-299 **Alexander Tovbis*** (alexander.tovbis@ucf.edu), Orlando, FL 32816. *Painlevé transcendents and universality of transitions at the point of gradient catastrophe for some integrable systems and orthogonal polynomials: the Riemann-Hilbert Problem approach.*

Using the nonlinear steepest descent (Deift-Zhou) method for Riemann-Hilbert problems, we give the leading order description (with error estimates) of the point of gradient catastrophe for the focusing NLS in terms of the tritronquée solution to the Painlevé I (P1) and rational breathers for the NLS.

Similar phenomenon (double scaling limit) was studied for the asymptotic of recurrence coefficients for orthogonal polynomials with complex varying weight $e^{-N(\frac{1}{2}z^2+\frac{1}{4}tz^4)}$ on the cross near the critical values of the parameter $e^{-N(\frac{1}{2}z^2+\frac{1}{4}tz^4)}$ that are governed by P1. We also study the global asymptotic regime for complex t and another crtical point $t_2 = \frac{1}{4}$ that is governed by P2. It is interesting to note that in some cases the singular behavior of the recurrence coefficients near t_2 occurs away from the poles of the corresponding P2 transcendents. This is a join work with Marco Bertola. (Received January 28, 2014)

1097-35-303 **Dehua Wang*** (dwang@math.pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *Hyperbolic conservation laws of isometric embedding in geometry.*

Recent results on solutions to the hyperbolic systems of conservation laws for isometric embedding in geometry will be presented. (Received January 25, 2014)

1097-35-309 **Hailiang Liu***, Iowa State University, Ames, IA 50011. *The alternating evolution methods for hyperbolic problems.*

In this talk, I shall present a brief review of the recent developments in alternating evolution (AE) methods for numerical computation of first order partial differential equations, with hyperbolic conservation laws and Hamilton-Jacobi equations as two canonical examples. The main difficulty of such computation arises from the nonlinearity of the model, making it necessary to incorporate an appropriate amount of numerical viscosity to capture the entropy/viscosity solution as physically relevant solutions. The alternating evolution method is based on the AE system of the original PDEs, the discretization technique ranges from finite difference, finite volume and the discontinuous Galerkin methods. In all these cases, the AE solver can produce accurate solutions with equal computational time than the traditional solvers. In particular, the AE formulation allows the same discontinuous Galerkin discretization for both conservative and non-conservative PDEs under consideration. In order to make the presentation more concise and to highlight the main ideas of the algorithm, we use simplified models to describe the details of the AE method. Sample simulation results on a few models are also given. (Received January 25, 2014)

1097-35-323 **Jason Metcalfe*** (metcalfe@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *The Strauss conjecture on black hole backgrounds.*

This talk is based on joint work with H. Lindblad, C. Sogge, M. Tohaneanu, and C. Wang, and it focuses on an analog of the Strauss conjecture on black hole backgrounds. The Strauss conjecture asks for what power-type nonlinearities can semilinear wave equations be guaranteed to have global existence when the initial data are sufficiently small. In the flat case, such global existence was first resolved in generic dimension by Georgiev, Lindblad, and Sogge. Here, we resolve a similar question on Kerr black hole space-times with sufficiently small angular momenta. The main tools are an analog of a weighted Strichartz estimate developed in a joint work with Hidano, Smith, Sogge, and Zhou and localized energy estimates on these space-times, such as those proved by Tataru and Tohaneanu. (Received January 26, 2014)

1097-35-336 **Eitan Tadmor** and **Changhui Tan*** (ctan@cscamm.umd.edu). *Critical thresholds on Eulerian dynamics and applications for non-local models.*

In this talk, I will discuss global existence and regularity results for pressure-less Eulerian dynamics. Due to the competition between the nonlinear conviction and the external force, there exists a critical threshold which distinguishes initial data into two categories: on one side of the critical threshold, we have existence and regularity of global strong solution; on the other side, the solution will blow up in finite time. Several models evolving different forcing terms will be discussed. In particular, we prove critical thresholds for models with non-local force, including hydrodynamic Cucker-Smale flocking model, and modified Euler-Poisson system. (Received January 26, 2014)

1097-35-341 **Luan Hoang**, **Truyen Nguyen*** (tnguyen@uakron.edu) and **Tuoc Phan**. *Global Existence of Smooth Solutions to a Cross-Diffusion system.*

We study the initial value problem for a cross-diffusion system in bounded domains of any dimension. This system was proposed by Shigesada, Kawasaki and Teramoto in 1979 to describe the habitat segregation phenomena between two species which are competing in the same domain. A global-time existence of smooth solutions is established by deriving global $W^{1,p}$-estimates for weak solutions to a class of nonlinear parabolic equations with nonlinear diffusion. A perturbation argument and a new double scaling technique are introduced to obtain the estimates for large reaction terms. This is a joint work with Luan Hoang and Tuoc Phan. (Received January 26, 2014)

1097-35-354 **Richard S Laugesen*** (laugesen@illinois.edu) and **Bartlomiej A Siudeja** (siudeja@uoregon.edu). *Magnetic spectral bounds on starlike plane domains.*

We extremize functionals of the magnetic spectrum on plane domains under Dirichlet or Neumann boundary conditions. These "isoperimetric" type results involve geometric functionals such as moment of inertia and area. The results cover the first eigenvalue, spectral zeta function, partition function, and much more, and the method promises to extend to nonlinear operators such as the p-Laplacian. (Received January 26, 2014)

1097-35-357 **Michael Renardy** (mrenardy@math.vt.edu), McB 406, Virginia Tech, Blacksburg, VA 24061-0123, and **Taige Wang*** (tigerwtg86@gmail.com), McB 465, Virginia Tech, Blacksburg, VA 24061-0123. *Large Amplitude Oscillatory Shear Flows for a Model of a Thixotropic Yield Stress Fluid.*

We discuss a model of a viscoelastic fluid (Larson's PEC model) which is able to describe thixotropic yield stress behavior in the limit of large relaxation time. This limit naturally introduces a small parameter. We use the methods of matched asymptotics to describe the dynamics of large amplitude oscillatory shear flows. Regimes of fast, slow and yielded dynamics are identified. The relative size of the period of the oscillation to the relaxation time is of crucial importance in determining how these regimes arise during oscillatory shear flow. The fact that yielding occurs on a faster time scale than unyielding is of crucial importance, leading to an intermediate frequency range where the flow always remains yielded, while complete cycles of yielding and unyielding occur at slower frequencies. (Received January 26, 2014)

1097-35-358 **Naian Liao*** (naian.liao@vanderbilt.edu), 1326 stevenson center, Vanderbilt University, Math Department, Nashville, TN 37240, **Emmanuele DiBenedetto** (gianazza@imati.cnr.it), 27100 Pavia, Italy, and **Ugo Gianazza**. *Recent Progress on Local Behaviors of a Logarithmic Diffusion Equation.*

In this talk, I will explain some recent progress on the local behavior of the equation $u_t = \Delta \ln u$ including a Harnack-type inequality, L^1 form Harnack inequality and local special analyticity. I will also show you their connection with the porous medium equation $u_t = \Delta(u^m/m)$ and all estimates are stable as m tends to 0. (Received January 27, 2014)

1097-35-367 **Eirik Endeve*** (endevee@ornl.gov), Oak Ridge, TN 37831. *Discontinuous Galerkin Methods for Simulation of Supernova Neutrino Transport.* Preliminary report.

Explosions of massive stars (i.e., core-collapse supernovae) are the dominant source of heavy elements in the Universe. As multi-messenger events, they are targeted by instruments covering most of the electromagnetic spectrum, as well as by gravitational wave and neutrino detectors. Multi-scale simulations are necessary to understand details of the explosion mechanism, and their connection to the observed signals. To this end, we are developing numerical methods for simulation of supernova neutrino transport. In this work, we aim to develop robust, high-order methods for phase space advection that preserve a maximum principle for the distribution function f (i.e., $f \in [0,1]$ for neutrinos), and that are applicable to curvilinear phase space coordinates. Our numerical methods are based on the Runge-Kutta discontinuous Galerkin method. We discuss the physical model, the construction of maximum-principle-satisfying methods for phase space advection, and present numerical results from implementations in spherical and axial symmetry. Our results demonstrate that the method is high-order accurate and that the distribution function preserves the maximum principle. We also discuss challenges of simulating radiation propagating in a strong gravitational field. (Received January 27, 2014)

1097-35-370 **Carmen Chicone*** (chiconec@missouri.edu), Department of Mathematics, Columbia, MO 65211. *Time domain reflectometry with applications to electric properties of soils.* Preliminary report.

A time-domain reflectometer produces a front type traveling wave of voltage (and current) on a transmission line, the wave is reflected from regions along the line where the dielectric properties of the media surrounding the conductors change, and the time-trace of reflected voltages is recorded by the instrument. The problem is to recover the positions and dielectric parameters of the media from the recorded voltage. The basic dynamical model is a hyperbolic system of PDEs with spatially dependent coefficients, which in the simplest special case is a system of hyperbolic conservation laws. The modeling challenges include appropriate formulation of boundary conditions for well-posed PDEs and specialization to well-posed inverse problems. Numerical challenges include the appropriate choices of discretization, time stepping, and boundary conditions to approximate solutions of the system of PDEs and numerical methods to approximate solutions of the inverse problem. A tutorial on the general problem will be presented. As time permits a specific application to soil structure and moisture content will be discussed. (Received January 27, 2014)

1097-35-382 **Petronela Radu*** (pradu@math.unl.edu), Lincoln, NE 68502. *Decay of higher order energies for nonlocal wave equations with damping.*

In this talk I will present some recent results regarding the long time behavior of solutions to nonlocal wave equations with damping. These equations appear as models in nonlocal diffusion, when one uses the Cattaneo-Vernotte flux to replace the Fourier law. Several methods suitable for this investigation will be presented, some which are reminiscent of the local setting, and I will also point out some of the major challenges encountered in the nonlocal case. (Received January 27, 2014)

1097-35-383 **Jeffrey J Langford*** (jjl026@bucknell.edu), Bucknell University, 1 Dent Drive, Lewisburg, PA 17837. *Comparison results in balls, shells, and spheres.*

In this talk, we compare the solution of a given PDE

$$\begin{aligned} -\Delta u &= f \quad \text{in } \Omega, \\ \frac{\partial u}{\partial n} &= 0 \quad \text{on } \partial\Omega, \end{aligned}$$

to the solution of a second PDE where the data has been "rearranged"

$$-\Delta v = f^{\#} \quad \text{in } \Omega,$$
$$\frac{\partial v}{\partial n} = 0 \quad \text{on } \partial\Omega.$$

For us, Ω will equal a ball, a shell, or a sphere (with no boundary conditions). We show how to estimate various norms of u using the analogous norms of v. As time permits, we will discuss physical applications of these results. (Received January 27, 2014)

1097-35-385 **Michele Coti Zelati*** (micotize@indiana.edu). *On the stability of the weak attractor of the 3D Navier-Stokes equations.*

We consider the three-dimensional Navier-Stokes-Voigt (NSV) equations and we analyze, from the asymptotic behavior view point, its Navier-Stokes (NS) limit as the relaxation parameter vanishes. We show that the NSV-attractors converge to the weak NS-attractor in the Hausdorff semidistance induced by the weak L^2-metric on the absorbing set of the Navier-Stokes equations. Some results related to the strong topology of L^2 are also proved. (Received January 27, 2014)

1097-35-389 **Stephen Pankavich*** (pankavic@mines.edu), 1500 Illinois St, Stratton Hall 224, GOLDEN, CO 80401. *Global Classical Solutions for the Relativistic Vlasov-Maxwell-Fokker-Planck system.*

The Vlasov-Maxwell system is a fundamental kinetic model of plasma dynamics. When one considers relativistic velocities and includes effects due to collisions with a fixed background of particles, the result is the relativistic Vlasov-Maxwell-Fokker-Planck system. The first Lorentz-invariant model of this type was recently derived by Calogero and Felix in 2010. Here, we shall discuss the first well-posedness results for global-in-time classical solutions of this system posed in a lower-dimensional setting. Our methods utilize a gain in regularity stemming from the diffusive term to arrive at smooth solutions stemming from initial data which lack even weak differentiability properties. (Received January 27, 2014)

1097-35-390 **Jeffrey J Langford*** (jjl026@bucknell.edu), Bucknell University, 1 Dent Drive, Lewisburg, PA 17837. *A proof of Kawohl's conjecture.*

In the early 1980's, B. Kawohl conjectured that the solution u to the Poisson PDE

$$-\Delta u = f \quad \text{in } R,$$
$$\frac{\partial u}{\partial n} = 0 \quad \text{on } \partial R,$$

in the unit rectangle R oscillates no more than the solution v to a "rearranged" problem

$$-\Delta v = f^{\#} \quad \text{in } R,$$
$$\frac{\partial v}{\partial n} = 0 \quad \text{on } \partial R,$$

where the function $f^{\#}$ is obtained by rearranging f's vertical slice functions monotonically. We provide a proof of this conjecture using the star function method and tools from complex analysis. (Received January 27, 2014)

1097-35-392 **Shu-Ming Sun** (sun@math.vt.edu), McBryde Hall 432, Blacksburg, VA 24061, and **Yu Ran*** (yran@math.vt.edu), McBryde Hall 465, Blacksburg, VA 24061. *Nonhomogeneous Dirichlet Initial Boundary Value Problems for Nonlinear Schrödinger Equations (NLS) in 2-Dimension.*

My study focuses on the initial and boundary value problems (IBVP) of a class of nonlinear Schrödinger equations posed on a half plane $R \times R^+$ and on a strip domain $R \times [0, L]$ with a variety of nonhomogeneous boundary data in 2-dimensional space. The local well-posedness for the initial data in H^s and boundary data in $H^{s_1}(I_t; L^2) \bigcap L^2(I_t; H^{s_2})$ or $H^{s_3}(I_t; L^2) \bigcap L^2(I_t; H^{s_4})$ are provided with $0 \le s \le 2$ for the nonlinear term. The main strategy is to derive an equivalent integral equation from the NLS by semi-group theory and then perform the Fixed Point theorem. Along the process, it is the key to select proper auxiliary function spaces and prepare all the corresponding norm estimates for completing the argument of the theorem. The global well-posedness is also investigated for $s = 1$. In fact, the IBVP posed on the half plane and the one posed on the strip domain are two separated problems because of the techniques applied. The first problem is more related to the initial value problem (IVP) posed on the R^2, while the second can be studied as an IVP over a half-periodic domain.

The corresponding conditions for regularity of the solution are carefully considered as well. (Received January 27, 2014)

1097-35-397 **Svetlana Roudenko*** (roudenko@gwu.edu), Department of Mathematics, Washington, DC 20052. *The focusing nonlinear Schrodinger equation: dichotomies and blow-up dynamics.*

We consider the focusing nonlinear Schroedinger equation with finite energy initial data in the mass-supercritical regime. We first discuss the contracting sphere blow-up dynamics (joint work with Justin Holmer and Galina Perelman), and then present a dichotomy for scattering and blow-up solutions with finite variance (joint work with Thomas Duyckaerts). In both results the solutions can have an arbitrary mass. (Received January 29, 2014)

1097-35-399 **Constance M Schober*** (cschober@ucf.edu), University of Central Florida, Dept. of Mathematics, Orlando, FL 32816, and **Anna Calini**, College of Charleston, Dept. of Mathematics, Charleston, SC 29424. *Observable and reproducible rogue waves.*

In physical regimes described by the cubic, focusing, nonlinear Schrödinger (NLS) equation, the N-dimensional homoclinic orbits of a constant amplitude wave with N unstable modes appear to be good candidates for experimentally observable and reproducible rogue waves. These homoclinic solutions include the Akhmediev breathers ($N = 1$), which are among the most widely adopted spatially periodic models of rogue waves, and their multi-mode generalizations ($N > 1$), and will be referred to as multi-mode breathers. Numerical simulations and a linear stability analysis indicate that the breathers with a maximal number of modes (maximal breathers) are robust with respect to rather general perturbations of the initial data in a neighborhood of the unstable background. (Received January 27, 2014)

1097-35-405 **Evans M Harrell***, School of Math, Georgia Tech, Atlanta, GA 30332-0160, and **Joachim Stubbe**, **Ahmad El Soufi** and **Saïd Ilias**. *On sums of eigenvalues of elliptic operators on homogeneous spaces.*

Using a new variational technique for sums of eigenvalues, where orthogonalization is replaced by averaging, we derive sharp upper bounds on sums of eigenvalues for a wide category of elliptic operators on homogeneous spaces. Among the operators we can treat are Laplace-Beltrami-Schrödinger operators, the Witten Laplacian, and the operator of vibrations of inhomogeneous membranes. When the operator is defined on a domain with a boundary, Neumann conditions are imposed, in the weak sense. (Received January 27, 2014)

1097-35-406 **Andrei Tarfulea*** (tarfulea@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544, and **Peter Constantin** and **Vlad Vicol**. *Long Time Dynamics of the Forced Critical Surface Quasi-geostrophic Equation.*

We prove the existence of a compact global attractor in H^1 for the dynamics of the forced critical surface quasi-geostrophic equation (SQG) by bounding the solution (after a transient time) independently of the initial data. We also prove the attractor has finite fractal (box-counting) dimension. (Received January 27, 2014)

1097-35-417 **Charis Tsikkou*** (tsikkou@math.wvu.edu), West Virginia University, Department of Mathematics. *Conservation Laws with no Classical Riemann Solutions: Existence of Singular Shocks.*

The basic tool in the construction of solutions to the Cauchy problem for conservation laws with smooth initial data is the Riemann problem. We review the results obtained for the solutions to the Riemann problem and present systems of two equations with no classical solutions. We then use the blowing-up approach to geometric singular perturbation problems to show that the systems exhibit unbounded solutions (singular shocks) with Dafermos profiles. (Received January 27, 2014)

1097-35-418 **Jerome A. Goldstein*** (jgoldste@memphis.edu) and **Junqiang Han**, , Peoples Rep of China. *Linearized stability of power equilibria of some semilinear parabolic problems: Intervention of the inverse square potential.*

The PDE

$$\frac{\partial u}{\partial t} = (-1)^{m+1}\Delta^m u + u^p$$

for $p > 1$, $m \in \mathbb{N}$, $t > 0$, $x \in \mathbb{R}^N$, has positive radial solutions of the form

$$u(x,t) = \varphi(r) = Cr^{-a};\ r = |x|,\ a > 0.$$

The usual forms of the Principle of Linearized Stability/Instability are inadequate to give definitive results for this problem. We discuss improved versions of this criterion, and we discuss the degree of instability of these solutions, which have unexpected dependence on p, m and N. (Received January 27, 2014)

1097-35-420 **Alim Sukhtayev*** (alim@math.tamu.edu), Department of Mathematics, Mailstop 3368, College Station, TX 77843, and **Andrew Comech** and **Gregory Berkolaiko**. *Energy criterion of linear instability of solitary waves in models of classical self-interacting spinor fields.*

We study the linear stability of localized modes in self-interacting spinor fields, using the generalization of the Grillakis-Shatah-Strauss approach. We show that vanishing of the energy functional indicates the border of the region of linear instability. (Received January 27, 2014)

1097-35-443 **Mark S. Ashbaugh*** (ashbaughm@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211-4100, **Rafael D. Benguria** (rbenguri@fis.puc.cl), Facultad de Fisica, Pontificia Universidad Catolica de Chile, Casilla 306, 22 Santiago, Chile, and **Rajesh Mahadevan** (mahadevan@udec.cl), Departmento de Matematica, Universidad de Concepcion, Avenida Esteban (s/n), 160-C Concepcion, Chile.
Rayleigh-Faber-Krahn-type Lower Bounds for the First Eigenvalue of the Vibrating Clamped Plate under Compression. Preliminary report.

This is a preliminary report on lower bounds for the first eigenvalue of the vibrating clamped plate under constant compression, in the context of geometric considerations for plates of different shapes. In mathematical terms, the problem is that of bounding the first eigenvalue of a certain 4th order partial differential operator with leading term the bi-Laplacian from below by a positive constant over the square of the area of the domain. In parallel with the case of the vibrating membrane with fixed edges, the sharp result of this type (saturated for a disk) will be called a Rayleigh-Faber-Krahn-type inequality. We present a Rayleigh-Faber-Krahn-type result for the vibrating clamped plate under compression which holds for small enough compression. (Received January 27, 2014)

1097-35-445 **Alin Pogan*** (apogan@indiana.edu), Rawles Hall, 831 East 3rd St, Bloomington, IN 47405, **Arnd Scheel** (scheel@math.umn.edu), 206 Church Street S.E, Minneapolis, MN 55455, and **Kevin Zumbrun** (kzumbrun@indiana.edu), Rawles Hall, 831 East 3rd St, Bloomington, IN. *Quasi-Gradient Systems, Modulational Dichotomies, and Stability of spatially periodic patterns.*

We discuss relations between the constrained variational problem and stability of solutions of a class of degenerate quasi-gradient systems admitting constraints, including Cahn-Hilliard equations, one- and multi-dimensional viscoelasticity, and coupled conservation law-reaction diffusion systems arising in chemotaxis and related settings. Using the relation between variational stability and the signature of $\frac{\partial c}{\partial \omega}$, where c denote the values of the imposed constraints and ω the associated Lagrange multipliers at a given critical point, we obtain as in the Hamiltonian case a general criterion for co-periodic stability of periodic waves, illuminating and extending a number of previous results obtained by direct Evans function techniques. We also prove that co-periodic and sideband stability are incompatible for all of these models. (Received January 27, 2014)

1097-35-450 **Yulia Karpeshina*** (karpeshi@uab.edu) and **Roman Shterenberg**. *On Schroedinger Operator with Quasi-periodic Potential in Dimension Two.* Preliminary report.

We consider $H = -\Delta + V(x)$ in dimension two, $V(x)$ being a quasi-periodic potential. We prove that the spectrum of H contains a semiaxis and there is a family of generalized eigenfunctions at every point of this semiaxis with the following properties. First, the eigenfunctions are close to plane waves $e^{i\langle \vec{k},\vec{x}\rangle}$ at the high energy region. Second, the isoenergetic curves in the space of momenta $\vec{k}$ corresponding to these eigenfunctions have a form of slightly distorted circles with holes (Cantor type structure). A new method of multiscale analysis in the momentum space is developed to prove these results. (Received January 27, 2014)

1097-35-451 **Fabiana Travessini De Cezaro*** (fabi.travessini@gmail.com), The University of Memphis, Mathematical Sciences, 316 Dunn Hall, Memphis, TN 38152, and **Gustavo Perla Menzala** (perla@lncc.br), Av. Getulio Vargas, 333, Quitandinha, Petropolis, 25651075, Brazil. *Existence and Uniqueness of Marguerre-Vlasov's shallow shell model with thermal effects.*

We consider the dynamic system of Marguerre Vlasov with thermal effects. This system is widely accepted as the dynamic model that describes vibrations of shallow shells. The wellposedness of regular and weak solutions is showed and uniform decay rate is obtained for the associated energy. (Received January 27, 2014)

1097-35-459 **Gisèle Ruiz Goldstein*** (ggoldste@memphis.edu), Department of Mathematical Sciences, University of Memphis, Germantown, TN 38138, and **Alain Miranville** and **Giulio Schimperna**. *Mass Conservation in a Cahn-Hilliard System with Semipermiable Walls.*

We study the Cahn-Hilliard system

$$\psi_t = \Delta\mu \qquad \text{in } \Omega \tag{1}$$

$$\mu = -\Delta\psi + f(\psi) \qquad \text{in } \Omega \tag{2}$$

$$w\psi_t = \delta\Delta_{LB}\mu + \frac{\partial\mu}{\partial\mathbf{n}} \qquad \text{on } \partial\Omega \tag{3}$$

$$w\mu = \sigma\Delta_{LB}\psi + \frac{\partial\psi}{\partial\mathbf{n}} + g(\psi) \qquad \text{on } \partial\Omega. \tag{4}$$

Here ψ is the relative concentration, μ the chemical potential, f (resp. g) the derivative of the bulk potential F (resp. the surface potential G), and δ and σ the coefficients of the boundary diffusion. The interesting feature of our model centers on (4) which represents mass conservation when mass transfer between the bulk and the walls are considered We derive this system from physical principles and discuss existence, uniqueness, continuous dependence, and stability of solutions. (Received January 27, 2014)

1097-35-482 **George Avalos*** (gavalos@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Rational Decay Properties of Fluid-Structure Interactive PDE.*

In this talk, we shall demonstrate how delicate frequency domain relations and estimates, associated with coupled systems of partial differential equation models (PDE's), may be exploited so as to establish results of uniform and rational decay. In particular, our focus will be upon decay properties of coupled PDE systems of different characteristics; e.g., hyperbolic versus parabolic characteristics. (Received January 28, 2014)

1097-35-483 **Alberto Bressan*** (bressan@math.psu.edu), McAllister Building, University Park, PA 16802. *Some counterexamples in the theory of conservation laws.*

The first part of the talk is concerned with sticky particle models in two space dimensions. Examples of Cauchy problems can be constructed with two and with zero solutions, respectively. Similar results apply to the equations of pressureless gases in two space dimensions, with L^∞ initial data.

The second set of examples concern the p-system of isentropic gas dynamics. For initial data with large total variation, one can consider front tracking approximate solutions, where, at each interaction the strength of outgoing waves is the same as in the exact solution but some error is present in the wave speeds. In this setting, it is possible to construct approximate solutions, in such a way that the total strength of all wave fronts becomes arbitrarily large. The result remains valid even with a uniformly positive gas density. (Received January 28, 2014)

1097-35-485 **Allen M. Tesdall*** (allen.tesdall@csi.cuny.edu), Department of Mathematics, College of Staten Island, City University of New York, Staten Island, NY 10314, and **Richard Sanders**. *Recent progress on irregular weak reflection.*

Recent experiments with shock tubes have led to suggestions that, under von Neumann paradox conditions, different reflection patterns may occur depending upon the particular set of parameters used. In particular, a four-wave pattern consisting of three shocks and an expansion fan at a single triple point, with a smooth supersonic patch behind the triple point, appears to occur in some experiments. In others, a sequence of triple points and supersonic patches occurs, as found in numerical solutions by the authors and coworkers. We study this possibility of multiple solution structures using high resolution numerical solutions. (Received January 28, 2014)

1097-35-489 **Roberto Triggiani*** (rtrggani@memphis.edu) and **Shitao Liu**. *An inverse problem for a third order PDE arising in high-intensity ultrasound: global uniqueness and stability by one boundary measurement.*

Both canonical recovery (inverse) problems of (i) uniqueness and (ii) stability are investigated for a third order (in time) PDE arising in high-intensity ultrasound, by means of just one boundary measurement performed on an appropriate portion of the boundary. Final results are expressed in terms of sharp assumptions on the data. Carleman estimates in Lasiecka-Triggiani-Zhang's work (2000) for second order hyperbolic equations are one of the key tools of this investigation. (Received January 28, 2014)

1097-35-491 **Roberto Triggiani*** (rtrggani@memphis.edu) and **Zhifei Zhang**. *Global uniqueness and stability in determining the electric potential of an inverse problem for the Schrodinger equation on a Riemannian manifold.*

We consider an inverse problem for a Schrodinger equation defined on an open, bounded, connected set of a complete n-dimensional Riemannian manifold, with non-homogeneous Dirichlet boundary conditions. The goal is to recover the electric potential by means of a Neumann boundary measurement on an explicit sub portion of the boundary. Both uniqueness and stability of the recovery are obtained in terms of sharp conditions on the data. A key ingredient of the investigation are the Carleman estimates in Triggiani-Xu (2007) of the Schrodinger equation on a Riemannian manifold. (Received January 28, 2014)

1097-35-492 **John V Matthews*** (matt-matthews@utc.edu), 615 Mccallie Avenue, Chattanooga, TN 37403-2598, and **Boris P Belinskiy** and **James W Hiestand**. *Heat equation; first eigenvalue of a Sturm-Liouville problem; and optimal design of a bar.* Preliminary report.

We minimize, with respect to the cross sectional area, the mass of a bar given the rate of heat transfer. The bar serves as an extended surface to enhance the heat transfer surface of a larger heated known mass to which the bar is attached. This paper is an extension of the previous authors' paper where heat transfer from the sides of the bar was neglected and only conduction through its length was considered. The rate of cooling is defined by the first eigenvalue of the corresponding Sturm-Liouville problem. We compare the mass of the bar with the mass for the bar of the same rate of heat transfer but of a constant cross-section area. (Received January 28, 2014)

1097-35-498 **Irena Lasiecka** (lasiecka@memphis.edu), Department of mathematical Sciences, University of Memphis, Memphis, TN 38152-3370, and **Xiaojun Wang*** (xwang13@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN. *Optimal decay rates for the energy in systems arising in nonlinear mechanic with memory effects.* Preliminary report.

We consider viscoelastic nonlinear plate equation with memory kernel quantified by the following differential inequality: $g' + H(g) \leq 0, s \geq 0$ where $ H(s)$ is a given continuous, positive, increasing, and convex function such that $H(0) = 0$. We shall show that the energy of the nonlinear PDE with viscoelasticity is driven by the same inequality. The results presented provide an uniform framework for obtaining optimal decay rates for the energy of nonlinear mechanical systems which contain memory effects. The study of PDE with a memory will be reduced to solving an appropriate nonlinear ODE systems. The method is based on the idea introduced in Lasiecka and Tataru ["Uniform boundary stabilization of semilinear wave equation with nonlinear boundary dissipation," Differential and Integral Equations 6, 507–533 (1993)]. (Received January 28, 2014)

1097-35-502 **Irena Lasiecka***, Department of Mathematical Sciences, University of Memphis, Memphis, TN , and **Philip Graber** (philip.graber@inria.fr), INRIA, Paris, France. *Gevrey class regularity for a strongly damped wave equation with hyperbolic dynamic boundary conditions.*

We consider a linear system of PDEs of the form

$$\begin{aligned} u_{tt} - c\Delta u_t - \Delta u = 0 \ &in\ \Omega \times (0,T) \\ u_{tt} + \partial_n(u + cu_t) - \Delta_\Gamma(c\alpha u_t + u) = 0 \ &on\ \Gamma_1 \times (0,T) \\ u = 0 \ &on\ \Gamma_0 \times (0,T) \end{aligned} \tag{1}$$

on a bounded domain Ω with boundary $\Gamma = \Gamma_1 \cup \Gamma_0$. We show that the system generates a strongly continuous semigroup $T(t)$ which is analytic for $\alpha > 0$ and of Gevrey class for $\alpha = 0$. In both cases the flow exhibits a regularizing effect on the data. In particular, we prove quantitative time-smoothing estimates of the form $\|(d/dt)T(t)\| \leq |t|^{-1}$ for $\alpha > 0$, $\|(d/dt)T(t)\| \leq |t|^{-2}$ for $\alpha = 0$. The argument is based on microlocalization in the boundary collar. Moreover, when $\alpha = 0$ we prove a novel result which shows that these estimates hold under relatively bounded perturbations up to 1/2 power of the generator. (Received January 28, 2014)

1097-35-520 **Radu C Cascaval*** (radu@uccs.edu). *Models for Flow Optimization and Control in Arterial Networks.* Preliminary report.

We describe a Boussinesq-type system for modeling the dynamics of pressure-flow in arterial networks, considered as a 1d spatial network. Numerical solutions of the system of PDEs are compared with simplified models based on particle-tracking arguments, and are used to study flow optimization task, depending on the geometry and size of the network. Physiologically realistic control mechanisms are also tested in the context of these simplified models. (Received January 28, 2014)

1097-35-527 **Jesus Rosado Linares*** (jesus.rosado.linares@gmail.com), 520 Portola Plaza, MS Building 6363, Los Angeles, CA 90095. *Effects of emotion in collective behavior models.*

Will review the derivation of a general kinetic model for swarming based in the three zones of interaction (attraction, alignmentn and avoidance) and extend it to describe the influence of emotional contagion between the individuals of the group. We will address both kind of models numerically, to gain insight on the asymptotic behavior of the system (Received January 29, 2014)

1097-35-529 **Mohammad Rammaha*** (mrammaha1@unl.edu), **Yanqiu Guo**, **Sawanya Sakuntasathien**, **Edriss Titi** and **Daniel Toundykov**. *Hadamard well-posedness for a hyperbolic equation of viscoelasticity with supercritical sources and damping.*

Let $\Omega \subset \mathbb{R}^3$ be a smooth bounded domain. We consider the following model of viscoelasticity:

$$\begin{cases} u_{tt} - k(0)\Delta u - \int_0^\infty k'(s)\Delta u(x,t-s)ds + g(u_t) = f(u), \quad \text{in } \Omega \times (0,\infty), \\ u(x,t) = 0, \quad \text{on } \Gamma \times \mathbb{R}, \\ u(x,t) = u_0(x,t), \quad \text{in } \Omega \times (-\infty, 0], \end{cases}$$

where u denotes a scalar component of the elastic deformation vector, g is a monotone feedback, and $f(u)$ is a source. The relaxation function $k(s)$ satisfies the typical conditions: $k(0), k(\infty) > 0$ and $k'(s) \leq 0$ for all $s > 0$. The memory term $\int_0^\infty k'(s)\Delta u(x,t-s)ds$ quantifies the viscous resistance and provides a weak form of energy dissipation. It also emphasizes the full past history as time goes to $-\infty$, as opposed to the finite-memory model where the history is taken only over the interval $[0,t]$.

We employ the theory of monotone operators and nonlinear semigroups, combined with energy methods to establish the existence of a unique local weak solution. In addition, it is shown that the solution depends continuously on the initial data, and is global provided the damping dominates the source in appropriate sense. (Received January 29, 2014)

1097-35-530 **Svetlana Roudenko***, Department of Mathematics, Washington, DC 20052. *Dynamics of blow up solutions in the 3d focusing NLS equation.*

We consider the focusing nonlinear Schroedinger equation with finite energy initial data in 3d (the mass-supercritical regime) and discuss the dynamics of the contracting sphere blow-up solution (joint work with Justin Holmer and Galina Perelman). Such blow-up solutions can have an arbitrary mass. (Received January 29, 2014)

37 ► Dynamical systems and ergodic theory

1097-37-21 **Ben R Hayes***, brh6@ucla.edu. *Metric Mean Dimension and Topological Entropy for Algebraic Actions of Sofic Groups.*

We consider actions of a countable discrete sofic group by automorphisms on a compact abelian group, these are called algebraic actions.

We relate the metric mean dimension and topological entropy of such actions to the L^2-invariants of the dual module. Specifically, we shall show that the metric mean dimension of this action is the von Neumann rank of the dual module, and in the case of principal actions we show that the topological entropy is related to Fuglede-Kadison detereminants.

This work partially extends results of Li-Thom and Li-Liang for the case of amenable groups. Lastly, we show that a complete analogue of the results of Li-Thom for computation of entropy is impossible, and that the Yuzvinskii addition formula must fail for some sofic groups. (Received November 30, 2013)

1097-37-59 **James T Campbell*** (jtcdyn@gmail.com), Department of Mathematical Sciences, Dunn Hall 373, Memphis, TN 38152, and **Jared T. Collins**. *Blowup points and baby Mandelbrot sets for a family of rational maps.* Preliminary report.

We discuss the dynamical behavior of the family of rational maps of the form

$$f_{d,\lambda}(z) = \lambda\left(z + \frac{1}{z^{d-1}}\right),\ d \geq 3,\ \lambda \in \mathbb{C}.$$

We make the useful observation that for fixed $d \geq 3$, this family is conjugate to the family of relaxed Newton maps for $p_d(z) = z^d - 1$. This allows us to move from one family to the other in order (if necessary) to find a simpler proof of each result, as well as establishing a dictionary of results from one family to the other. Among other things, we show that the parameter planes for these maps contain infinitely many copies of the Mandelbrot set, and infinitely many "blowup points", which are parameters for which the Julia set is the entire plane. (Received January 07, 2014)

1097-37-143 **Martin Schmoll*** (schmoll@clemson.edu). *Dynamics on Panov planes.* Preliminary report.

We report about the current state of ongoing research together with Chris Johnson. We consider complex planes equipped with a doubly periodic quadratic differential and the linear dynamics defined by those differentials. We use tools from topological dynamics and ergodic theory, in order to generalize some of our previous results. (Received January 18, 2014)

1097-37-213 **Dogan Comez** and **Semyon Litvinov*** (snl2@psu.edu), 76 University Drive, Hazleton, PA 18202. *On pointwise ergodic theorems for infinite measure.* Preliminary report.

For a positive $L^1-L^\infty-$contraction in the L^1-space of semifinite measure, we establish the pointwise convergence of general and Besicovitch weighted ergodic averages of functions in $\mathcal{L}^p$, $1 \leq p < \infty$. These results are extended to not necessarily positive operators as well. Also, Wiener-Wintner ergodic theorem is proved for the case of sigma-finite measure. (Received January 22, 2014)

1097-37-219 **Azer Akhmedov** (azer.akhmedov@ndsu.edu), Department of Mathematics, NDSU Department # 2750, PO Box 6050, Fargo, ND 58108-6050, and **Dogan Comez*** (dogan.comez@ndsu.edu), Department of Mathematics, NDSU Department #2750, PO Box 6050, Fargo, ND 58108-6050. *Good modulating sequences for the ergodic Hilbert transform.*

In this talk we will investigate the classes of bounded sequences of complex numbers that are universally good for the ergodic Hilbert transform in L_p-spaces, $2 \leq p \leq \infty$. The class of bounded Besicovitch sequences satisfying a rate condition is among such sequence classes. (Received January 22, 2014)

1097-37-237 **Jan P. Boronski*** (jan.boronski@osu.cz) and **Piotr Oprocha**. *Rotational chaos and strange attractors on the 2-torus.*

Veerman calls an attractor in an annulus strange if it has two orbits with different (rational) rotation numbers (the associated dynamics is then referred to as rotational chaos). The first example of a strange attractor dates back to the work of Birkhoff published in 1932. Roughly speaking, Birkhoff attractor is an attractor for a (properly chosen) map $f = (f_1, f_2)$ of the annulus which is dissipative and satisfies twist condition.

The name "strange attractor" was to some extent motivated by the fact that (Birkhoff) attractor with two different rotation numbers must be different from the circle, where the rotation number of a homeomorphism is always well defined and unique. By the result of Barge&Gillete from 1991, any such attractor must be indecomposable. Therefore probably the "strangest" attractor that can be expected is the pseudocircle, a peculiar fractal-like continuum constructed by R.H. Bing in 1951, which is hereditarily indecomposable. It is known that the pseudocircle occurs as an attracting minimal set for a C^∞-smooth planar diffeomorphism (Handel 1982), or as the boundary of a Siegel disk for a holomorphic map (Cheritat 2011). We show that the pseudocircle can also appear as a strange attractor, exhibiting rotational chaos, on the 2-torus. (Received January 23, 2014)

1097-37-305 **Sasa Kocic*** (skocic@olemiss.edu), Hume Hall 305, P.O.Box 1848, University, MS 38677-1848. *Generic rigidity of circle maps with breaks.*

We prove that C^r-smooth ($r > 2$) circle diffeomorphisms with a break, i.e., a single singular point where the derivative has a jump discontinuity, are generically not $C^{1+\varepsilon}$-rigid, for any $\varepsilon > 0$. That is, for almost all irrational $\rho \in (0,1)$, and every $\varepsilon > 0$, there is a pair of C^r-smooth circle diffeomorphisms with a break, with the same rotation number ρ and the same size of the break which are not $C^{1+\varepsilon}$-smoothly conjugate to each other. This result complements our recent proof (joint with K. Khanin) that such maps are generically C^1-rigid. It stands in remarkable contrast to the result of J.-C. Yoccoz that C^r-smooth circle diffeomorphisms are generically $C^{r-1-\varkappa}$-rigid, for any $\varkappa > 0$. (Received January 25, 2014)

1097-37-313 **Francis C. Motta** (motta@math.colostate.edu), 1874 Campus Delivery, Colorado State University, Fort Collins, CO 80523-1874, **Patrick D. Shipman*** (shipman@math.colostate.edu), 1874 Campus Delivery, Colorado State University, Fort Collins, CO 80523-1874, and **Bethany D. Springer** (springer@math.colostate.edu), Department of Mathematics, Regis College, 3333 Regis Boulevard, Denver, CO 80221. *Optimally Topologically Transitive Orbits of the Bernoulli Shift Map.*

We present a re finement of the notion of subset density for orbits of a discrete-time dynamical system on a metric space, which we think of as a measure of an orbit's approach to density. We consider first a motivating example: the family of rigid rotations $R_\theta : [0,1) \to [0,1)$ ($\theta \in (0,1)$) defined by $R_\theta(x) = (x+\theta) \bmod 1$. We then explore this notion for Bernoulli shifts on sequences over a finite alphabet, which leads to a connection to (infinite) de Bruijn sequences. (Received January 26, 2014)

1097-37-344 **Stewart Baldwin*** (baldwsl@auburn.edu), Department of Mathematics and Statistics, Auburn University, Auburn, AL 36849-5310. *Symbolic dynamics for the Julia set of $f_c(z) = z^n + c$, where $n > 2$ (preliminary report).*

Let J_c be the Julia set of the complex map $f_c(z) = z^n + c$. If J_c is locally connected, then there is a quotient map $q : \mathbb{S} \to J_c$ such that $f_c \circ q = q \circ g$, where $g(z) = z^n$ and $\mathbb{S}$ is the unit circle. If $n = 2$, the traditional approach to doing symbolic dynamics for f_c has been to use three symbols $\{0, 1, *\}$, with 0 and 1 coding the components of $\mathbb{S} \setminus \{d, -d\}$, where $d \in \mathbb{S}$ is a point such that $q(d)$ "corresponds to" c (in a way which can be made precise), and with $*$ being a "wild card" symbol coding the set $\{d, -d\}$.

In recent work, it was shown that for the case when $n = 2$ and J_c has an attracting periodic orbit, the symbolic dynamics of $f_c|J_c$ is more natural if two wild cards $\{*, \#\}$ are used instead, with $*$ coding d, and the new symbol # coding $-d$ [See *J. Fixed Point Theory Appl.* 7 (2010): 201-222]. As one might expect, the natural generalization of these results in the case where $n > 2$ is to use n wild cards, one coding a periodic point d of g, and each of the others coding a preperiodic element of $g^{-1}(g(d))$. However, there are certain differences between the cases $n = 2$ and $n > 2$ which keep the generalization from being routine. These complications will be discussed. (Received January 26, 2014)

1097-37-361 **Mrinal Kanti Roychowdhury*** (roychowdhurymk@utpa.edu), Dept of Mathematics, UTPA, 1201 West University Drive, Edinburg, TX 78539. *Quantization dimension of Gibbs-like measures.*

'Quantization' refers to the process of approximating the continuous set of values in the image data with a finite (preferably small) set of values. It is a process of approximation, and a good quantizer is one which represents the original signal with minimum loss of distortion. 'Quantization dimension' gives the speed how fast some specified measure of the error (also called the distortion or noise, between the quantized distribution and the original distribution) goes to zero as n goes to infinity. I will talk about the quantization dimension of a Gibbs-like measure μ_h supported by a cookie-cutter set E which is generated by a single cookie-cutter mapping f. (Received January 27, 2014)

1097-37-373 **Máté Wierdl*** (wierdlmate@gmail.com), dept of math sci, univ of memphis, memphis, TN 38152, and **Nikos Frantzikinakis** and **Emmanuel Lesigne**. *Random differences in Szemerédi's theorem on arithmetic progressions.*

Szemerédi's theorem on arithmetic progressions says that if a set A of positive integers has positive density, then for any ℓ, the set A contains an arithmetic progression $a, a + d, a + 2d, \ldots, a + \ell d$ of length $\ell + 1$. There has been considerable recent activity in trying to restrict the difference in this arithmetic progression to some specified set, like the set of squares $1^2, 2^2, 3^2, \ldots, n^2, \ldots$ or the set of "prime minus ones" $2 - 1, 3 - 1, 5 - 1, \ldots, p - 1, \ldots$.

In this talk, we examine the question of randomly generated differences, that is, when the difference of the arithmetic progression is restricted to some random set of integers. We give an exposition of recent progress and mention unsolved problems.

This is joint work with Nikos Fratzikinakis of Greece, and Emmanuel Lesigne, France. (Received January 27, 2014)

1097-37-381 **Eugen A Ghenciu*** (ghenciue@uwstout.edu) and **Mario Roy**. *Gibbs states for non-irreducible countable Markov shifts.*

We study Markov shifts over countable (finite of infinite) alphabets. In particular, we derive necessary and sufficient conditions for the existence of a Gibbs state for a certain class of infinite Markov shifts. (Received January 27, 2014)

1097-37-402 **Miaohua Jiang*** (jiangm@wfu.edu), PO BOX 7388, Department of Mathematics, Wake Forest University, Winston Salem, NC 27109. *Extension of Laminations into Foliations in Hyperbolic Systems.*

For uniformly hyperbolic systems of codimension one, We show that the local invariant stable or unstable laminations can be extended into differentiable foliations of open sets. This extension enables proofs of derivative formulas of the generalized SRB measure and its entropy, the root to the Bowen's equation, and the Hausdorff dimension of the hyperbolic set when the manifold is of dimension two. (Received January 27, 2014)

1097-37-470 **Joanna Furno*** (furnoj@dickinson.edu). *Haar Measures and Hausdorff Dimensions of Non-Archimedean Julia Sets.* Preliminary report.

Just as the Julia sets of some polynomials on the complex numbers are contained in bounded subintervals of the real line, the Julia sets of some polynomials on the p-adic numbers are contained in the p-adic integers, for a fixed prime p. First, I will give the Haar measures and Hausdorff dimensions for examples of such p-adic Julia sets. Then I will discuss the problems that arise when asking similar questions for more general p-adic Julia sets and possible solutions in Berkovich space. (Received January 28, 2014)

1097-37-473 **Karin Reinhold*** (reinhold@albany.edu), Department of Mathematics and Statistics, University at Albany SUNY, 1400 Washington Ave, Albany, NY 12054. *Convergence of random averages.* Preliminary report.

We study the convergence of weighted ergodic averages with weights given by non-stationary random variables. (Received January 28, 2014)

39 ► Difference and functional equations

1097-39-409 **Maxim Zinchenko*** (maxim@math.unm.edu). *CMV Matrices with Super Exponentially Decaying Verblunsky Coefficients.*

For the class of five diagonal unitary CMV matrices we establish one-to-one correspondences between the matrices with super exponentially decaying coefficients and the corresponding spectral data associated with the Jost solutions. (Received January 27, 2014)

41 ► Approximations and expansions

1097-41-471 **Alfredo N. Wetzel*** (wreagan@umich.edu), Department of Mathematics, 5080 East Hall, 530 Church Street, Ann Arbor, MI 48109, and **Peter D. Miller** (millerpd@umich.edu), Department of Mathematics, 5826 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Explicit Construction of the Direct Scattering Transform for the Benjamin-Ono Equation with Rational Initial Conditions.* Preliminary report.

The Benjamin-Ono (BO) equation describes the weakly nonlinear evolution of one-dimensional interface waves in a dispersive medium. It is an integrable system with a known inverse scattering transform and is often viewed as a prototypical problem for the study of multi-dimensional integrable systems and Riemann-Hilbert problems with a non-local jump condition. In this talk, we propose a construction for the scattering data of the BO equation with a rational initial condition, under mild restrictions. The construction procedure consists in building the Jost function solutions explicitly to recover from these the reflection coefficient, eigenvalues, and phase constants. For this class of initial conditions, all of these steps are explicit and the recovery of the scattering data can be done by using the analyticity properties of the Jost functions. We finish by showing that this procedure validates certain well-known formal results obtained in the zero-dispersion limit. This work can be seen as a significant extension of Kodama, Ablowitz, and Satsuma's who only considered specific Lorentzian initial conditions to obtain the location of the eigenvalues. (Received January 28, 2014)

42 ► Fourier analysis

1097-42-53 **Michael Goldberg*** (goldbeml@ucmail.uc.edu), Department of Mathematical Sciences, Universiy of Cincinnati, Cincinnati, OH 45221-0025. *Bochner-Riesz estimates for functions with vanishing Fourier transform.*

The Bochner-Riesz multipliers are characterized by a nonsmooth transition at the unit sphere, therefore one can expect better behavior when they are applied to functions whose Fourier transform vanishes on the unit sphere. We prove a range of improved $L^p \to L^q$ estimates in $\mathbf{R}^n$, $n \geq 2$, for Bochner-Riesz multipliers acting on such functions. The problem arises naturally in applications including the uniqueness of solutions to the Helmholtz equation, or the absence of embedded resonances for Schrödinger operators with potentials in $L^r(\mathbf{R}^n)$. (Received January 05, 2014)

1097-42-198 **A. Logunov**, **L. Slavin*** (leonid.slavin@uc.edu), **D. Stolyarov**, **V. Vasyunin** and **P. Zatitskiy**. *Weak integral conditions for BMO.*

We study the question of how much one can weaken the defining condition of BMO. Specifically, we show that if Q is a cube in $\mathbb{R}^n$ and $h : [0,\infty) \to [0,\infty)$ is such that $h(t) \underset{t\to\infty}{\longrightarrow} \infty$, then

$$\sup_{J \text{ subcube } Q} \frac{1}{|J|} \int_J h\big(\big|\varphi - \tfrac{1}{|J|}\textstyle\int_J \varphi\big|\big) < \infty \quad \Longrightarrow \quad \varphi \in \mathrm{BMO}(Q).$$

Under some additional assumptions on h we obtain estimates on $\|\varphi\|_{\mathrm{BMO}}$ in terms of the supremum above. We also show that even though the condition $h(t) \underset{t\to\infty}{\longrightarrow} \infty$ is not necessary for this implication to hold, it becomes necessary if one considers the dyadic BMO. (Received January 22, 2014)

1097-42-480 **Roza Aceska*** (roza.aceska@vanderbilt.edu), Vanderbilt University Dept. Mathematics, 1326 Stevenson Center Lane, Nashville, TN 37240. *Undersampled signals in hybrid-type evolutionary systems.*

We address the problem of spatiotemporal undersampling, in which an initial state f of an evolution process $f_t = A_t f$ is to be recovered from a combined set of coarse samples from varying time instances. At any fixed time instance t_i, the samples are insufficient for recovery of f. We present a new approach for processing time-variant signals within a hybrid-type of an evolutionary system with locally adapted smoothness. We formulate the dynamical sampling problem in this new setting, compensate for the insufficient spatial sampling density by utilizing samples obtained at different time levels and provide a perfect reconstruction. (Received January 28, 2014)

43 ► *Abstract harmonic analysis*

1097-43-38 **Costel P Peligrad*** (peligrc@ucmail.uc.edu), University of Cincinnati, Department of Mathematical Sciences, P.O. Box 45221-0025, Cincinnati, OH 45221-0025. *Minimal and outer actions of compact groups on operator algebras.* Preliminary report.

Let M be a von Neumann algebra and α an action of a compact group G on M . The action α is called minimal if it is faithful and the relative commutant of the fixed point algebra, $(M^\alpha)' \cap M$, is trivial. We study the relationship between the minimality of the dynamical system (M, α, G) and the outerness of the action and the dual co action. In case M is a C* algebra, α is called minimal if the relative commutant of M^α in the algebra of local multipliers, $\mathcal{M}_{loc}(M)$ of M is trivial. We describe several structural properties of the w^*-dynamical system that are equivalent to minimality and study the corresponding ones for the case of C*-dynamical systems.
(Received December 23, 2013)

1097-43-187 **Ryan Alvarado*** (rjamt9@mail.missouri.edu) and **Marius Mitrea**. *Hardy Spaces in Ahlfors-Regular Quasi-Metric Spaces.*

This talk focuses on the how the geometry of a given ambient can directly affect the amount of analysis the underlying space can support. To illustrate 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. More specifically, in the above context we will introduce Hardy spaces defined via a grand maximal function and prove that a rich H^p theory exists for an optimal range of p's, which depends on both the geometric and measure theoretic aspects of the ambient. The presented work is in collaboration with M. Mitrea. (Received January 21, 2014)

44 ► *Integral transforms, operational calculus*

1097-44-279 **Jarod Hart*** (jarod.hart@wayne.edu) and **Alessandro Monguzzi** (jarod.hart@wayne.edu). *A Biparameter Tb Theorem with an Application to Holomorphic Extension in $\mathbb{C}^2$.*

In this joint work with Alessandro Monguzzi, we prove a new Tb type boundedness criterion for biparameter Calderón-Zygmund operators. We use this Tb theorem to prove L^p bounds for a biparameter Cauchy integral transform defined on certain Lipschitz surfaces in $\mathbb{C}^2$ when $1 < p < \infty$. In this setting, the biparameter Cauchy integral transform plays the role that the biparameter Hilbert transform on the product upper half plane in $\mathbb{C}^2$. Consequently, we prove the following holomorphic extension result for appropriate Lipschitz surfaces $\Gamma \subset \mathbb{C}^2$: given $1 < p < \infty$ and an $L^p(\Gamma)$ function g defined on $\Gamma \subset \mathbb{C}^2$, we define a function G on $\mathbb{C}^2$ that is holomorphic away from Γ and agrees with g on Γ, in an appropriate limiting sense. Furthermore, $G(w) \to g(z)$ almost everywhere on Γ and in $L^p(\Gamma)$ as $w \in \mathbb{C}^2$ approaches $z \in \Gamma$. (Received January 24, 2014)

45 ► Integral equations

1097-45-359 **Gunduz Caginalp*** (caginalp@pitt.edu), **Xinfu Chen** and **Emre Esenturk**, , South Korea. *Phase Field Models: Macroscopic Anisotropy and Non-Local Models.*

Establishing the connection between macroscopic anisotropy and microscopic interactions is of both theoretical and practical interest. The phase field approach can be used in different ways in order to facilitate this link. One of these involves the use of integral equations, which also permits an understanding of non-local interactions. The technique allows one to derive macroscopic conditions at the interface from the microscopic potentials. Differential geometry and asymptotic analysis yield interface conditions in arbitrary spatial dimension. The interface condition can be expressed in various mathematical formulations, e.g., in terms of the principal curvature directions of the interface, or the second order directional derivatives of the interface and the Hessian of the surface tension. (Received January 27, 2014)

46 ► Functional analysis

1097-46-163 **Brent A Nelson*** (bnelson6@math.ucla.edu). *Free monotone transport without a trace.*

In their paper, "Free monotone transport," Guionnet and Shlyakhtenko solve a free analogue of the Monge-Ampère equation to produce a non-commutative analogue of Brenier's monotone transport theorem. One application of this result is that for sufficiently small $|q|$ the q-deformed free group factor $\Gamma_q(\mathbb{R}^n)$ is isomorphic to the free group factor $\Gamma(\mathbb{R}^n)$. By developing this theory in the non-tracial setting one can show that given a strongly continuous one-parameter group of orthogonal transformations U_t on $\mathbb{R}^n$ and sufficiently small $|q|$ the q-deformed free Araki-Woods factor $\Gamma_q(\mathbb{R}^n, U_t)$ is isomorphic to the free Araki-Woods factor $\Gamma(\mathbb{R}^n, U_t)$. In this talk we will give an overview of these results and outline the free probability methods used to obtain them. (Received January 20, 2014)

1097-46-170 **Dabrowski Yoann**, **Ken Dykema*** (kjd@tamu.edu), **Claus Koestler**, **Kunal Mukherjee** and **John Williams**. *Quantum symmetric states.*

The quantum symmetric states on the universal free product of a C*-algebra A with itself infinitely many times are the states that are invariant under the canonical co-actions of S. Wang's quantum permutation groups. By a variant of Koestler and Speicher's noncommutative de Finetti theorem, these are characterized terms of freeness over the tail algebra. We study some natural sets of quantum symmetric states, and show that they are Choquet simplexes. (Received January 20, 2014)

1097-46-172 **David Sherman*** (dsherman@virginia.edu). *Recent results on the model theory of II_1 factors.*

I will start with some background on the application of continuous model theory to tracial von Neumann algebras. Then I will present some analytic results based on logical theorems, and vice versa. Includes joint work with Ilijas Farah, Isaac Goldbring, and Bradd Hart. (Received January 20, 2014)

1097-46-186 **Vaughan F R Jones*** (vaughan.f.jones@vanderbilt.edu). *Unitary representations of the Thompson groups from planar algebras.* Preliminary report.

We will discuss the appearance of the Thompson groups as local scaling transformations in a preliminary attempt at a continuum limit for planar algebras. (Received January 21, 2014)

1097-46-196 **Teffera M Asfaw*** (teffera6@vt.edu), Department of Mathematics, Virginia Polytechnic Institute and State Univ, McBryde Hall 576, Blacksburg, VA VA 24061. *New surjectivity results for perturbed weakly coercive operators of monotone type in reflexive Banach space.* Preliminary report.

Let X be a real reflexive locally uniformly convex Banach space with locally uniformly convex dual X^*. Let $T : X \supseteq D(T) \to 2^{X^*}$ be maximal monotone and $S : X \to 2^{X^*}$ be bounded pseudomonotone. Let p be a nonnegative integer. Assume, further, that there exist nonnegative constants $a_i (i = 1, 2, ..., p)$ such that

$$< v^* + w^*, x > \geq -\sum_{i=1}^{p} a_i \|x\|^i - \alpha(\|x\|)\|x\|^{p+2}$$

for all $x \in D(T)$ with sufficiently large $\|x\|$, $v^* \in Tx$ and $w^* \in Sx$, where $\alpha : [0, \infty) \to [0, \infty)$ such that $\alpha(t) \to 0$ as $t \to \infty$. New surjectivity results are given for the operator $T + S$ along with weakly coercive type hypothesis on $T + S$. The results are new and improve the corresponding theory for coercive operators of monotone type. The theory developed herein can be suitably applied in the study of partial differential equations, variational and hemi-variational inequality problems in appropriate Sobolev spaces. To demonstrate the applicability of the theory, an example of time periodic parabolic partial differential equation, which models nonmonotone semipermeability problem, is provided. (Received January 21, 2014)

1097-46-210 **Kelly Bickel*** (kbickel3@math.gatech.edu) and **Greg Knese**. *Generalized Two Variable de Branges-Rovnyak Spaces.*

Let b be a holomorphic function mapping the unit disk to itself. Then the deBranges-Rovnyak space H(b): (1) is the state space of the minimal coisometric transfer function realization of b, (2) extends analytically past an open set of the torus iff b extends there with unit norm, and (3) is finite dimensional for rational inner b.

If b is a two-variable holomorphic function mapping the bidisk into the closed unit disk, one can still define a de Brange-Rovnyak space H(b) using the reproducing kernel definition. However, such H(b) spaces are too large to satisfy properties (1)-(3). In this talk, we introduce a class of pairs of Hilbert spaces associated to such b, which are obtained via Agler decompositions of b and are contained contractively in H(b). We will discuss a simple method constructing Agler decompositions of b and show that the resulting pairs of Hilbert spaces satisfy the two-variable generalizations of (1)-(3). (Received January 22, 2014)

1097-46-221 **Dietmar Bisch***, Vanderbilt University, Department of Mathematics, SC 1326, Nashville, TN 37240. *Infinite depth subfactors.* Preliminary report.

We will discuss various invariants for infinite depth subfactors which supplement the standard invariant. In particular, these give information on non-amenable, hyperfinite subfactors with trivial, i.e. Temperley-Lieb, standard invariant. (Received January 22, 2014)

1097-46-240 **Dietmar Bisch**, **Vaughan F.R. Jones** and **Zhengwei Liu*** (zhengwei.liu@vanderbilt.edu). *Singly generated planar algebras.*

The classification of singly generated planar algebras was initiated by Bisch and Jones. We will give complete classification of singly generated Yang-Baxter relation planar algebras which extends the former result. It involves three families of planar algebras, Fuss-Catalan, BMW, the subgroup E_{N+2} of quantum $SU(N)$. (Received January 23, 2014)

1097-46-306 **Jesse Peterson*** (jesse.d.peterson@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240, and **Andreas Thom**. *Character rigidity for special linear groups.*

A character on a group is a positive definite function which takes the identity to 1 and is constant on conjugacy classes. Characters on a finite group give an essential tool for understanding the representation theory of the group and motivated by this Thoma in 1964 initiated the study of characters on infinite groups. In 1966 Kirillov classified all characters on $SL_n(k)$ for k a field and $n > 2$. In my talk I will present the classification for $SL_2(k)$, as well as for SL_2 of rings of integers (and their localizations) with infinitely many units. I will also present some applications of these results. (Received January 25, 2014)

1097-46-434 **Michael Hinz*** (mhinz@math.uni-bielefeld.de) and **Alexander Teplyaev**. 1-*forms and vector fields on fractals.*

We survey some of our recent results on a vector analysis on fractals based on Dirichlet forms. They rely on the approach to generalized L_2-differential 1-forms by Cipriani and Sauvageot. It yields a feasible notion of first order derivation on fractal spaces carrying a Dirichlet form, what allows to study quasilinear scalar equations and vector equations (such as magnetic Schrödinger equations or Navier-Stokes systems). In particular, we will explain a new Hodge type theorem for topologically one-dimensional fractals. (Received January 27, 2014)

47 ► Operator theory

1097-47-58 **James E Tener*** (jtener@math.berkeley.edu). *Conformal nets and geometric conformal field theory.* Preliminary report.

We will introduce Graeme Segal's geometric description of a conformal field theory, and discuss the construction of the free fermion model. It is believed that Segal CFTs can be related to the operator algebraic notion of a conformal net of von Neumann algebras on the circle, but there is no general theory that makes this rigorous. However, we will discuss how we are able to make this connection precise in the free fermion model, and obtain the fusion of representations of conformal nets as a "unitary boundary value" of the geometric theory. (Received January 07, 2014)

1097-47-161 **John D. Williams*** (`jwilliams@math.tamu.edu`), Texas A&M, Dept. of Mathematics, Mail Stop 3368, College Station, TX 77843-3368. *Analytic Function Theory for Operator-Valued Free Probability.*

In this talk, we present recent results on the theory of analytic functions for operator-valued free probability. In particular, we prove classification results for the various non-commutative functions that arise as transforms associated to B-valued distributions. This allows us to study these objects from a function theoretic perspective and lead to new questions in the theory of analytic, vector-valued functions. (Received January 20, 2014)

1097-47-174 **Eva A. Gallardo-Gutierrez*** (`eva.gallardo@mat.ucm.es`), Departamento de Análisis Matemático, Facultad de Matemáticas, Universidad, Complutense de Madrid, Plaza de Ciencias 3, 28040 Madrid, Spain, and **Carl C. Cowen** (`ccowen@math.iupui.edu`), Department of Mathematical Sciences, Indiana University-Purdue University, Indianapolis, Indianapolis, IN IN 46202. *Rota's universal operators.*

The *Invariant Subspace Problem* for Hilbert spaces is a long-standing question and the use of universal operators in the sense of Rota has been one tool for studying the problem. The best known universal operators have been adjoints of analytic Toeplitz operators or unitarily equivalent to them. We present many examples of Toeplitz operators whose adjoints are universal operators and exhibit some of their common properties. Some ways in which the invariant subspaces of these universal operators interact with operators in their commutants are given. Special attention is given to the closed subalgebra, not always the zero algebra, of compact operators in their commutants. (Received January 21, 2014)

1097-47-236 **Shuaibing Luo** and **Stefan Richter*** (`richter@math.utk.edu`), Department of Mathematics, University of Tennessee, Knoxville, TN 37996. *Hankel operators on the Dirichlet space.* Preliminary report.

Let D denote the Dirichlet space of analytic functions f on the open unit disc $\mathbb{D}$ such that f' is square integrable over $\mathbb{D}$, and let S denote the Dirichlet shift, i.e. the operator defined on D by $Sf(z) = zf(z)$. An operator $A \in \mathcal{B}(D)$ is called a Hankel operator, if $AS = S^*A$. It is clear that the null space of a Hankel operator is invariant for S and the closure of its range is invariant for S^*.

We show that one recovers all invariant subspaces of S and S^* this way. This fact motivates the proof of the following analogue of a Bergman space result of Shimorin's: If for $n = 1, 2, \ldots$ $\mathcal{M}_n$ and $\mathcal{M}$ are non-zero S-invariant subspaces with projections P_n and P and extremal functions φ_n and φ, then $P_n \to P$ in the weak operator topology, if and only if $\varphi_n \to \varphi$ locally uniformly in $\mathbb{D}$. (Received January 23, 2014)

1097-47-243 **Matthew Fleeman*** (`mcfleema@mail.usf.edu`) and **Dmitry Khavinson**. *Extremal Domains for Self-Commutators in the Bergman Space.*

In recent work, Olsen and Reguera have shown that Putnam's inequality for the norm of self-commutators can be improved by a factor of $\frac{1}{2}$ for Toeplitz operators with analytic symbol φ acting on the Bergman space $A^2(\Omega)$. This improved upper bound is sharp when $\varphi(\Omega)$ is a disk. In this talk we show that disks are the only domains for which the upper bound is attained. (Received January 23, 2014)

1097-47-253 **Milivoje Lukic*** (`milivoje.lukic@rice.edu`). *Higher order Szegő theorems of arbitrary order.*

We study the relation between a probability measure $d\mu = w(\theta)d\theta + d\mu_s$ on the unit circle and its sequence of Verblunsky coefficients α. The CMV matrix determined by α has μ as its spectral measure, making this a spectral theoretic model closely related to Jacobi and Schrödinger operators.

Higher order Szegő theorems are equivalence statements relating integral conditions on $\log w$ with conditions on α; they can be viewed as statements about the absolutely continuous spectrum for slowly decaying sequences α. We will present a higher-order Szegő theorem for the case of a single critical point of arbitrary order. This is the first known result of this form in the regime of very slow decay, i.e. with ℓ^p conditions with arbitrarily large p. (Received January 24, 2014)

1097-47-273 **Greg Knese*** (`geknese@math.wustl.edu`), Washington University in St. Louis, Department of Mathematics, One Brookings Drive, Campus Box 1146, St. Louis, MO 63130. *Hilbert spaces associated to bounded analytic functions on the bidisk and applications to stable polynomials.*

We will discuss how recent results regarding Agler decompositions for bounded analytic functions on the bidisk can yield information about various classes of stable polynomials. In particular, Agler decompositions yield sums of squares formulas which yield determinantal representations for a special class of polynomials from optimization called hyperbolic polynomials. Recent work with J. Geronimo and P. Iliev as well as work with K. Bickel will play a key role. (Received January 24, 2014)

1097-47-310 **Ken Dykema** and **Anna Skripka*** (askripka@unm.edu). *Perturbation formulas for traces on normed ideals.*

We prove perturbation results for traces on normed ideals in semifinite von Neumann algebra factors. This includes the case of Dixmier traces. In particular, we establish existence of spectral shift measures and show that these measures can have singular components in the case of Dixmier traces. We also establish a linearization formula for a Dixmier trace applied to perturbed operator functions. (Received January 25, 2014)

1097-47-312 **Denis Potapov**, **Anna Skripka*** (askripka@unm.edu) and **Fedor Sukochev**. *Trace formulas for perturbations with resolvent differences in Schatten-von Neumann ideals.*

We obtain higher order trace formulas corresponding to perturbations such that the difference of the resolvents is in some Schatten-von Neumann ideal. This extends earlier results of Krein and Neidhardt obtained for trace class and Hilbert-Schmidt resolvent differences, respectively. (Received January 25, 2014)

1097-47-372 **Konstantin A Makarov*** (makarovk@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, and **Eduard Tsekanovskii**. *On the addition and multiplication theorems.*

We discuss the classes $\mathfrak{C}$, $\mathfrak{M}$, and $\mathfrak{S}$ of analytic functions that can be realized as the Livšic characteristic functions of a symmetric densely defined operator $\dot{A}$ with deficiency indices $(1,1)$, the Weyl-Titchmarsh functions associated with the pair $(\dot{A}, A)$ where A is a self-adjoint extension of $\dot{A}$, and the characteristic function of a maximal dissipative extension $\widehat{A}$ of $\dot{A}$, respectively. We show that the class $\mathfrak{M}$ is a convex set, both of the classes $\mathfrak{S}$ and $\mathfrak{C}$ are closed under multiplication and, moreover, $\mathfrak{C} \subset \mathfrak{S}$ is a double sided ideal in the sense that $\mathfrak{S} \cdot \mathfrak{C} = \mathfrak{C} \cdot \mathfrak{S} \subset \mathfrak{S}$. We introduce the concept of an operator coupling of two unbounded maximal dissipative operators and establish an analog of the Livšic-Potapov multiplication theorem for the operators associated with the function classes $\mathfrak{C}$ and $\mathfrak{S}$. We also show that the modulus of the von Neumann parameter characterizing the domain of $\widehat{A}$ is a multiplicative functional with respect to the operator coupling. (Received January 27, 2014)

1097-47-493 **Aaron Saxton*** (aaron.saxton@uky.edu). *Sub-Exponential Decay Estimates on Trace Norms of Localized Functions of Schrödinger Operators.*

In 1973, Combes and Thomas discovered a general technique for showing exponential decay of eigenfunctions. The technique involved proving the exponential decay of the resolvent of the Schrödinger operator localized between two distant regions. Since then, the technique has been been applied to several types of Schrödinger operators. Recent work has also shown the Combes–Thomas method works well with trace class and Hilbert–Schmidt type operators. In this talk, we build on those results by applying the Combes–Thomas method in the trace, Hilbert–Schmidt, and other trace-type norms to prove sub-exponential decay estimates on functions of Schrödinger operators localized between two distant regions. (Received January 28, 2014)

1097-47-510 **Jireh Loreaux*** (loreaujy@mail.uc.edu), University of Cincinnati, Department of Mathematical Sciences, 2600 Clifton Ave, Cincinnati, OH 45221, and **Gary Weiss**. *An infinite dimensional Schur-Horn Theorem for positive compact operators, the nonzero kernel case.*

The classical Schur-Horn Theorem relates the eigenvalues of a self-adjoint $n \times n$ matrix to the set of possible diagonals of such a matrix with respect to different orthonormal bases. In particular, it states that the diagonal of a self-adjoint matrix is majorized by the eigenvalues (repeated according to multiplicity). Conversely, any sequence majorized by the eigenvalue sequence appears as the diagonal with respect to an appropriate basis.

We prove an infinite dimensional Schur-Horn theorem for positive compact operators with infinite dimensional kernel, one of the two open cases posed by V. Kaftal and G. Weiss. In their paper, Kaftal and Weiss characterized the diagonals of operators in the unitary orbit of a positive compact operator when either the operator is of finite rank or has zero kernel. Here we show how the characterization problem depends on the dimension of the kernel when its range projection is infinite. The key tools are new kinds of majorization which we call p-majorization and approximate p-majorization. (Received January 28, 2014)

49 ► Calculus of variations and optimal control; optimization

1097-49-90 **Jiongmin Yong*** (jiongmin.yong@ucf.edu), 4000 Central Florida Blvd, Orlando, FL 32816. *Time-Inconsistent Optimal Control Problems.*

Classical optimal control problem is time-consistent, in the sense that an optimal control found for a given initial time and state will stay optimal thereafter. In real world, such kind of ideal situation hardly happens, if not completely impossible. There are at least two main reasons leading to time-inconsistency: people's time-preferences and risk-preferences. In this talk, we will briefly discuss these issues and will present some time-consistent equilibrium solutions to the time-inconsistent problems. (Received January 13, 2014)

1097-49-122 **Jingrui Sun*** (sjr@mail.ustc.edu.cn) and **Jiongmin Yong** (jiongmin.yong@ucf.edu). *Linear Quadratic Stochastic Differential Games: Closed-Loop Saddle Points.*

A linear quadratic stochastic two-person zero-sum differential game is considered. The controls for both players are allowed to appear in both drift and diffusion of the state equation. The weighting matrices in the performance functional are not assumed to be definite/non-singular. A necessary and sufficient condition for the existence of a closed-loop saddle point is established in terms of the solvability of a Riccati differential equation with *certain regularity*. It is possible that the closed-loop saddle point fails to exist, and at the same time, the corresponding Riccati equation admits a solution (which does not have needed regularity). Also, we will indicate that the solution of the Riccati equation may be non-unique. (Received January 16, 2014)

1097-49-128 **Philip Jameson Graber*** (jameson.graber@ensta-paristech.fr), 828 Boulevard des Marechaux, 91400 Palaiseau, France, and **Pierre Cardaliaguet**. *Mean field games of first order.*

Mean field game systems were introduced by Lasry and Lions in 2006-7 to describe differential games with large numbers of players. In this presentation we consider a system of mean field games with local coupling in the deterministic limit. Our first main result is the following: under general structure conditions on the Hamiltonian and coupling, we have existence and uniqueness of the weak solution, which is characterized as the minimizer of the optimal control of Hamilton-Jacobi and continuity equations. Our second main result is that the solution converges in the long time average to the solution of the associated ergodic problem. The results have potential applications to differential games as well as transport theory. (Received January 17, 2014)

1097-49-271 **Hem R Joshi*** (joshi@xavier.edu), 3800 Victory Parkway, Department of Mathematics and CS, Xavier University, Cincinnati, OH 45207-4441, and **Nicholas Clark**. *Highly Active Antiretroviral Therapy: Modeling and Optimizing HIV Treatment.* Preliminary report.

Highly active antiretroviral therapy (HAART) is the current standard treatment for the Human immunodeficiency virus (HIV).We will introduce an existing system of ordinary differential equations (ODEs) describing the interaction of the HIV virus with the human immune system. Then modify this system to incorporate variables representing typical HAART treatment with two different classes of drugs (reverse transcriptase and protease inhibitors). We will prove existence of an optimal control, find optimality condition, and solve the system numerically using a Runge-Kutta algorithm. We will illustrate numerical solution, discuss the uses and limitations of this type of biological models. (Received January 24, 2014)

1097-49-364 **Chun Liu*** (liu@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Title: Energetic Variational Approaches in Charge Transport.* Preliminary report.

Abstract: Almost all biological activities involve transport of charged ions in specific biological environments. In this talk, I will discuss a unified energetic variational approach developed specifically for these multiscale-multiphysics problems. I will discuss the relevant classical theories and relevant physical approaches and methods. I will focus on the mathematics, in particular the analytical issues arising from these studies. (Received January 27, 2014)

1097-49-423 **Elsa Schaefer*** (elsa@marymount.edu), 2807 North Glebe Road, Arlington, VA 22207. *Optimal Control for Models of Cholera: is more better?*

In recent years, researchers have considered a wide variety of models for cholera, a diarrheal disease which has a huge economic and human cost in developing nations. When choosing models to describe available disease data using traditional model-fitting criteria, a quite simple SIR + water/bacteria model is typically selected along with well-chosen spatial compartments. In this work, I consider several more complex models for cholera that reflect more of the mechanistic knowledge we have for the spread of disease through the population, as well as data-fitting techniques to choose parameter sets that allow each model to best describe the data. When optimal control theory is applied to these complex models, there is an opportunity to consider trade-offs in approaches for slowing the spread of cholera that more simple models cannot consider. However, does a lack of uniqueness in well-fitting n-tuples of unknown parameter values negate the potential value of these models? (Received January 27, 2014)

1097-49-468 **Rachel Leander***, MTSU Box 34, Murfreeesboro, TN 37132, and **Suzanne Lenhart** and **Vladimir Protopopescu**. *Using Optimal Control Theory to Identify Network Structures that Foster Synchrony.*

Network structure is known to influence a population's propensity to synchronize. We use optimal control theory to construct networks that allow heterogeneous populations to maintain high levels of synchrony, explore the relationship between population heterogeneity and the structure of the optimal networks, and identify salient optimal network features that may enhance synchrony. (Received January 28, 2014)

1097-49-488 **Michael R Kelly*** (mkelly14@utk.edu). *Optimal fishery harvesting on a nonlinear parabolic PDE in a heterogeneous spatial domain.* Preliminary report.

The overexploitation of fisheries has called for an improved understanding of spatiotemporal dynamics of resource stocks. One way to protect fish populations from overexploitation is the inclusion of no-take marine reserves, which prohibit the removal of natural resources from an area of the ocean. There has been previous work done on this subject, which sought after yield maximizing strategies without imposing these no-take reserves into the model. The question of whether the implementation of alternative boundary conditions, deemed more favorable to the fish stock, on a heterogeneous domain could produce an alternative optimal harvesting strategy. We use the tool of optimal control to investigate harvesting strategies for maximizing yield of a fish population in a heterogeneous, finite domain. We determine whether these solutions include no-take marine reserves as part of the optimal solution. The fishery stock is modeled using a nonlinear, parabolic partial differential equation with logistic growth, movement by diffusion and advection, and with Robin boundary conditions. The objective is to find the harvest rate that maximizes the discounted yield. Optimal harvesting strategies are found numerically. (Received January 28, 2014)

1097-49-517 **Donald Adongo*** (dadongo@murraystate.edu), Department of Mathematics and Statistics, Faculty Hall 6C, Murray, KY 42071, and **K. Renee Fister** and **Holly Gaff**. *Applications of Optimal Control to Rift Valley Fever.*

Rift Valley Fever (RVF) is a mosquito-born pathogen that infects primarily domestic animals. Humans have no immunity and get infected from exposure to both the infected animals and mosquitoes. A compartment model for the spread of RVF in mosquitoes and livestock populations is studied using optimal control techniques so as to minimize the total number of vaccinated animals at some given final time. An analysis for the optimal vaccination strategy is carried out for given low and high transmission parameters. Numerical results indicate the dependence of vaccination on the level of effectiveness of the protocol. It is important to note that the cost vaccines can be exorbitant in addition to consumers demanding products from vaccine free animals. (Received January 28, 2014)

51 ► Geometry

1097-51-11 **Aaron D Valdivia*** (avaldivia@flsouthern.edu), Florida Southern College, 111 Lake Hollingsworth Drive, Lakeland, FL 33801. *Asymptotic translation distance in the complex of curves.*

Gadre and Tsai proved asymptotic bounds for the asymptotic translation distance in the curves for closed surfaces. We will prove the same asymptotic bounds surfaces whose genus and punctures are given by g=rn for some rational number r. Furthermore we prove their conjecture about surfaces with fixed genus and arbitrary punctures. The later result is analogous to Tsai's result for the minimal dilatations of psuedo-Anosov mapping classes. (Received October 17, 2013)

1097-51-51 **Leonid V. Kovalev*** (lvkovale@syr.edu). *Bi-Lipschitz embedding of projective metrics.*

A metric on a convex subset of Euclidean space is called projective if line segments are unique geodesics. We give a sufficient condition for a projective metric to admit a bi-Lipschitz embedding into Euclidean space of the same dimension, with the standard metric. It remains unknown if every doubling projective metric can be embedded into a standard-metric Euclidean space by a bi-Lipschitz map. (Received January 03, 2014)

1097-51-83 **John Harvey*** (jharvey2@nd.edu). *Equivariant convergence of Alexandrov spaces.*
Perelman's celebrated stability theorem showed that if a sequence of compact Alexandrov spaces with a uniform lower curvature bound converges in the Gromov–Hausdorff sense to a compact Alexandrov space of the same dimension, then the objects in the tail of the sequence are homeomorphic to the limit.

That theorem is extended here to equivariant Gromov–Hausdorff convergence. If a fixed compact Lie group acts by isometries on each member of the sequence, and the sequence of actions is equicontinuous, then the objects in the tail of the sequence are equivariantly homeomorphic to the limit. (Received January 12, 2014)

1097-51-88 **Hung Lu*** (hlu@hpu.edu), 1188 Fort Street Mall, Honolulu, HI 96813, and **Michel L. Lapidus** and **Machiel van Frankenhuijsen**. *Minkowski measurability and tube formulas for p-adic fractal strings Minkowski measurability and exact tube formulas for p-adic self-similar fractal strings.*
We present an exact volume formula for the tubular neighborhood of a p-adic self-similar fractal string $\mathcal{L}_p$, expressed in terms of the underlying complex dimensions. The periodic structure of the complex dimensions allows one to obtain a concrete form for the resulting fractal tube formula. Moreover, we derive and use a truncated version of this fractal tube formula in order to show that $\mathcal{L}_p$ is not Minkowski measurable and obtain an explicit expression for its average Minkowski content. The general theory is illustrated by two simple examples, the 3-adic Cantor string and the 2-adic Fibonacci string. (Received January 13, 2014)

1097-51-136 **Christina Sormani*** (sormanic@member.ams.org). *Intrinsic Flat Arzela-Ascoli Theorems.*
We prove two Arzela-Ascoli Theorems: one for uniformly Lipschitz functions whose domains are converging in the intrinsic flat sense, and one for sequences of uniformly local isometries between spaces which are converging in the intrinsic flat sense. We prove a basic Bolzano-Weierstrass Theorem for sequences of points in such sequences of spaces. We prove that when a sequence of manifolds has a precompact intrinsic flat limit then the metric completion of the limit is the Gromov-Hausdorff limit of regions within those manifolds. See http://comet.lehman.cuny.edu/sormani/research/intrinsicflat.html for more information about intrinsic flat convergence. (Received January 17, 2014)

1097-51-200 **Serdal Sahin*** (sserdal433@gmail.com), Yildiz Technical University, Department of Mathematics, Davutpasa Campus, 34210 Istanbul, Turkey, and **Salim Yüce**, Yildiz Technical University, Department of Mathematics, Davutpasa Campus, 34210 , Turkey. *Higher Order Accelerations Under the Inverse One-Parameter Planar Hyperbolic Motion.*
In this talk firstly, we investigated the hyperbolic plane which is a geometric representation of the hyperbolic numbers (split-complex numbers, universal clifford algebra $\mathbb{R}^{1,0}$) similarly to comlex plane. Then, after a brief summary of one parameter planar hyperbolic motion and inverse one parameter planar hyperbolic motion we give higher order accelerations under inverse one parameter planar hyperbolic motion. (Received January 22, 2014)

1097-51-292 **Curtis Pro*** (cpro@math.toronto.edu). *Almost maximal volume.* Preliminary report.
We consider the class of Riemannian manifolds with a lower bound on sectional curvature, upper bound on diameter, and volume almost maximal. (Received January 25, 2014)

1097-51-337 **Raquel Perales*** (praquel@math.sunysb.edu), Department of Mathematics, Stony Brook University, Stony Brook, NY 11794. *Volumes and Intrinsic Flat Limits of Sequences of Manifolds with Boundary.*
We consider complete connected Riemannian manifolds with boundary assuming nonnegative Ricci curvature, area of the boundary bounded above and inward pointing mean curvature of the boundary bounded above. We prove a volume comparison theorem and a Laplacian comparison theorem for the function distance to the boundary. We apply these theorems to prove two intrinsic flat compactness theorems for sequences of such manifolds with uniform bounds. (Received January 26, 2014)

1097-51-384 **P Solorzano***, Department of Mathematics, UCR, 900 University Ave, Riverside, CA 92521. *Waning in homogeneous bundles.* Preliminary report.
Consider a transformation group (G, M) with G a compact Lie group. For any bi-invariant metric on G the Cheeger deformation induces a 1-parameter family of metrics on M that converge to the orbit space M/G.

Suppose further that the action is principal. The corresponding 1-parameter family of Sasaki metrics on TM is analyzed and its limit described in terms of the holonomy group of the normal homogenous space G/H. Examples include, but are not restricted to, connection metrics on principal G-bundles. (Received January 27, 2014)

1097-51-438 **Philip L. Bowers*** (bowers@math.fsu.edu), Department of Mathematics, FSU, Tallahassee, FL 32306, and **Ken Stephenson**, Department of Mathematics, University of Tennessee, Knoxville, TN 37996. *Determining the type of conformal tilings.*

The idea of *conformal tiling* grew out of the study of the finite subdivision rules introduced by Cannon, Floyd, and Parry in their investigation of the Cannon Conjecture in geometric topology. After presenting the main ideas behind conformal tiling and expansion complexes, we introduce the *type problem* that asks whether the conformal tiling associated to a planar polygonal complex tiles the hyperbolic or the Euclidean plane. Using the technology of conformal hierarchies of tilings, we show how to resolve the type problem for single tile type, dihedrally symmetric rules that generate conformal tilings and prove that type is constantly parabolic across the local isomorphism class of such a tiling. We report briefly on Dane Mayhook's recent generalization to rotationally symmetric rules that relaxes the *conformal* hierarchy to a *combinatorial* hierarchy and then applies ideas from Bowers-Stephenson to an associated fractal tiling due to Cannon-Floyd-Parry. If time permits, we end with some examples of hyperbolic tilings and some open problems. (Received January 27, 2014)

52 ► Convex and discrete geometry

1097-52-182 **Jeremiah Bartz*** (jbartz@fmarion.edu), Francis Marion University. *Multinets in $\mathbb{P}^2$ induced via cancellation.* Preliminary report.

Multinets are specific configuration of points and lines in $\mathbb{P}^2$ which play an important role in hyperplane arrangement theory. Few examples are known. Recently, a method for producing multinets from nets in $\mathbb{P}^3$ was identified. In this talk, multinets obtained using this method in the case involving a cancellation step are discussed. Several examples will be presented including multinets of odd degree. (Received January 21, 2014)

1097-52-327 **James Ashe***, jashe@jcsu.edu, Charlotte, NC. *Generalized branching in circle packing.*

Branching in circle packing is achieved by allowing a chain of circles to circuit around a mutual neighbor twice or more before closing up. As a triangulation has only finitely many locations to place the branch point, circle packing is unable to provide analogues of many analytical functions. To overcome this difficulty, a method involving continuous parameters called generalized branching is introduced. Using generalized branching, examples of previously unrealizable discrete functions in circle packing are illustrated and shown to computationally exist with the software package `CirclePack`. Furthermore the circle radii used in generalized branched packings are proven to exist and be unique. (Received January 26, 2014)

1097-52-378 **Clifford T. Taylor***, clifford.taylor@uky.edu. *Triangulations Induced by Lifting and Deleting.* Preliminary report.

Let k, $d > 0$ be fixed integers and let $\mathcal{Q} \subseteq \mathbb{R}^d$ be a collection of points which we lift into $\mathbb{R}^{d+1}$. We will assign to each k-subset of the points of $\mathcal{Q}$ a triangulation obtained by deleting the specified k-subset and projecting down the lower hull of the resulting lifting. Next, for each triangulation we form the characteristic vector outlined by Gelfand, Kapranov, & Zelevinsky by assigning to each vertex the sum of volumes of all adjacent simplices. We then form a vector for the lifting, which we call the GKZ vector, by summing the characteristic vectors. Lastly, we construct a polytope $\Sigma_k(\mathcal{Q}) \subseteq \mathbb{R}^{|\mathcal{Q}|}$ by taking the convex hull of all obtainable GKZ vectors by liftings of $\mathcal{Q}$, and note that $\Sigma_0(\mathcal{Q})$ is the secondary polytope. In this talk, we discuss the case where $k = d = 1$ and will prove that the GKZ vectors for two liftings match iff the corresponding induced triangulations match and that all distinct GKZ vectors are all extremal in $\Sigma_1(\mathcal{Q})$. We will also discuss the affine relationships satisfied by the GKZ vectors and outline a labeling method which will allow us to enumerate the vertices of $\Sigma_1(\mathcal{Q})$. (Received January 27, 2014)

53 ► Differential geometry

1097-53-7 **Rodrigo Ristow Montes*** (ristow@ufpr.br), Rua Amazonas 818 ap 32, Curitiba, Parana 80610030, Brazil. *Constant Contact Angle Surfaces in the Lorentz Group L^3.*

In this paper we establish the equation for the Gaussian Curvature and for the Laplacian of a constant mean curvature surface in the Lorentz Group $\mathbb{L}^3$. Using the Gauss equation we prove that constant mean curvature surfaces in $\mathbb{L}^3$ with constant contact angle have constant Gaussian curvature. Also, we provide a congruence theorem for constant mean curvature surfaces immersed in the Lorentz space $\mathbb{L}^3$ (Received September 03, 2013)

1097-53-33 **Benjamin Linowitz*** (linowitz@umich.edu), 530 Church Street, Ann Arbor, MI 48109, and **John Voight**, 6188 Kemeny Hall, Hanover, NH 03755. *The arithmetic of quaternion orders and isospectral hyperbolic surfaces.*

A well-known construction associates to an order in a quaternion algebra (defined over a totally real number field) a hyperbolic surface. In 1980 Vigneras used this construction in order to prove the existence of hyperbolic surfaces which were isospectral (have the same spectrum with respect to the Laplace-Beltrami operator) but not isometric. Key to Vigneras' method was a characterization of the values contained in the spectrum of an arithmetic manifold as embedding numbers of certain rank two commutative orders into quaternion orders. In this talk we will review the embedding theory of quaternion orders and show how the notion of "selectivity" may be used to construct isospectral hyperbolic surfaces of extremely small volume. We will further show that our examples have minimal volume amongst all isospectral hyperbolic surfaces arising from maximal arithmetic Fuchsian groups. This is joint work with John Voight. (Received December 19, 2013)

1097-53-67 **Xiaoyang Chen*** (xchen3@nd.edu). *A diameter rigidity theorem for Riemannian submersions.*

We will discuss a diameter rigidity theorem for Riemannian submersions from positively curved manifolds, which can be seen as a foliated version of the well-known S.Y. Cheng's maximal diameter theorem. (Received January 10, 2014)

1097-53-168 **Alexander Dranishnikov*** (dranish@math.ufl.edu), 1400 Stadium Rd, Gainesville, FL 32611. *On Gromov's scalar curvature conjecture.*

Gromov's conjecture states that the universal covering of a closed n-manifold with positive scalar curvature has macroscopic dimension $<$ n-1. We prove this conjecture for manifolds with the fundamental group G provided G is a virtual duality group and it satisfies the coarse Baum-Connes conjecture. (Received January 20, 2014)

1097-53-183 **Ricardo Mendes*** (mendes.2@nd.edu), 255 Hurley, Dept of Mathematics - U. of Notre Dame, Notre Dame, IN 46556, and **Renato Bettiol**. *Strongly positive sectional curvature and Thorpe's trick.*

(joint work with Renato Bettiol)

We consider a curvature condition for Riemannian manifolds that is stronger than positive sectional curvature (sec$>$ 0) and weaker than having positive-definite curvature tensor. We show that some familiar operations which preserve sec$>$ 0 in fact also preserve this stronger condition, such as Riemannian submersions and Cheeger deformations. We also investigate which of the currently known examples of metrics with sec$>$ 0 have in fact strongly positive curvature. In particular, we show that all homogeneous examples do, except for the Cayley plane and its flag manifold. (Received January 21, 2014)

1097-53-202 **Maree Jaramillo*** (maree@math.ucsb.edu). *Fundamental Groups of Spaces with Bakry-Emery Ricci tensor Bounded Below.*

The Bakry-Emery Ricci tensor is a natural extension of Ricci curvature on smooth metric measure spaces. Since topological and geometric information can be obtained for manifolds with Ricci curvature bounded from below, it is natural to ask if the same information holds true for smooth metric measure spaces with Bakry-Emery Ricci tensor bounded from below. Using Guofang Wei and Will Wylie's comparison theorems and an extension of Kevin Brighton's gradient estimate on smooth metric measure spaces, we extend the Almost Splitting Theorem of Cheeger-Colding to the smooth metric space setting. Using this Almost Splitting theorem, we show that the fundamental group of the smooth metric measure space with a lower bound on volume has almost abelian fundamental group. We also show that the number of generators of the fundamental group of a smooth metric measure space with Bakry-Emery Ricci tensor bounded from below is uniformly bounded. The results on the fundamental group are extensions of theorems which hold for Riemannian manifolds with Ricci curvature bounded from below. (Received January 22, 2014)

1097-53-256 **Barbara Herzog*** (barbara.herzog@doane.edu), Doane College, 1014 Boswell Avenue, Crete, NE 68333, and **Fred Wilhelm**. *Sub-Index for Critical Points of Distance Functions.*

Morse Theory is based on the idea that a smooth function on a manifold yields data about its topology. Specifically, Morse's Isotopy Lemma tells us that two sublevels are diffeomorphic provided there are no critical points between the corresponding levels. Further, the index of the Hessian constrains the change in homotopy type caused by a critical point.

Since Riemannian distance functions are not smooth everywhere, critical points and the Hessian cannot be defined in the usual way. In 1977 Grove and Shiohama created a definition of critical point for distance functions and used it to generalize Morse's Isotopy Lemma to this case. Their generalization had a profound impact on Riemannian geometry. However, without a definition of index, the remainder of Morse Theory cannot be generalized.

I will present a new notion, called sub-index, and show how to use it to gain information about the change in homotopy type caused by critical points of distance functions. (Received January 24, 2014)

1097-53-320 **Conrad Plaut***, Ayres Hall 227, University of Tennessee, Knoxville, TN 37996. *A New Topological Invariant and its Relation to Geometric Structures.* Preliminary report.

What we call "entourage covers" were essentially introduced by Berestovskii-Plaut in 2006, and include the δ-covers of Sormani-Wei. However, δ-covers depend on the metric, while entourage covers are a topological invariant of compact topological spaces. Not every covering map is an entourage cover: we show that any Peano continuum with a universal cover has only finitely many entourage covers. This topological invariant behaves unusually; e.g. if a X deformation retracts to A, X has "no fewer" entourage covers than A. Yet for example, the the double cover of a solid 2-torus is an entourage cover, but the double cover of the circle is not. So entourage covers can distinguish between these two spaces. Entourage covers are closely related to the geometric structures that a space can have. For example, the fact that the double cover of a solid 2-toris is an entourage cover derives from the fact that it may be metrized to Gromov-Hausdorff approximate $\mathbf{RP}^2$. Such geometric methods (including using recent work of Plaut-Wilkins on Gromov-Hausdorff convergence and covering maps) are useful to identify entourage covers, but we presently have no practical way to show that a given cover is not an entourage cover. (Received January 26, 2014)

1097-53-342 **Christine Escher*** (tine@math.orst.edu). *Diffeomorphism types of non-negatively curved manifolds.*

In this talk I will summarize joint work with Wolfgang Ziller. In contrast to the positive curvature setting, there exist comparatively many examples with non-negative sectional curvature. Hence it is natural to ask whether, among the known examples, it is possible to topologically distinguish manifolds with non-negative curvature from those admitting positive curvature. We study the topology of various sphere bundles over $\mathbb{C}P^2$ which admit a metric of non-negative sectional curvature. We then compare their diffeomorphism types with known examples of positively curved manifolds. I will also discuss a recent simplification of the homeomorphism invariants of such manifolds obtained jointly with Pongdate Montagantirud. (Received January 26, 2014)

1097-53-363 **Jeffrey S. Meyer*** (jmeyer@math.ou.edu), Jeffrey S. Meyer, Department of Mathematics, University of Oklahoma, Norman, OK 73019-3103. *Spectral geometry of totally geodesic submanifolds of arithmetic hyperbolic manifolds.*

To what extent do the totally geodesic submanifolds of a Riemannian manifold determine its geometry? In general this question is intractable, but the situation is very different when number theoretic techniques can be applied to analyze arithmetic locally symmetric spaces. A few years ago McReynolds and Reid used central simple algebras over number fields to answer this question for surfaces in arithmetic hyperbolic 3-manifolds, and very recently McReynolds generalized these arguments to, among other things, include the case of surfaces in products of arithmetic hyperbolic 2- and 3-manifolds.

In this talk, we will report on our recent work in which we used quadratic forms over number fields to answer this question for totally geodesic submanifolds of large classes of arithmetic hyperbolic n-manifolds, for $n \geq 4$. We will discuss the main theorems as well as the number theoretic tools of the theory of quadratic forms over number fields which allow for this geometric analysis. This presentation will be concrete and contain many motivating examples.

(Received January 27, 2014)

1097-53-408 **Kenneth S. Knox*** (kknox5@utk.edu). *The convergence theory of Riemannian manifolds with boundary under geometric bounds.*

After surveying some convergence theorems for compact Riemannian manifolds and compact Riemannian manifolds with boundary, we will discuss some new work on the convergence theory of Riemannian manifolds with boundary. As an application of the new convergence theory, we will discuss some 'geometric stability theorems' that can be thought of as generalizations of the classical rigidity theory associated to isometric immersions of surfaces into Euclidean space. (Received January 27, 2014)

1097-53-519 **Guy David** and **Marie Snipes***, snipesm@kenyon.edu. *A Non-Probabilistic Proof of the Assouad Embedding Theorem with Bounds on the Dimension.*

We give a non-probabilistic proof of a theorem of Naor and Neiman that asserts that if (E, d) is a doubling metric space, there is an integer $N > 0$, depending only on the metric doubling constant, such that for each exponent $\alpha \in (1/2, 1)$, one can find a bilipschitz mapping $F\colon (E, d^{\alpha}) \to \mathbb{R}^N$. (Received January 28, 2014)

54 ► General topology

1097-54-29 **Clement Boateng Ampadu*** (drampadu@hotmail.com), 31 Carrolton Road, Boston, MA 02132. *On a fixed point theorem in G-modular metric spaces in the sense of Ciric.*

Let X be a non-empty set, and $G_{[0,\infty)} : X \times X \times X \to [0, \infty)$ be a mapping. In this paper we introduce a notion of G-Modular metric spaces in the sense of Chistaykov [Modular metric spaces I: basic concepts, Nonlinear Analysis, vol. 74, pp. 1–14, 2010.], and use it to prove fixed point theorem for a quasi contractive mapping in the sense of Ciric. (Received December 12, 2013)

1097-54-368 **Fernando A Schwartz*** (fernando@math.utk.edu), 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 37996-1320. *Computational Topology and Geometry.*

In this talk I will describe how some techniques from topology and geometry can be applied to the analysis of large data sets. I will present real-world examples and discuss some of my current research projects in the area. (Received January 27, 2014)

55 ► Algebraic topology

1097-55-20 **Mustafa Hajij*** (mhajij1@lsu.edu), Louisiana State University, Dept. of Mathematics, Baton Rouge LA, LA 70808. *The colored Kauffman skein relation and the tail of the colored Jones polynomial.*

Using the colored Kauffman skein relation, we study the highest and the lowest $4n$ coefficients of the n^{th} unreduced colored Jones polynomial of alternating links. This gives a natural extension of the result by Kauffman in regard with Jones polynomial of alternating links and its highest and lowest coefficients. We use our techniques to give a new and natural proof for the existence of the tail of the colored Jones polynomial for alternating links. (Received November 27, 2013)

1097-55-318 **Nikolay Brodskiy*** (brodskiy@math.utk.edu), Department of Mathematics, The University of Tennessee, 227 Ayres Hall, Knoxville, TN 37996. *Creating and topologizing universal covering spaces.*

Classical theory of covering spaces works well for spaces with small loops being homotopically trivial (e.g. manifolds). With increasing interest in spaces with rich local structure (e.g. fractals), there have been various attempts of creating a more general theory of covering spaces. I will outline recent progress in the area. (Received January 26, 2014)

1097-55-348 **Jay Wilkins*** (leonard.wilkins@uconn.edu), University of Connecticut, Department of Mathematics, 196 Auditorium Rd. Unit 3009, Storrs, CT 06269-3009. *Universal Covers and the Critical Ultrametric on the Fundamental Group.*

I will discuss some recent results relating universal covers and the geometry and topology of associated fundamental groups of compact geodesic spaces. In particular, I will relate the existence of a universal cover to finite generation, finite presentability, and countability of the revised and uniform fundamental groups. These connections will be further related to the homotopy critical spectrum of Plaut-Wilkins and the covering spectrum of Sormani-Wei, the latter of whom first showed that the existence of a universal cover is equivalent to a finite covering/critical spectrum. Using these ideas, I will also introduce and discuss the critical pseudometric on the classical fundamental group, which is an ultra-pseudometric and an ultrametric on the revised fundamental group. Discreteness of the revised fundamental group in this metric is also equivalent to the existence of a universal cover. (Received January 26, 2014)

57 ► *Manifolds and cell complexes*

1097-57-32 **Joseph Maher*** (joseph.maher@csi.cuny.edu), **Vaibhav Gadre** and **Giulio Tiozzo**. *Statistics for geodesics in the modular surface and Teichmuller space.*

The coefficients in the continued fraction expansion of a real number are related to the behaviour of the corresponding geodesic ray in the upper half space model for hyperbolic space, and the distribution of coefficients depends on how you choose the real number, for example using Lebesgue measure, or from a random process on PSL(2,Z). We discuss how to generalize these well known results to Teichmuller space, the space of all hyperbolic metrics on a surface. (Received December 18, 2013)

1097-57-36 **Hongbin Sun*** (hongbins@math.princeton.edu), Mathematics Department, Princeton University, Fine Hall, Washington Road, Princeton, NJ 08540. *A Transcendental Invariant of Pseudo-Anosov Maps.*

For each pseudo-Anosov map, we will associate it with a $\mathbb{Q}$-submodule of $\mathbb{R}$. This invariant is defined by an interaction between the Thurston norm and the dilatation of pseudo-Anosov maps. We will develop a few nice properties of our invariant and give a few examples to show that our invariant can be nontrivial. These nontrivial examples give an answer to a question asked by McMullen: the minimal point of the restriction of the dilatation function on fibered face need not be a rational point. (Received December 19, 2013)

1097-57-37 **Sang-hyun Kim** and **Thomas Koberda***, Mathematics Department, PO Box 208283, New Haven, CT 06520-8283. *Anti-trees and right-angled Artin subgroups of planar braid groups.* Preliminary report.

We discuss a new result which shows that every right-angled Artin group quasi–isometrically embeds in a planar pure braid group. As a consequence, we obtain examples of quasi–isometrically embedded closed hyperbolic manifold subgroups of pure braid groups up to dimension eight. (Received December 20, 2013)

1097-57-40 **Shijie Gu*** (sgu@unr.edu), Davidson Math and Science Center DMS 314, 1664 N. Virginia Street, Reno, NV 89557-0084. *On the Shrinkable U.S.C. Decomposition Spaces of Spheres.*

Let G be a u.s.c decomposition of S^n, H_G denote the set of nondegenerate elements and π be the projection of S^n onto S^n/G. Suppose that each point in the decomposition space has arbitrarily small neighborhoods with $(n-1)$-sphere frontiers which miss $\pi(H_G)$, and such frontiers satisfies the Mismatch Property. Then this paper shows that this condition implies S^n/G is homeomorphic to S^n $(n \geq 4)$. This answers a weakened form of a conjecture asked by Daverman [3, p. 61]. In the case $n = 3$, the strong form of the conjecture has an affirmative answer from Woodruff [12]. (Received December 24, 2013)

1097-57-119 **Cody Armond** and **Oliver T. Dasbach***, Louisiana State University, Department of Mathematics, Baton Rouge, LA 70803. *The colored Jones polynomial and q-series identities.*

Various ways to compute the colored Jones polynomial for a given link give rise to combinatorial identities for q-series that one can extract from the colored Jones polynomial. We will discuss this for some classes of knots. (Received January 15, 2014)

1097-57-120 **Walter Neumann** and **Anastasiia Tsvietkova***, One Shields Ave, Davis, CA 95616. *Intercusp geodesics and the invariant trace field of hyperbolic 3-manifolds.* Preliminary report.

The invariant trace field is one of the most used tools in the study of hyperbolic manifolds from the number-theoretical point of view. It is often used to approach questions about commensurability and arithmeticity of manifolds. We will discuss how this number field is related to the intrinsic geometry of a cusped hyperbolic 3-manifold, and to intercusp geodesics in particular. This geometric perspective allows one to compute the invariant trace field of many hyperbolic link complements from their diagrams. This is a joint work with Walter Neumann, based on earlier joint work with Morwen Thistlethwaite. (Received January 15, 2014)

1097-57-121 **David G. Wright*** (wright@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602, and **Dennis Garity** and **Dušan Repovš**. *Contractible 3-manifolds that are the union of two Euclidean spaces.* Preliminary report.

David Gabai recently showed that the Whitehead manifold is the union of two submanifolds each of which is homeomorphic to $\mathbb{R}^3$ and whose intersection is homeomorphic to $\mathbb{R}^3$. We show that there are uncountably many contractible 3-manifolds with this property. We also show that there are uncountably many contractible 3-manifolds that fail to have this property. (Received January 16, 2014)

1097-57-166 **Thomas L. Thickstun*** (tt04@txstate.edu), Math Department, Texas State University, San Marcos, TX 78666. *The cell-like approximation theorem for Pontryagin surfaces.* Preliminary report.

Theorem (joint with Robert J. Daverman): Any cell-like self-map of the Pontryagin surface is approximable by homeomorphisms. (Received January 20, 2014)

1097-57-248 **Jack S Calcut*** (jcalcut@oberlin.edu), Department of Mathematics, Oberlin College, Oberlin, OH 44074. *Connected Sum at Infinity.*

The Connected Sum at Infinity operation (CSI), also called end sum, was introduced by Gompf to study exotic $\mathbb{R}^4$'s. It has been used by Ancel to study Davis manifolds and by Tinsley and Wright and by Myers to study 3-manifolds. After recalling the definition and basic properties of CSI, we will present a few of its applications and discuss its dependence on choices in dimension 4. The latter is joint work with Patrick Haggerty and answers affirmatively a conjecture of Siebenmann. Some open questions will be included. (Received January 23, 2014)

1097-57-249 **Dennis J. Garity*** (garity@math.oregonstate.edu) and **Dušan Repovš** (dusan.repovs@guest.arnes.si). *Homogeneity Groups of Ends of Open 3-Manifolds.*

For every finitely generated Abelian group G, we construct an irreducible open 3-manifold M_G whose end set is homeomorphic to a Cantor set and with end homogeneity group of M_G isomorphic to G. The end homogeneity group is the group of self-homeomorphisms of the end set that extend to homeomorphisms of the 3-manifold. This is the same as the embedding homogeneity group of the Cantor set. The techniques involve computing the embedding homogeneity groups of carefully constructed Antoine type Cantor sets made up of rigid pieces. In addition, a generalization of an Antoine Cantor set using infinite chains is needed to construct an example with integer homogeneity group. Results about local genus of points in Cantor sets and about geometric index are also used. (Received January 23, 2014)

1097-57-284 **Kun Wang*** (kwang@math.ohio-state.edu), 231 W 18th Ave, Columbus, OH 43210. *Group actions on CAT(0)-spaces and the Farrell-Jones conjecture.* Preliminary report.

In this talk, I will propose a new type of group actions, generalizing the notion of proper group actions. Many non-proper group actions on CAT(0)-spaces are of this type, typically stabilizers of these actions can be infinite. The motivation for the introduction of such actions arises from the study of the Farrell-Jones Conjecture for groups admitting "nice" but not necessary proper actions on CAT(0)-spaces. (The conjecture is known to be true for CAT(0)-groups by works of A. Bartels, W. Lueck and C. Wegner). I will then present some results obtained so far to show how this notion of group actions can be applied to the study of the Farrell-Jones conjecture. (Received January 24, 2014)

1097-57-290 **Pedro Ontaneda*** (marge@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University, Binghamton, NY 13902. *The Space of Nonpositively Curved Metrics of a Negatively Curved Manifold.*

Previously Tom Farrell and I proved that the space of negatively curved metrics on a closed negatively curved manifold M^n has infinitely many path-components, provided $n > 9$. Similar results were proved for some higher homotopy groups. In this talk we will show how to extend these results to the nonpositively curved case. This is joint work with Tom Farrell. (Received January 25, 2014)

1097-57-302 **Violeta Vasilevska*** (violeta.vasilevska@uvu.edu), 800 W University Parkway, Orem, UT 84058. *Hopfian Manifolds as Shape m_{simpl} Fibrators.* Preliminary report.

Shape $\mathrm{m}_{\mathrm{simpl}}$ fibrators are manifolds that can "detect" approximate fibrations in a "special" PL setting. In this talk, the shape $\mathrm{m}_{\mathrm{simpl}}$ fibrators properties of Hopfian manifolds and their products will be discussed. Additionally, particular types of Hopfian group will be introduced and their properties discussed. It will be shown how important these special groups are as fundamental groups of the shape $\mathrm{m}_{\mathrm{simpl}}$ fibrators discussed. (Received January 25, 2014)

1097-57-326 **Melissa L Macasieb*** (macasieb@math.umd.edu). *Knot groups generated by two conjugate elements.* Preliminary report.

We consider an infinite family of groups generated by two conjugate elements and show that such groups cannot be isomorphic to any known knot group. This family of groups is closely related to the well-known and well-understood family of 2-bridge knot groups. (Received January 26, 2014)

1097-57-339 **Boris Okun*** (okun@uwm.edu) and **Kevin Schreve** (kschreve@uwm.edu). *Action dimension and L^2-homology.* Preliminary report.

The Singer Conjecture states that L^2-homology of the fundamental group of an aspherical closed manifold vanishes except possibly in the middle dimension. The goal of this work is to obtain an equivalent statement, applicable to all groups.

The action dimension of a group G is is the least dimension of a contractible manifold which admits a proper G-action. A closely related notion, cocompact action dimension *ca-dim*(G), is the least dimension of a contractible manifold (possibly with boundary) which admits a proper cocompact G-action. The Action Dimension Conjecture states that L^2-homology of any group G vanishes above *ca-dim*$(G)/2$.

We prove that the Singer Conjecture and the Action Dimension Conjecture are equivalent. (Received January 26, 2014)

1097-57-353 **Denise M Halverson*** (halverson@math.byu.edu), 263 TMCB, Brigham Young University, Provo, UT 84602. *Paving the way to solving the R. L. Moore problem.*

The generalized version of the R.L. Moore problem asks to characterize spaces X such that $X \times \mathbb{R}$ is a manifold. This is a very important problem in geometric topology that is related other famous unsolved problems such as the Bink-Borsuk Conjecture and the Busemann Conjecture. An overview of the progress that has been made in this area, with particular emphasis on the contributions of Robert J. Daverman will be presented. (Received January 26, 2014)

1097-57-365 **F C Tinsley*** (ftinsley@coloradocollege.edu). *Characterizing ends of inward tame manifolds.* Preliminary report.

(joint with C R Guilbault) Our efforts to understand inward tame manifolds naturally has led us to consider an inward tame, one-ended manifold M^n with $n \geq 6$ that has a special nested sequence of neighborhoods of the end $(N_i, \partial N_i | i = 1, 2, \cdots, \infty)$ in which each inclusion $\partial N_i \hookrightarrow N_i$ induces a $\mathbb{Z}\pi_1(\partial N_{i-1})$-homology equivalence. We discuss the geometric structure of such ends and whether the Wall obstruction vanishes. (Received January 27, 2014)

1097-57-374 **Michael W. Davis**, **Jim Fowler*** (fowler@math.osu.edu) and **Jean-François Lafont**. *Aspherical manifolds that cannot be triangulated.*

Kirby and Siebenmann showed that there are manifolds that do not admit PL structures, and yet the possibility remained that all manifolds could be triangulated. Freedman showed that there are 4-manifolds that cannot be triangulated. Davis and Januszkiewicz applied a hyperbolization procedure to Freedman's 4-manifolds to get closed aspherical 4-manifolds that cannot be triangulated. But what about higher dimensions?

In the late 1970s, Galewski and Stern and independently, Matumoto, showed that non-triangulable manifolds exist in all dimensions > 4 if and only if homology 3-spheres with certain properties do not exist. Manolescu showed that there were no such homology 3-spheres, and hence non-triangulable manifolds exist in every dimension > 4.

By carefully applying a hyperbolization technique to the Galewski-Stern examples, we show, for all $n \geq 6$, that there exists a closed aspherical n-manifold which cannot be triangulated. (Received January 27, 2014)

1097-57-440 **Qayum Khan*** (qkhan@indiana.edu). *Classification of free actions of C_p on $S^1 \times S^n$.* Preliminary report.

Let p be an odd prime, and let $n \geq 3$ be an integer. We classify the set of equivariant homeomorphism classes of free C_p-actions on the product $S^1 \times S^n$ of spheres. The parameterization is expressed in terms of algebraic number theory.

The techniques are various applications of homotopy theory and surgery theory. The case of $p = 2$ was completed by B Jahren and S Kwasik in 2011. The new issues for the odd p case are the presence of nontrivial ideal class groups and a group of equivariant self-equivalences that has quadratic growth in p. (Received January 27, 2014)

1097-57-494 **Hyunshik Shin*** (hshin@math.gatech.edu). *Algebraic degrees of stretch factors in mapping class groups.*

Thurston showed that for a closed surface of genus g, pseudo-Anosov dilatation is an algebraic integer whose algebraic degree is bounded above by $6g-6$. In this talk, we will describe a construction of pseudo-Anosov maps whose dilatation is a special algebraic number, called a Salem number, with degree equal to $2g$. Our example also gives a new approach to a conjecture of Penner. (Received January 28, 2014)

1097-57-528 **Timothy A Schroeder*** (tschroeder@murraystate.edu), Faculty Hall 6C, Murray, KY 42071. *ℓ^2-Betti numbers and graph embeddings.*

Associated to any Coxeter system (W, S) is a labeled simplicial complex L, called the nerve of (W, S), and a complex Σ, called the Davis complex, on which W acts properly and cocompactly. Results and conjectures regarding the (reduced) ℓ^2-homology of Σ provide avenues along which to approach questions regarding embeddings of a graph. We explain this connection and describe a program for estimating the genus of a graph. (Received January 29, 2014)

58 ► Global analysis, analysis on manifolds

1097-58-49 **Krystyna Kuperberg*** (kuperkm@auburn.edu), 221 Parker Hall, Auburn University, Mathematics, Auburn, AL 36849. *Estimating the dimension of invariant sets in continuous dynamical systems.*

We describe a method of estimating Hausdorff dimension of invariant sets in continuous dynamical systems using flow boxes in a similar fashion as it is done in the box-counting method of Minkowski and Bouligand. (Received January 02, 2014)

1097-58-137 **Jorge Basilio*** (jorge.math.basilio@gmail.com) and **Christina Sormani** (sormanic@member.ams.org). *Limits of 3D Manifolds with Nonnegative Scalar Curvature.* Preliminary report.

Here we explore to what extent one may hope to preserve geometric properties of three dimensional manifolds with lower scalar curvature bounds under Gromov-Hausdorff and Intrinsic Flat limits. We introduce a new construction of three dimensional manifolds with positive scalar curvature called sewing. We produce sequences of such manifolds which converge to spaces demonstrating that rigidity theorems for manifolds with nonnegative scalar curvature fail to hold for these limits including the Scalar Torus Rigidity Theorem and the rigidity part of the Positive Mass Theorem. Since the notion of nonnegative scalar curvature is not strong enough to persist alone, we propose that one pair a lower scalar curvature bound with a lower bound on the area of a closed minimal surface when taking sequences as this will prevent the sewing of manifolds and possibly also the existence of counter examples. (Received January 17, 2014)

1097-58-201 **Ralph M Kaufmann*** (rkaufman@math.purdue.edu), Purdue, Department of Mathematics, West Lafayette, IN 47907, **Birgit Wehefritz-Kaufmann**, Purdue, Department of Mathematics, West Lafayette, IN 47907, and **Sergei Khlebnikov**, Purdue, Department of Physics, West Lafayette, IN 47907. *Singularities, swallowtails and topological properties in families of Hamiltonians,.*

We discuss the results of our joint work on families of Hamiltonians. In particular, we describe a characteristic map to the unfolding of an A-type singularity which allows one to characterize the singularities in the spectrum. The motivation comes from a concrete material and its effective C^*-geometry.

We also comment on further new developments like symmetries and non-commutative aspects. (Received January 22, 2014)

60 ► Probability theory and stochastic processes

1097-60-4 **Jaykov Foukzon*** (jaykovfoukzon@list.ru). *The Solution Classical Feedback Optimal Control Problem for m-Persons Differential Game with Imperfect Information.* Preliminary report.

The paper presents a new approach to construct the Bellman function v(t,x) and optimal control u(t,x) directly by way of using strong large deviations principle for the solutions Colombeau-Ito's SDE. The generic imperfect dynamic models of air-to-surface missiles are given in addition to the related simple guidance law. A four examples have been illustrated, corresponding numerical simulations have been illustrated and analyzed. Open Journal of Optimization, Vol. 2 No. 1, 2013, pp. 16-25. doi: 10.4236/ojop.2013.21003. (Received May 04, 2013)

1097-60-17 **Parisa Fatheddin*** (fatheddin@math.utk.edu), 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 37996-1320, and **Jie Xiong** (jxiong@math.utk.edu), 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 37996-1320. *Large and Moderate Deviations for a Class of SPDEs.*

A class of stochastic partial differential equations (SPDEs) with non-Lipschitz coefficients will be introduced and its application to two commonly studied population models will be noted. I will discuss our method to achieve large and moderate deviation principles for this class and how we dealt with its non-Lipschitz property. (Received November 20, 2013)

1097-60-42 **Yimin Xiao*** (xiao@stt.msu.edu), 619 Red Cedar Road, Michigan State University, East Lansiing, MI 48824. *Local Nondeterminism and Sample Path Properties of Stable Random Fields.* Preliminary report.

We show that several classes of α-stable random fields $X = \{X(t), t \in \mathbb{R}^N\}$ have the property of local nondeterminism (LND). For the case of $0 < \alpha < 1$ and X being the harmonizable fractional stable motion, our result with Antoine Ayache (2013) solves an open problem in Nolan (1989). As applications of LND, we study fractal properties of these stable random fields. (Received December 26, 2013)

1097-60-48 **Yan-Xia Ren** (yxren@math.pku.edu.cn), School of Mathematical Sciences, Peking University, Beijing, 100871, Peoples Rep of China, **Renming Song*** (rsong@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801, and **Rui Zhang**, School of Mathematical Sciences, Peking University, Beijing, 100871, Peoples Rep of China. *Central limit theorems for supercritical branching Markov processes.*

In this talk I will present some recently established spatial central limit theorems for a large class of supercritical branching Markov processes with general spatial-dependent branching mechanisms. These results are generalizations of the spatial central limit theorems proved in Adamczak and Milos (2011) for branching OU processes with binary branching mechanisms. Compared with the results of Adamczak and Milos (2011), our central limit theorems are more satisfactory in the sense that the normal random variables in our theorems are non-degenerate. Moreover, we also find the covariance structure of the limiting Gaussian field. (Received January 02, 2014)

1097-60-65 **Florence Merlevède** and **Magda Peligrad*** (peligrm@ucmail.uc.edu), Department of Mathematical Sciences, University of Cincinnati, PoBox 210025, Cincinnati, OH 45215, and **Marwa Banna**. *On the universality of the limiting spectral distribution for a large class of random matrices with correlated entries.*

We develop a method for studying the eigenvalue distribution for a nxn symmetric matrix with dependent entries. The technique is based on a blend of blocking procedure and Lindeberg's method. For a large class of random matrices with correlated entries, which are functions of independent random variables, we show that the asymptotic behavior of the empirical spectral distributions can be obtained by analyzing a Gaussian matrix with the same covariance structure. This method leads to a variety of interesting asymptotic results for matrices with dependent entries, including applications to linear processes as well as nonlinear Volterra-type processes entries. (Received January 09, 2014)

1097-60-85 **Paul H. Jung***, 1300, University Blvd., Birmingham, AL 35294. *Lévy-Khnitchine random matrix ensembles and Poisson weighted infinite forests.*

We study a class of random matrices which includes and generalizes Wigner matrices, heavy-tailed random matrices, and sparse random matrices such as the adjacency matrices of Erdös-Reényi random graphs with $p_n = \frac{1}{n}$. Our $n \times n$ random matrices have entries which are i.i.d. up to symmetrization. The distributions may depend on n, however, the sums of rows must converge in distribution; it is then well-known that the limiting distributions are infinitely divisible. We prove the existence of a limiting spectral distribution (LSD) for ensembles in this class by using the Stieltjes transform in combination with Aldous and Steele's local weak convergence theory. We show that the limiting spectrum corresponds to the spectral measure at the root of a Poisson weighted infinite forest. This graph is formed by connecting, in a certain fashion, infinitely many Poisson weighted infinite trees. This representation of the LSD allows one to see that its Stieltjes transform satisfies a recursive distributional equation. One particular case covered by our results are matrices with i.i.d. entries having infinite second moment, but in the domain of attraction of a Gaussian distribution. Our results show that in this case the limiting spectrum is the Wigner semi-circle law. (Received January 12, 2014)

1097-60-86 **Michael Grabchak*** (mgrabcha@uncc.edu), Department of Mathematics and Statistics, 9201 University City Blvd, Charlotte, NC 28223. *Properties of tempered stable distributions.*

Tempered stable distributions were introduced in Rosiński (2007) as models that look like infinite variance stable distributions in some central region, but they have lighter (i.e. tempered) tails. Such models have found applications in a variety of areas including mathematical finance, biostatistics, computer science, and physics. We extend this class to allow for more variety in the tails. While some cases no longer correspond to stable distributions they serve to make the class more flexible, and in certain subclasses they have been shown to provide a good fit to data. To characterize the possible tails we give detailed results about finiteness of various moments. We also give necessary and sufficient conditions for the tails to be regularly varying. This last part allows us to characterize the domain of attraction to which a particular tempered stable distribution belongs. We then characterize the weak limits of sequences of tempered stable distributions. (Received January 12, 2014)

1097-60-131 **Shui Feng*** (shuifeng@univmail.cis.mcmaster.ca). *Conditional Total Frequency Counts of the Ewens-Pitman Model.*

In this talk we generalize some existing non conditional asymptotic results for the Ewens-Pitman model to conditional setting. Specifically, given an initial sample from the model, we establish conditional fluctuation limits and conditional large deviation principles for the number of blocks generated by a large additional sample. This is a joint work with Stefano Favaro. (Received January 17, 2014)

1097-60-157 **Amarjit Budhiraja*** (budhiraj@email.unc.edu), 357 Hanes Hall, CB# 3260, Chapel Hill, NC 27599, and **Paul Dupuis** and **Arnab Ganguly**. *Moderate Deviations Principles for Stochastic Dynamical Systems.*

We consider stochastic differential equations with jumps in finite and infinite dimensions. Moderate deviations principles are obtained for the process centered by the law of large numbers limit with suitable scaling, as the jump rates approach infinity and jump sizes approach zero. The key ingredient in the proofs is a variational representation for positive functionals of a Poisson random measure. This is joint work with P. Dupuis and A. Ganguly. (Received January 20, 2014)

1097-60-164 **Yuri Bakhtin** (bakhtin@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332, and **Andrzej Swiech*** (swiech@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332. *Scaling limits for conditional diffusion exit problems, and asymptotics for nonlinear elliptic equations.*

We present a PDE approach to scaling limits for conditional diffusion exit problems. It is based on Doob's h-transform and new asymptotic convergence gradient estimates for nonlinear elliptic equations that allow to reduce the problem to a known case. The results describe a class of situations where conditioning on exit through unlikely locations leads to a Gaussian scaling limit for the exit distribution. This supplements the large deviation principle of the Freidlin–Wentzell theory on exit problems for diffusion processes with results of classical central limit theorem kind. (Received January 20, 2014)

1097-60-191 **Yizao Wang***, 2815 Commons Way, Department of Mathematical Sciences, Ci, OH. *Weak convergence to the maximum process of fractional Brownian motion with shot noise.*

We consider the maximum process of a random walk with heavy-tailed noise. The random walk may have stationary increments, but its sample path is assumed to converge weakly to a fractional Brownian motion. When the largest noise has the same magnitude of the maxima of the random walk, we establish an invariance principle for the maximum process in the Skorohod topology. The limiting process is the maximum process of the fractional Brownian notion with shot noise generated by Poisson point processes. (Received January 21, 2014)

1097-60-204 **Yaozhong Hu*** (yhu@ku.edu), Department of Mathematics, University of Kanasas, Snow Hall 405, Lawrence, KS, and **Jingyu Huang**, **David Nualart** and **Samy Tindel**. *Multiplicative stochastic heat equations driven by general Gaussian noises and intermittency.*

We present some results on linear stochastic heat equations with very general Gaussian multiplicative noises. The existence and uniqueness, Feynman-Kac formulas for the solutions or Feynman-Kac formulas for the moments of the solutions are established. They are applied to obtain Hölder continuity of the solution and the sharp exponential rate of the moments of the solutions. (Received January 22, 2014)

1097-60-224 **Tobias Hurth*** (thurth3@gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332. *Invariant densities for piecewise deterministic Markov processes.*

Consider a finite family of smooth vector fields on a finite-dimensional smooth manifold M. We fix one of the vector fields along with a starting point on M and follow the induced trajectory for an exponentially distributed random time. Then, we randomly switch to a different vector field and, starting at the point where the switch occurred, follow the corresponding trajectory for another random time. Iterating this construction defines a stochastic process X on M to which we adjoin a process A that keeps track of the driving vector fields. The two-component process (X,A) is Markov. In the talk, we explain how a Hoermander-type hypoellipticity condition along with a reachability condition lead to absolute continuity and uniqueness of its invariant measure. In the one-dimensional case, we also present asymptotics for the invariant densities near critical points of the vector fields. This is joint work with Yuri Bakhtin. (Received January 22, 2014)

1097-60-229 **Wlodek Bryc*** (brycw@math.uc.edu) and **Jacek Wesolowski**. *Evolutions of polynomials generated by quadratic harnesses.*

Quadratic harnesses are Markov processes with linear regressions and quadratic conditional variances under the two-sided conditioning. In general, quadratic harnesses are nonhomogeneous Markov processes with transition probabilities $P_{s,t}(x, dy)$ that can become negative when x falls outside of the time-dependent set $U_s \subset \mathbb{R}$ that consists of a nonempty interval and some isolated points. Thus transition operators are not well defined. On the other hand, under mild technical assumptions quadratic harnesses have polynomial conditional moments $E(X_t^n|X_s)$ for $s < t$ which induce a family of linear operators that act on polynomials.

The family of linear operators on polynomials with composition as multiplication is isomorphic to an algebra of sequences of polynomials which can be studied by purely algebraic means. Markov property then induces an "evolution" in this algebra and one can consider infinitesimal generators of this evolution. We relate the infinitesimal generator for evolutions induced by quadratic harnesses to the unique solution of a certain algebraic commutation equation. We then use this equation to find the infinitesimal generators that correspond to a special class of quadratic harnesses. (Received January 23, 2014)

1097-60-233 **N. H. Du**, **N. H. Dang** and **G. Yin*** (gyin@math.wayne.edu). *Some Recent Results on Certain Stochastic Predator-Prey Models.* Preliminary report.

We study stochastic predator-prey systems. The main effort focuses on asymptotic properties. We obtain sufficient and almost necessary conditions for permanence and ergodicity of the stochastic predator-prey models with Beddington-DeAngelis functional response. Both non-degenerate and degenerate diffusions are considered. One of the distinctive aspects of this work is that it characterizes the support of a unique invariant probability measure. (Received January 23, 2014)

1097-60-239 **Paul H Bezandry*** (pbezandry@howard.edu), 2441 6th Street, NW, Washington, DC 20059. *On the existence of almost automorphc solutions of nonlinear Volterra stochastic difference equation.*

In this talk, we introduce a concept of almost automorphy for random sequences. Using the Banach contraction principle, we establish the existence and uniqueness of an almost automorphic solution to some Volterra stochastic difference equation in a Banach space. Our main results extend some known ones in the sense of mean almost automorphy. As an application, almost automorphic solution to a concrete stochastic difference equation is analyzed to illustrate our abstract results. (Received January 23, 2014)

1097-60-247 **Olav Kallenberg*** (kalleoh@auburn.edu). *Some invariance properties involving stochastic integrals with respect to Lévy and related processes.* Preliminary report.

Stochastic integrals with respect to general Lévy processes have been studied intermittently for at least 60 years. In this talk, I will discuss some classical and more recent invariance properties of such and related integrals, involving various notions of random time change and decoupling. (Received January 23, 2014)

1097-60-254 **Magda Peligrad** (peligrm@mail.uc.edu) and **David Barrera*** (barrerjd@mail.uc.edu), Department of Mathematical Sciences, 4199 French Hall West, 2815 Common Way, Cincinnati, OH 45221-0025. *Quenched Limit Theorems for Fourier Transforms and Periodogram.*

We show that the Fourier transform of a stationary ergodic process, suitable centered and normalized, satisfies the quenched CLT conditioned by the past sigma algebra. For functions of Markov chains with stationary transitions this means that the CLT holds with respect to the law of the chain started at a point for almost all starting points.

We also discuss necessary and sufficient conditions for the validity of quenched CLT without centering. The results are highly relevant for the study of the periodogram of a Markov process with stationary transitions which does not start from equilibrium. The proofs are based on a blend of harmonic analysis, theory of stationary processes, martingale approximation and ergodic theory. (Received January 24, 2014)

1097-60-258 **Kei Kobayashi*** (kkobayas@utk.edu). *SDEs driven by a time-changed Lévy process and associated fractional order Kolmogorov-type equations.*

It is known that the transition probabilities of Brownian motion satisfy the associated forward Kolmogorov equation, which is a diffusion equation involving a first-order time derivative. In many applications, however, Kolmogorov-type equations with fractional order time derivatives are employed to model "subdiffusive" behaviors, where particles diffuse more slowly than Brownian motion predicts. Such anomalous phenomena suggest the use of time changes, where the simplest time change to be considered is the hitting time process of a stable subordinator. In this talk, we will see a connection between a class of SDEs driven by a time-changed Lévy process and a class of Kolmogorov-type equations involving fractional order time derivatives. (Received January 24, 2014)

1097-60-266 **Markus Riedle*** (markus.riedle@kcl.ac.uk), Department of Mathematics, King's College London, Strand, London, WC2R 2LS, United Kingdom, and **David Applebaum** and **Adam Jakuboswki**. *Cylindrical Lévy processes in Banach spaces and Hilbert spaces.*

The objective of this talk is the introduction of cylindrical Lévy processes and their stochastic integrals in Hilbert spaces.

The degree of freedom of models in infinite dimensions is often reflected by the request that each mode along a dimension is independently perturbed by the noise. In the Gaussian setting, this leads to the *cylindrical Wiener process* including from a model point of view the very important possibility to model a Gaussian noise in both time and space in a great flexibility (space-time white noise). Up to very recently, there has been no analogue for Lévy processes.

Based on the classical theory of cylindrical processes and cylindrical measures we introduce *cylindrical Lévy processes* as a natural generalisation of cylindrical Wiener processes. In Hilbert spaces we introduce a stochastic integral for operator-valued stochastic processes with respect to cylindrical Lévy processes. We apply the developed theory to derive the existence of a solution for a Cauchy problem and to consider spatial and temporal regularity and irregularity properties of the solution.

(parts of this talk are based on joint work with D. Applebaum or A. Jakubowski) (Received January 24, 2014)

1097-60-294 **P. Sundar*** (sundar@math.lsu.edu), Department of Mathematics, Lockett Hall, Louisiana State University, Baton Rouge, LA 70803. *Stochastic Navier-Stokes equations in exterior domains.*

The system of equations that models velocity of viscous, incompressible fluid flow in exterior domains plays a major role in fluid dynamics. Stochastic Navier-Stokes and related equations in exterior domains will be introduced, and their solvability will be established under suitable conditions on the noise term. The probabilistic behavior of solutions of such SPDEs will be studied. (Received January 25, 2014)

1097-60-300 **James Keesling*** (kees@ufl.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611-8105, **Louis Block** (block@ufl.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611-8105, and **Jo Ann Lee** (joann5@ufl.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611-8105. *Putting Hyperbolic Toral Automorphisms to Good Use.*

Let $M : T^n \to T^n$ be a hyperbolic toral automorphism. It is well-known that there is a Markov partition of T^n for M. The Markov partition can be associated with a tiling of R^n by self-affine tiles. We propose a way to use the Markov partition to produce a practical random-number generator. (Received January 25, 2014)

1097-60-329 **Brent Bundick** and **Yong Zeng*** (zengy@umkc.edu). *Real-time Stochastic Volatility Estimation via Filtering Equation of a Partially-Observed Heston Model for Ultra-High Frequency Data.*

This talk first briefly reviews a general partially-observed framework of Markov processes with marked point process observations recently proposed for ultra-high frequency data, and the Bayes Estimation via Filtering Equation (BEFE). In recent years, Graphics Processing Units (GPUs) evolved from rendering graphics (linear algebra-like computations) for electronic games and video applications to becoming low-cost and green supercomputing units. With harnessing the newly available GPU high performance computing power in mind and targeting a benchmark Heston stochastic volatility model, we develop a new easily-parallelized, uniformly consistent, recursive algorithm via BEFE for propagating and updating the joint posterior distributions. We show that the recursive algorithm is well suited for GPU parallel computing. We present simulation and empirical results obtained from supercomputers to demonstrate that the recursive algorithm works. Real time tracking and feeding stochastic volatility is made possible. (Received January 26, 2014)

1097-60-362 **Matthew P Clay** and **Nandor J Simanyi*** (simanyi@uab.edu), UAB Department of Mathematics, Campbell Hall, 1300 University Boulevard, Birmingham, AL 35294-1170. *More on discrete Renyi parking constants.* Preliminary report.

Renyi's parking problem (or $1D$ sequential interval packing problem) dates back to 1958, when Renyi studied the following random process: Consider an interval I of length x, and sequentially and randomly pack disjoint unit intervals in I until the remaining space permits placing any new segment. The expected value of the measure of the covered part of I is $M(x)$, so that the ratio $M(x)/x$ is the exoected filling density of the random process. Following a "recent" paper by Gargano-Weissensteel-Malerba-Lewinter (2005) we studied the discretized version of the above process by considering the packing of the $1D$ discrete lattice interval $\{0, 1, \ldots, n\}$ with disjoint blocks of $(k + 1)$ integers but, as opposed to the mentioned GWML(2005) result, our exclusion process is symmetric, hence more natural, and, furthermore, we were able to obtain useful recursion formulas for the expected number of r-gaps ($0 \leq r \leq k$) between neighboring blocks. We also provided very fast converging series and extensive computer simulations for these expected numbers, so that the limiting filling density of the long line segment (as $n \to \infty$) is Renyi's famous parking constant, $0.7475979203\ldots$. (Received January 27, 2014)

1097-60-419 **Balram S Rajput*** (rajput@math.utk.edu), 1403 Circle Drive, 319 Ayres Hall, Knoxville, TN 37996. *Complements to the tail probabilities of the "centered" strictly 1-semi-stable/stable random vectors.* Preliminary report.

We provide tail probility comparison of two related series of Banach-valued random vectors. Using this result, we show that the tail probabilities of a "centered" strictly 1-semi-stable/stable Banach-valued random vector and its symmetrized counterpart are uniformly comparable. These results complement those where analogous results are proved for strictly semi-stable/stable Banach-valued random vectors for alpha not equal to one. [This talk is based on joint work with Jan Rosinski.] (Received January 27, 2014)

1097-60-424 **Ernest Jum*** (ejum@utk.edu) and **Jan Rosinski**. *Numerical approximations of stochastic differential equations driven by Levy processes.* Preliminary report.

We consider the problem of simulation of a stochastic differential equation driven by a Lévy process. First, we replace the small jump part of the driving Lévy process by a suitable Brownian motion, as proposed by Asmussen and Rosinski, and obtain a jump-diffusion equation with good mean-square and weak error estimates. Next, we give both jump-adapted strong and weak numerical schemes in the spirit of Bruti and Platten. We then present numerical error estimates and give simulation results to illustrate our method. (Received January 27, 2014)

1097-60-453 **Natasha Blitvić*** (nblitvic@indiana.edu). *The Segal–Bargmann Transform for (q, t)-Gaussian Spaces.*

Classically, the Segal-Bargmann transform is a unitary isomorphism between the L^2 space of the Gaussian measure on $\mathbb{R}^d$ and the space of holomorphic functions on $\mathbb{C}^d$ that are square-integrable with respect to the complex Gaussian measure. An analogous construction is available in free probability, where, for $d = 1$, the L^2 space of the standard semicircle measure is seen to correspond to the Hardy space of the unit disk. The general free Segal-Bargmann transform (over any separable Hilbert space) was constructed by Biane and extended to the q-Gaussian algebras for $-1 \leq q < 1$ by Kemp. The q-deformed case was also studied in the one-dimensional setting by Maassen and van Leeuwen. In this talk, I will discuss the Segal-Bargmann transform for (q, t)-Gaussian non-commutative probability spaces, which are a combinatorially natural, but non-tracial, generalization of the q-Gaussian spaces. The proofs will draw on explicit combinatorial constructions and a revised two-parameter quantum calculus (compared to physics literature). This is joint work with Todd Kemp. (Received January 27, 2014)

1097-60-464 **Brent M. Werness*** (bwerness@math.washington.edu). *Discrete holomorphic functions on non-uniform lattices.*

The study of discrete analogues of holomorphic and harmonic functions has a long history which traces back most directly to work of Ferrand in the 1940's, Duffin in the 1950's. In recent years, the use of discrete analytic functions in the study of conformally invariant models from statistical physics by Smirnov and others has spread interest in these ideas. One of the central questions in the theory of discrete holomorphicity is: under what conditions do the discrete holomorphic functions converge to continuous holomorphic functions in the limit as the lattice shrinks to zero?

In this talk, I will present a generalization of the existing convergence results to lattices where there is only local control on the lattice, without any global restrictions on geometry. I will the provide a brief discussion of the probabilistic questions, related to the geometry of random quadrangulations, which motivated the development of this result. (Received January 28, 2014)

1097-60-481 **Krzysztof Burdzy**, **David Nualart** and **Jason Swanson***, University of Central Florida, 4000 Central Florida Blvd, P.O. Box 161364, Orlando, FL 32816-1364. *Joint convergence along different subsequences of the signed cubic variation of fractional Brownian motion.*

The signed cubic variation of fractional Brownian motion (fBm) is obtained by considering the sum of the cubes of the increments of fBm over uniformly spaced time intervals whose lengths, Δt, tend to zero. It is well-known that when the Hurst parameter of fBm is set to $H = 1/6$, this sum converges in distribution to a Brownian motion that is independent of the original fBm. In this talk, I will discuss recent joint work with Chris Burdzy and David Nualart in which we study the asymptotic correlation between two distinct sums of this type, where the difference between the two sums is in the value of Δt. (Received January 28, 2014)

62 ► Statistics

1097-62-230 **Barbara Gonzalez*** (bgonzalez@roosevelt.edu) and **Nabendu Pal**. *A Note on Parameter Estimation Under a t-Model.*

We consider estimating the parameters of a t distribution. The maximum likelihood estimators (MLEs) do not have closed expressions. In this note we propose several estimators of the parameters, including some approximations of the exact MLEs, and compare them in terms of standardized bias and mean squared error. Among other things, we have presented a simple approach to estimate the degrees of freedom efficiently. (Received January 23, 2014)

1097-62-499 **Ali A Al-sharadqah*** (alsharadqaha@ecu.edu), Department of Mathematics, 124 Austin Building, East Carolina University, Greenville, NC 38655, and **Kenichi Kanatani**, **Nikolai Chernov** and **Y Sugaya**. *Hyper-renormalization: A new 'non-minimization' approach and its applications in Computer Vision.*

The technique of "renormalization" for geometric estimation attracted much attention when it appeared in early 1990s for having higher accuracy than any other then known methods. The key fact is that it directly specifies equations to solve, rather than minimizing some cost function. "non- minimization approach" will be exploited to modify renormalization so that it outperforms the standard reprojection error minimization. Doing a precise error analysis in the most general situation, we derive a formula that maximizes the accuracy of the solution; we call the resulting scheme hyper-renormalization. Applying it to ellipse fitting, fundamental matrix computation, and homography computation, we conclude that it is the best strategy that we can take. Our emphasis is on the general principle, rather than on individual methods for particular problems (Received January 28, 2014)

65 ► Numerical analysis

1097-65-13 **Nguyen Hoang*** (nhoang@westga.edu), Department of Mathematics, University of West Georgia, Carrollton, GA 30118. *On node distributions for interpolation and spectral methods.*

A scaled Chebyshev node distribution is studied in this paper. It is proved that the node distribution is optimal for interpolation in $C_M^{s+1}[-1,1]$, the set of $(s+1)$-time differentiable functions whose $(s+1)$-th derivatives are bounded by a constant $M > 0$. Node distributions for computing spectral differentiation matrices are proposed and studied. Numerical experiments show that the proposed node distributions yield results with higher accuracy than the most commonly used Chebyshev-Gauss-Lobatto node distribution. (Received October 20, 2013)

1097-65-15 **Pankaj Kumar SrivastavaA*** (pankaj.srivastava@jiit.ac.in), Noida, Uttar Prad 201304, India. *Application of Non polynomial Spline for Approximation of Solution of Differential Equation Arises in Human Morphology.*

Nonpolynomial quintic spline functions based algorithms are used for computing an approximation to the nonlinear two point second order singular boundary value problems arising in human morphology. After removing the singularity by L' hospital rule, the resulting BVP is then efficiently treated by employing nonpolynomial quintic spline for finding the numerical solution. Some examples have been included and comparison of the numerical results made with other methods. (Received November 11, 2013)

1097-65-56 **Mahboub Baccouch*** (mbaccouch@unomaha.edu), DSC 233, Dept. of mathematics, 6001 dodge st., Omaha, NE 68182. *A superconvergent local discontinuous Galerkin method for the second-order wave equation on Cartesian grids.* Preliminary report.

We propose and analyze a new superconvergent local discontinuous Galerkin (LDG) method for the spatial discretization of the second-order wave equation on Cartesian grids. We prove the L^2 stability of the scheme and optimal L^2 error estimates for the semi-discrete formulation. In particular, we identify special numerical fluxes for which the L^2-norm of the solution and its gradient are of order $p+1$, when tensor product polynomials of degree at most p are used. We further show that the LDG solution is $O(h^{p+2})$ superconvergent at Radau points obtained as a tensor product of the roots of $(p+1)$-degree right Radau polynomial. Furthermore, numerical computations show that the first component of the solution's gradient is $O(h^{p+2})$ superconvergent at tensor product of the roots of left Radau polynomial in x and right Radau polynomial in y while the second component is $O(h^{p+2})$ superconvergent at the tensor product of the roots of the right Radau polynomial in x and left Radau polynomial in y. We use the superconvergence results to construct asymptotically correct a posteriori LDG error estimates. Finally, we present several numerical examples to validate the theoretical results. (Received January 06, 2014)

1097-65-70 **Yingda Cheng*** (ycheng@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Andrew J Christlieb** and **Xinghui Zhong**. *Energy-conserving discontinuous Galerkin schemes for the Vlasov-Maxwell system.*

In this talk, we present the discontinuous Galerkin (DG) methods to solve the Vlasov-Maxwell system. The scheme employs DG discretizations for both the Vlasov and the Maxwell's equations, resulting in a consistent description of the probability density function and electromagnetic fields. We prove that using this description the total particle numbers are conserved, and the total energy could be preserved upon a suitable choice of numerical flux for the Maxwell‘s equations and the underlying polynomial spaces on the semi-discrete level, if boundary effects can be neglected. We further established error estimates based on several flux choices. We test the scheme on the Weibel instability and verify the order and conservation of the method. (Received January 10, 2014)

1097-65-87 **Xiu Ye***, 2801 S. University ave, little rock, AR 72204. *A New Class of Finite Element Methods: Weak Galerkin Methods.*

When the classic continuous finite element methods cannot meet the needs of modern computational techniques such as hp adaptive and hybrid meshes, discontinuous piecewise polynomials are used in the finite element procedures.

This presentation will study the finite element methods that use totally discontinuous approximation functions. Discontinuous Galerkin (DG) methods are such kind methods including IPDG methods, LDG methods and HDG methods. DG methods enforce the continuity of the approximation solutions cross elements by either tuning the penalty parameters or introducing additional equations. The weak Galerkin (WG) finite element method provides a framework for handling discontinuous functions. This general framework will provide a platform for deriving new methods and simplifying the existing methods. (Received January 12, 2014)

1097-65-107 **Yifan Zhang**, **Wei Wang*** (weiwang1@fiu.edu), **Johnny Guzman** and **Chi-Wang Shu**. *Multi-scale discontinuous Galerkin method for solving elliptic problems with curvilinear unidirectional rough coefficients.*

In this talk, we propose a multi-scale discontinuous Galerkin (DG) method for second-order elliptic problems with curvilinear unidirectional rough coefficients by choosing a special non-polynomial approximation space. The key ingredient of the method lies in the incorporation of the local oscillatory features of the differential operators into the approximation space so as to capture the multi-scale solutions without having to resolve the finest scales. The unidirectional feature of the rough coefficients allows us to construct the basis functions of the DG non-polynomial approximation space explicitly, thereby greatly increasing the algorithm efficiency. We will show the error estimates for two-dimensional second-order DG methods and numerical examples to validate and demonstrate the effectiveness of the algorithm. (Received January 14, 2014)

1097-65-118 **Abner J Salgado*** (asalgad1@utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996. *From Micropolar Navier-Stokes equations to Ferrofluids: Analysis and Numerics.* Preliminary report.

The Micropolar Navier-Stokes Equations (MNSE), is a system of nonlinear parabolic partial differential equations coupling linear velocity, pressure and angular velocity: material particles have both translational and rotational degrees of freedom. The MNSE is a central component of the Rosensweig model for ferrofluids, describing the linear velocity, angular velocity, and magnetization inside the ferrofluids, while subject to distributed magnetic forces and torques. We present the basic PDE results for the MNSE (energy estimates and existence theorems), together with a first order semi-implicit fully-discrete scheme which decouples the computation of the linear and angular velocities. Similarly, for the Rosensweig model we present the basic PDE results, together with a fully-discrete scheme combining Continuous Galerkin and Discontinuous Galerkin techniques in order to guarantee discrete energy stability. Finally, we demonstrate the capabilities of the Rosensweig model and its numerical implementation with some numerical simulations in the context of ferrofluid pumping by means of external magnetic fields. (Received January 15, 2014)

1097-65-123 **Zhiliang Xu**, **Xu-Yan Chen** and **Yingjie Liu*** (yingjie@math.gatech.edu), School of Math, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332. *A New Runge-Kutta Discontinuous Galerkin Method with Conservation Constraints to Improve CFL Condition for Solving Conservation Laws.*

We present a new formulation of the Runge-Kutta discontinuous Galerkin (RKDG) method for conservation Laws. The new formulation requires the computed RKDG solution in a cell to satisfy additional conservation constraint in adjacent cells and does not increase the complexity or change the compactness of the RKDG method. This new formulation improves the CFL numbers even further over the first version presented in Xu et al, JCP 2011. (Received January 16, 2014)

1097-65-147 **Gang Bao** and **Junshan Lin***, Department of Mathematcs and Statistics, Auburn University, Auburn, AL , and **Seraphin Mefire**. *Numerical reconstruction of electromagnetic inclusions in three dimensions.*

In this talk, I will present a two-stage method to reconstruct electromagnetic inclusions in a three-dimensional bounded domain by boundary measurements: (1). At low frequency, a MUltiple SIgnal Classication (MUSIC) algorithm is used to obtain the locations of inclusions, which serve as an initial guess for reconstructions at higher frequencies; (2). A continuation method based on multiple frequency data is then applied to recover the shapes of inclusions accurately. The combined algorithm leads to an accurate and stable method for reconstructing the inclusions inside an object. Numerical examples are provided to illustrate the effectiveness of the approach. (Received January 25, 2014)

1097-65-169 **Vasilios Alexiades*** (alexiades@utk.edu), Math Dept., UTK, Knoxville, TN 37996. *Comparison of time stepping schemes for nanosecond laser ablation.*

Laser ablation is used in many areas of science and technology including medicine, archaeology, chemistry, environmental and materials sciences. We outline a computational model for radiative and collisional processes during laser ablation, and compare the performance of various low and high order time-stepping algorithms. (Received January 20, 2014)

1097-65-184 **Lili Ju*** (ju@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208, **Jian Zhang** (zhangjian@sccas.cn), Computer Network Information Center, Chinese Academy of Sciences, Beijing, Peoples Rep of China, **Liyong Zhu** (liyongzhu@buaa.edu.cn), School of Mathematics and Systems Science, Beihang University, Beijing, Peoples Rep of China, and **Qiang Du** (qdu@math.psu.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802. *Fast Explicit Integration Factor Methods for Semilinear Parabolic Equations.* Preliminary report.

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 efficient decompositions of compact spatial difference operators on a regular mesh with stable and accurate exponential time integrators. It can deal with stiff nonlinearity and both homogeneous and inhomogeneous boundary conditions of different types by use of multistep approximations and analytic evaluations of time integrals. Numerical experiments are also given to demonstrate effectiveness of the new method for both linear and nonlinear model problems. (Received January 24, 2014)

1097-65-206 **Xuan Huang**, **Samuel Khuvis**, **Zana Coulibaly** and **Matthias K. Gobbert*** (gobbert@umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, and **Bradford E. Peercy**. *Numerical Methods for Long-Time Simulations of Partial Differential Equations on Modern Parallel Computing Platforms.*

Systems of advection-diffusion-reaction equations occur in a wide variety of applications. Choices for spatial discretizations include finite difference, finite element, and finite volume methods. Sophisticated implicit time-stepping methods such as numerical differentiation formulas handle the stiffness of the ODE systems well and enable simulations to large final times, comparable to the laboratory time scales of the processes being modeled. Krylov subspace methods allow a memory-efficient matrix-free implementation of the linear solves and efficient parallel computing on several compute nodes with multi-core CPUs in a distributed-memory cluster. The appearance of GPUs with hundreds or thousands of computational elements and of 60-core Intel Phi processors as accelerators inside each compute node offers the potential to speed up dramatically the linear solves on each node. We will report on first results for prototype problems as well as a model for self-organizing calcium waves in a heart cell. (Received January 22, 2014)

1097-65-209 **S. Adjerid*** (adjerids@math.vt.edu), Department of Mathematics, Blacksburg, VA 24061, **M. Ben-Romdhane** (romdhane.m@gust.edu.kw), Department of Mathematics and Natural, Sciences. Mishref, Kuwait, Kuwait, **K. Moon** (hyoxt121@vt.edu), Department of Mathematics, Blacksburg, VA 24061, and **T. Lin** (tlin@vt.edu), Department of Mathematics, Blacksburg, VA 24061. *Immersed Discontinuous Galerkin Methods for Interface Problems.*

We discuss higher degree immersed finite element (IFE) spaces to be used with finite element methods to solve two dimensional second order elliptic interface problems without requiring the mesh to be aligned with the material interfaces. The interpolation errors in the proposed piecewise p^{th} degree spaces yield optimal $\mathcal{O}(h^{p+1})$ and $\mathcal{O}(h^p)$ convergence rates in the L^2 and broken H^1 norms, respectively, under mesh refinement. Moreover, a bilinear IFE space is constructed for solving the two dimensional acoustic problem. A partially penalized method is developed for elliptic interface problems and a discontinuous Galerkin method is constructed for solving first order hyperbolic systems. The finite element errors for both methods converge optimally with the proposed higher degree IFE spaces. Several numerical examples are presented to show the efficiency of our IFE spaces and methods. (Received January 22, 2014)

1097-65-222 **Cheng Wang*** (cwang1@umassd.edu), **Yunhua Xue** and **Jian-Guo Liu**. *Numerical simulation of boundary layer separation for incompressible fluid over an irregular domain.*

The development of boundary layer separation for incompressible flow, subject to no-slip boundary conditions, is a complicated process; many small scale fluid structures are involved. In particular, a numerical study of such a separation over an irregular domain becomes even more challenging, due to the boundary complexity. In this talk, we present a numerical simulation of a driven cavity flow over a triangular domain, using a simple finite element numerical scheme based on the vorticity-stream function formulation. Such a numerical scheme decouples the Stokes solver into two Poisson-like solvers at each time stage in the Runge-Kutta temporal discretization. As a result, the LBB condition is avoided and the numerical efficiency is greatly improved. Some numerical results are also provided. (Received January 22, 2014)

1097-65-227 **Nabil Chaabane*** (nabilch@vt.edu), 422 Marlington St., Blacksburg, VA 24060, and **Slimane Adjerid** and **Tao Lin**. *A Q_2−iso−Q_1/Q_1 immersed finite element for Stokes interface problems.*

We present the bilinear immersed finite element (IFE) methods for solving Stokes interface problems with structured Cartesian meshes that is independent of the location and geometry of interface. . Basic features of the bilinear IFE functions, including the unisolvent property, will be discussed. Numerical examples are provided to demonstrate that the bilinear IFE spaces have the optimal approximation capability, and that numerical solutions produced by a $Q_2-\text{iso}-Q_1/Q_1$ method with these IFE functions for Stokes interface problem also converge optimally in both L^2 and H^1 norms. (Received January 24, 2014)

1097-65-235 **Kihyo Moon*** (hyoxt121@vt.edu) and **Slimane Adjerid**. *Immersed Discontinuous Galerkin Methods for the Acoustic Interface Problem.*

In this talk we will discuss higher order immersed discontinuous Galerkin finite element methods for the acoustic interface problem. One and two dimensional acoustic wave propagation in inhomogeneous media will be covered. In order to apply the Discontinuous Galerkin method to acoustic problem, we partition the domain into subdomains and use polynomials on non interface elements containing one material and specially designed piecewise polynomial shape functions on interface elements containing more than one material. In order to make interface shape functions, physical interface conditions are used. Additionally, extended conditions and interior conditions are used for two dimensional interface shape functions. We use standard discontinuous Galerkin finite element method on non interface elements and immersed discontinuous Galerkin finite element method on interface elements for solving the acoustic problem. Computational examples will be given for one and two dimensional cases. (Received January 24, 2014)

1097-65-255 **Xinfeng Liu***, Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Compact implicit integration factor method for a class of high order differential equations.*

When developing efficient numerical methods for solving parabolic types of equations, severe temporal stability constraints on the time step are often required due to the high-order spatial derivatives and/or stiff reactions. The implicit integration factor (IIF) method, which treats spatial derivative terms explicitly and reaction terms implicitly, can provide excellent stability properties in time with nice accuracy. One major challenge for the IIF is the storage and calculation of the dense exponentials of the sparse discretization matrices resulted from the linear differential operators. The compact representation of the IIF (cIIF) can overcome this shortcoming and greatly save computational cost and storage. In this talk, by treating the discretization matrices in diagonalized forms, we will present an efficient cIIF method for solving a family of semilinear fourth-order parabolic equations, in which the bi-Laplace operator is explicitly handled and the computational cost and storage remain the same as to the classic cIIF for second-order problems. In particular, the proposed method can deal with not only stiff nonlinear reaction terms but also various types of homogeneous or inhomogeneous boundary conditions. (Received January 24, 2014)

1097-65-259 **Mark Ainsworth*** (mark_ainsworth@brown.edu), Division of Applied Mathematics, Brown University, Providence, RI 02912. *Dispersive Behaviour of High Order Finite Element Schemes for the One-Way Wave Equation.*

We study the ability of high order numerical methods to propagate discrete waves at the same speed as the physical waves in the case of the one-way wave equation. A detailed analysis of the finite element method is presented including an explicit form for the discrete dispersion relation and a complete characterisation of the numerical Bloch waves admitted by the scheme. A comparison is made with the spectral element method and the discontinuous Galerkin method with centred fluxes. It is shown that all schemes admit a spurious mode. The spectral element method is always inferior to the finite element and discontinuous Galerkin schemes; a somewhat surprising result in view of the fact that, in the case of the *second order wave equation*, the spectral element method propagates waves with an accuracy *superior* to that of the finite element scheme. The comparative behaviour of the finite element and discontinuous Galerkin scheme is also somewhat surprising: the accuracy of the finite element method is superior to that of the discontinuous Galerkin method in the case of elements of odd order by two orders of accuracy, but worse, again by two orders of accuracy, in the case of elements of even order. (Received January 24, 2014)

1097-65-260 **Jue Yan*** (jyan@iastate.edu), 396 carver hall, Math department, Ames, IA 50010. *Maximum Principle Satisfying high order Direct discontinuous Galerkin method for convection diffusion problems.* Preliminary report.

In this talk, we will discuss our recent studies on the Direct Discontinuous Galerkin (DDG) methods for convection diffusion equations. We propose a new algebraic methodology and a monotonicity argument (or convex combination argument) to bound the piecewise polynomial solutions in the given range. With quadratic polynomial approximations, we prove the DDG methods satisfy the strict maximum principle for a few model equations with 3rd order of accuracy. Sufficient conditions are given to guarantee the polynomial solutions bounded above and below by the given constants. Extension to two-dimensional rectangular meshes and triangular meshes will be discussed. Numerical examples will be presented to verify the optimal 3rd order of accuracy will be maintained with the maximum principle limiter applied. The positivity of the polynomial solutions is maintained sharply for nonlinear porous medium equations. For compressible Navier-Stokes equations with density-dependent viscosity and vacuum formations problems, we preserve the positivity of the density and pressure polynomial approximations at all time levels. (Received January 24, 2014)

1097-65-261 **Bernardo Cockburn** and **Alan Demlow*** (alan.demlow@uky.edu). *Hybridizable discontinuous Galerkin methods for elliptic PDE on surfaces.*

Hybridizable discontinuous Galerkin methods have some advantages when compared with both other DG methods and with conforming methods. We discuss the definition and analysis of such methods for elliptic PDE on surfaces. (Received January 24, 2014)

1097-65-286 **Hailiang Liu*** (hliu@iastate.edu), Iowa State University, Ames, IA 50011, and **Hui Yu**. *Maximum-principle-satisfying third order discontinuous Galerkin schemes for Fokker-Planck equations.*

We design and analyze up to third order accurate discontinuous Galerkin (DG) methods satisfying a strict maximum principle for Fokker–Planck equations. A procedure is established to identify an effective test set in each computational cell to ensure the desired bounds of numerical averages during time evolution. This is achievable by taking advantage of the two parameters in the numerical flux and a novel decomposition of weighted cell averages. Based on this result, a scaling limiter for the DG method with first order Euler forward time discretization is proposed to solve the one-dimensional Fokker–Planck equations. Strong stability preserving high order time discretizations will keep the maximum principle. It is straightforward to extend the method to two and higher dimensions on rectangular meshes. We also show that a modified limiter can preserve the strict maximum principle for DG schemes solving Fokker-Planck equations. As a consequence, the present schemes preserve steady states. Numerical tests for the DG method are reported, with applications to polymer models with both Hookean and FENE potentials. (Received January 24, 2014)

1097-65-293 **Ming-Jun Lai*** (mjlai@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *Bivariate Spline Solution to a Nonlinear PDE for Population Dynamics.*

We first explain a nonlinear PDE motivated from the population dynamics associated with epidemic study. There are three sources of non-linearity: 1) the PDE has a nonlinear diffusion, 2) the PDE has a nonlinear term like logistic term with higher order, and 3) the solution is non-negative which is crucial as no population function has a negative value. Next we present an analysis of the PDE by establishing the existence, uniqueness, stability and boundedness of the PDE weak solution. We mainly use a minimization approach to do the analysis. Finally, as the domain of the PDE has an irregular shape, the population of interest is over a country, we apply a finite element like method called bivariate spline method to numerically solve the nonlinear PDE. We design a convergent algorithm to do the computation and simulate many artificial density functions. We will use our MATLAB program to study several real life data sets and hopefully, the program will produce some reasonable guidelines for health department officials. (Received January 25, 2014)

1097-65-296 **He Yang** (yangh8@rpi.edu) and **Fengyan Li*** (lif@rpi.edu), Department of Mathematical Sciences, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180. *Stability and Error Estimate of an Exactly Divergence-Free Method for the Magnetic Induction Equations.*

The ideal magnetohydrodynamics (MHD) equations arise in many areas such as astrophysics and plasma physics, and they consist of a set of nonlinear conservation laws and a divergence-free condition on the magnetic field. Negligence of imposing the divergence condition in computational methods may lead to numerical instability or non-physical solutions. One class of methods, constrained transport methods, is widely used as a divergence-free treatment. However, it is not well understood why / how such methods work.

In this talk, an exactly divergence-free scheme by Li and Xu is considered as a candidate of the constrained transport schemes, and the method is adapted to solve the magnetic induction equations. For the resulting scheme, stability and error estimate are established. In addition, we identify stability mechanisms due to the spatial and temporal discretizations, and the role of the numerical solution being exactly divergence-free. This work makes an important first step to understand the divergence-free treatment especially within the constrained transport framework in MHD simulations. (Received January 25, 2014)

1097-65-297 **Andreas C Aristotelous*** (aaristot@math.duke.edu), **Karakashian** and **Wise**. *Second Order in Time, Adaptive Discontinuous Galerkin Methods for a Cahn-Hilliard Equation with a Mass Source.*

Fully discrete discontinuous Galerkin 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 January 25, 2014)

1097-65-298 **Robert D French*** (frenchrd@ornl.gov), Oak Ridge National Laboratory, 1 Bethel Valley Rd., MS 6008, Oak Ridge, TN 37831, and **Samuel N Jator** (jators@apsu.edu), Department of Mathematics and Statistics, Austin Peay State University, 601 College Street, Clarksville, TN 37044. *A variable-step block Extended Backward Differentiation Formula with two superfuture points for parabolic partial differential equations via the Method of Lines.*

A variable-step block Extended Backward Differentiation Formula (EBDF) with two superfuture points is proposed for solving parabolic partial differential equations (PDEs) via the Method of Lines. This is achieved by constructing a continuous representation of the EBDF with two superfuture points and using it to generate a 2-step Hyper-EBDF method along with three additional methods which are combined and applied in block form as simultaneous numerical integrators. The required solution is computed in a variable-step fashion, using as an error estimator a similarly constructed block based on the Conventional 2-step Adams-Moulton Method. This method is self-starting, A-stable, and well suited for solving stiff systems arising from the semi-discretization of parabolic PDEs. The performance of the method on the 2-dimensional heat equation is compared with methods in the literature. (Received January 25, 2014)

1097-65-317 **Amanda E Diegel*** (diegel@math.utk.edu), **Xiaobing H Feng** and **Steven M Wise**. *A Mixed Finite Element Method for a Cahn-Hilliard-Darcy-Stokes System.*

We analyze and present results for a mixed finite element method for a modified Cahn-Hilliard equation coupled with a non-steady Darcy-Stokes flow that models phase separation and coupled fluid flow in immiscible binary fluids and diblock copolymer melts. The time discretization is based on a convex splitting of the energy of the equation. We show that our scheme is unconditionally energy stable with respect to a spatially discrete analogue of the continuous free energy of the system and unconditionally uniquely solvable. We also show that the phase variable is bounded in $L^\infty(0,T;L^\infty)$ and the 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 show that these variables converge with optimal rates in the appropriate energy norms in both two and three dimensions and present numerical results supporting our analysis. (Received January 26, 2014)

1097-65-319 **Michael Neilan*** (neilan@pitt.edu), 301 Thackeray Hall, 139 University Place, Pittsburgh, PA 15260. *A C^0 finite element method for the biharmonic problem without extrinsic penalization.*

In this talk, a new symmetric C^0 finite element method for the biharmonic problem is constructed and analyzed. In our approach, we introduce one-sided discrete second order derivatives and Hessian matrices to formulate our scheme. We show that the method is stable and converge with optimal order in a variety of norms. A distinctive feature of the method is that the results hold without extrinsic penalization of the gradient across inter-element boundaries. (Received January 26, 2014)

1097-65-350 **Cory D. Hauck*** (hauckc@ornl.gov) and **Yulong Xing** (xingy@math.utk.edu). *A Low-Memory Approach to Discontinuous Galerkin Methods for Transport Equations and the Diffusion Limit.* Preliminary report.

It is well-known that under reasonable assumptions, Discontinuous Galerkin methods accurately capture the diffusion limit of kinetic transport equations. Unfortunately to do so, they require a relatively large number of unknowns per spatial zone. In an effort to reduce the memory footprint, we have developed a new, low-memory approach that, among other things, includes a hybrid DG-finite volume scheme. Initial numerical analysis and preliminary numerical results will be presented to show the potential of the approach. (Received January 26, 2014)

1097-65-377 **Ching-Shan Chou*** (chou@math.osu.edu), 231 West 18th Ave, Columbus, OH 43221, **Yulong Xing** (xingy@math.utk.edu), 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 37996, and **Chi-Wang Shu** (shu@dam.brown.edu), Division of Applied Mathematics, Providence, RI 02912. *Optimal energy conserving local discontinuous Galerkin methods for second-order wave equation in heterogeneous media.*

Solving wave propagation problems within heterogeneous media has been of great interest and has a wide range of applications in physics and engineering. The design of numerical methods for such general wave propagation problems is challenging because the energy conserving property has to be incorporated in the numerical algorithms in order to minimize the phase or shape errors after long time integration. In this talk, we will discuss multi-dimensional wave problems and consider linear second-order wave equation in heterogeneous media. We will present an LDG method, in which numerical fluxes are carefully designed to maintain the energy preserving property and accuracy. We propose compatible high order energy conserving time integrators and prove the optimal error estimates and the energy conserving property for the semi-discrete methods. Our numerical experiments demonstrate optimal rates of convergence, and show that the errors of the numerical solution do not grow significantly in time due to the energy conserving property. (Received January 27, 2014)

1097-65-388 **Thomas Lewis*** (tllewis3@uncg.edu) and **Michael Neilan** (neilan@pitt.edu). *The Dual-Wind Discontinuous Galerkin Method.*

A new symmetric discontinuous Galerkin method for second order elliptic problems will be proposed. We show that the numerical method has a unique solution without the introduction of interior or boundary penalizations. Thus, the numerical method features a way to naturally enforce boundary conditions and address the issues associated with a fully discontinuous solution space. The key building block for the method will be the introduction of one-sided discrete derivative operators for piecewise weakly differentiable functions. Using both the up-wind gradient operator and the down-wind gradient operator, we formulate the new discontinuous Galerkin method that is symmetric when written in primal form. We will also summarize the convergence results as well as provide numerical test results that demonstrate the optimal convergence rates for the proposed numerical method. (Received January 27, 2014)

1097-65-395 **Susanne C. Brenner**, **Li-Yeng Sung** and **Yi Zhang*** (yzhan112@utk.edu), 1403 Circle Drive, Knoxville, TN 37996. *Post-Processing Procedures for an Elliptic Distributed Optimal Control Problem with Pointwise State Constraints.*

We consider an elliptic distributed optimal control problem with state constraints and compare three post-processing procedures that compute approximations of the optimal control from the approximation of the optimal state obtained by a quadratic C^0 interior penalty method. (Received January 27, 2014)

1097-65-400 **Fidele F Ngwane*** (ngwanef@mailbox.sc.edu), 807 hampton street, walterboro, SC 29488, and **Samuel N Jator** (jators@apsu.edu), 601 College Street, clarksville, TN 37044. *An eighth-order trigonometric fitted method for the direct solution of second order initial value problems.*

In this paper, we derive a trigonometric fitted continuous method for directly solving second order initial value problems. This numerical method is implemented in block form. We discuss the stability properties and present some numerical examples to demonstrate the accuracy of the method. (Received January 27, 2014)

1097-65-403 **Tao Lin*** (tlin@vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061. *Partially Penalized Immersed Finite Element Methods For Interface Problems.*

We present partially penalized immersed finite element (IFE) methods for solving the popular second order elliptic interface problems on structured Cartesian meshes even if the involved interfaces have nontrivial geometries. Closely related to the linear and bilinear IFE methods in the literature which are based on the traditional Galerkin formulation, these new IFE methods contain extra stabilization terms introduced only at interface edges for the purpose penalizing the discontinuity in IFE functions. The error estimation shows that these penalized IFE methods converge optimally in an energy norm. A group of trace inequalities are established for both linear and bilinear IFE functions that are not only critical for the error analysis of these IFE methods, but also are of a great potential to be useful in error analysis for other IFE methods. Numerical examples are provided to demonstrate that these new IFE methods outperform IFE methods published before according to the accuracy in the vicinity of the interface. (Received January 27, 2014)

1097-65-446 **Seong Jun Kim*** (skim396@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332-0160. *Numerical methods for highly oscillatory dynamical systems using multiscale structure.*

The main aim of this talk is to design efficient numerical algorithms for a class of highly oscillatory dynamical systems with multiple time scales. Classical numerical methods for such problems need temporal resolution to resolve the finest scale and become, therefore, inefficient when the much longer time intervals are of interest. In order to accelerate computations and improve the long time accuracy of numerical schemes, we take advantage of various multiscale structures established from a separation of time scales. The framework of the heterogeneous multiscale method is considered as a general strategy both for the design and the analysis of multiscale methods.
(Received January 27, 2014)

1097-65-456 **Xiaobing Feng** (xfeng@math.utk.edu), Department of Mathematics, The University of Tennessee, Knoxville, TN 37996, **Junshan Lin** (jzl0097@auburn.edu), Department of Mathematics, Auburn University, Auburn, AL 36849, and **Cody Lorton*** (lorton@math.utk.edu), Department of Mathematics, The University of Tennessee, Knoxville, TN 37996. *An Efficient Numerical Method for Wave Scattering in Random Media.*

Wave scattering in random media arises in many scientific and engineering fields including geoscience, materials science and medical science. Computing quantities of interest for the solutions of such wave problems, especially, in the high frequency case, poses a daunting computational challenge because of sheer amount of computations required to solve those problems. Due to their strong indefiniteness, highly oscillatory nature of solutions, and lack of efficient iterative solvers, standard numerical approaches such as brute force Monte Carlo methods and stochastic Galerkin methods are either too expensive to use or do not work well. In this talk we shall present a newly developed multi-resolution approach for the random Helmholtz problem with large wave numbers. In this approach the original random Helmholtz problem is reduced to a finite number of deterministic and non-homogeneous Helmholtz problems with random source terms, which are discretized by some unconditionally stable discontinuous Galerkin methods. An efficient solver with computational complexity of order $O(3N^3/2)$ is also proposed to solve the resulting algebraic problems. Convergence analysis and numerical experiments will be presented to demonstrate the potential advantages of the proposed numerical approach. (Received January 27, 2014)

1097-65-490 **David Kai Zhang*** (dzhang314@gmail.com) and **Samuel N Jator** (jators@apsu.edu). *A General Algorithm for the Efficient Derivation of Linear Multistep Methods.*

Traditionally, linear multistep methods (LMMs) for the numerical solution of initial value problems, such as Adams methods and backward differentiation formulas, have been derived through the use of polynomial interpolation and collocation through continuous schemes. While these methods can be implemented in modern computer algebra systems, they require the use of highly expensive operations such as symbolic matrix inversion. This imposes a severe limit on the complexity of LMMs that can be derived. In this presentation, we present a generalized algorithm for deriving LMMs based upon Taylor series expansion. By our approach, we show that the derivation of a LMM containing $k+1$ terms is reducible to the numerical solution of a $k \times k$ linear system, allowing for the efficient derivation of methods including hundreds or thousands of terms. Furthermore, we show that this algorithm is trivially generalizable to methods including arbitrarily many off-grid points, and that it can be generalized to create LMMs for directly solving initial value problems of arbitrarily high order, with the inclusion of all intermediate derivative terms. Specific methods are stated and tested numerically on well-known problems given in the literature. (Received January 28, 2014)

1097-65-500 **Yukun Li*** (yli@math.utk.edu), Department of Mathematics, The University of Tennessee, Knoxville, TN 37996. *Discontinuous Galerkin methods for the Allen-Cahn equation and the mean curvature flow.*

This talk is concerned with some new convergence results for interior penalty discontinuous Galerkin (IPDG) approximations of the Allen-Cahn and its sharp interface limit known as the mean curvature flow. The main result to be presented is the convergence of the numerical interfaces to the sharp interface of the mean curvature flow as both the numerical mesh parameters and the phase field parameter (called the interaction length) tend to zero. The crux 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. This is a joint work with Xiaobing Feng of the University of Tennessee at Knoxville. (Received January 28, 2014)

1097-65-516 **Petr Plechac***, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *How accurate is Born-Oppenheimer molecular dynamics for crossings of potential surfaces?*

I will discuss numerical analysis issues that arise in approximations of observables in quantum systems described by many-body Schroedinger equation. I will present quantitative error estimates for molecular dynamics observables compared with observables determined by the time-independent Schrödinger equation, including the case with crossing or nearly crossing electron potential surfaces that can yield large errors. The derivation combines mathematical stability analysis of eigenvalue problems with quantitative numerical Ehrenfest molecular dynamics computations of perturbations. This is a joint work with Håkon Hoel (KAUST), Ashraful Kadir (KTH), Mattias Sandberg (KTH) and Anders Szepessy (KTH). (Received January 28, 2014)

68 ► Computer science

1097-68-501 **Robert Anthony Bridges*** (bridgesra@ornl.gov), **John P Collins**, **Erik M Ferragut**, **Jason A Laska** and **Blair Sullivan**. *Detecting anomalous graphs using a generative probabilistic model.* Preliminary report.

This talk will present current research for detecting anomalies in data represented as a series of graphs by applying a novel probabilistic framework for anomaly detection. In general, given a probability distribution we have developed a mathematically rigorous way to generalize the "tails" of the distribution. This definition provides comparability across distributions and admits theorems that allow a user to regulate the alert rate; in particular, it is extremely well suited for applications to dynamic, streaming data. Lastly, we apply this methodology to a series of graphs by estimating the parameters for a generative model, specifically, the BTER-model, and identify anomalous graphs and, subsequently, subgraphs, thereby isolating areas of interest. As complex networks are becoming increasingly important for modeling a variety of data, this research will facilitate a streaming method to pinpoint graphs and their specific nodes that appear anomalously. (Received January 28, 2014)

1097-68-532 **Sanjay Chawla*** (sanjay.chawla@sydney.edu.au), School of Information Technologies, Sydney, NSW 2006, Australia. *Building Blocks of Data Science.*

In this talk I will make an attempt to flesh out the core components of what is being called Data Science. The umbrella term "Data Science" incorporates elements of Computer Science, Information theory and Statistics expressed in the language of optimization theory. The identification of these core elements will help towards arriving at a declarative framework for Data Science and decouple its use from implementation. This in turn may lead to overcome the "Data Science Crunch" – where organizations own and have access to large quantities of data and appreciate its potential value, but lack human talent and a support framework to exploit it to its fullest. (Received January 29, 2014)

76 ► Fluid mechanics

1097-76-144 **William Layton*** (wjl@pitt.edu), Math/ Univ of Pittsburgh, Pittsburgh, PA 15260. *Ensemble algorithms for simulation of fluid flows.*

The talk presents work developing algorithms wherein a flow ensemble can be calculated at marginal extra cost over 1 realization, breaking / rebalancing the deadlock between single high resolution flow forecasts and computing a flow ensemble. Several interesting uses for the algorithms will be given beyond the expected ones to UQ. sensitivity analysis and increased forecast skill including new ensemble turbulence models and evaluation of predictability by computing at no cost effective, averaged Lyapunov exponents. (Received January 18, 2014)

81 ► Quantum theory

1097-81-57 **Matilde Marcolli*** (matilde@caltech.edu), Math Department, Caltech, 1200 E California Blvd, Pasadena, CA 91125, and **Xiang Ni** (xni@caltech.edu), Math Department, Caltech, 1200 E California Blvd, Pasadena, CA 91125. *Rota-Baxter algebras of singular hypersurfaces and applications to quantum field theory.* Preliminary report.

Extending earlier results of Ceyhan and the first author, we construct Rota-Baxter algebras associated to singular hypersurfaces using differential forms with logarithmic poles. We adapt the general formalism of algebraic renormalization, based on Hopf algebras and Rota-Baxter algebras to this setting and we apply it to the case of Feynman integrals in momentum space, reformulated in terms of determinant hypersurfaces as in previous work of Aluffi and the first author. We show that one can obtain a new type of regularization of Feynman integrals, different from the usual methods adopted in physics, which also has different properties with respect to the nature of the resulting periods. (Received January 07, 2014)

1097-81-69 **Bruno Nachtergaele**, **Wolfgang Spitzer** and **Shannon Starr*** (slstarr@uab.edu), UAB Department of Mathematics, Campbell Hall, 1300 University Boulevard, Birmingham, AL 35294-1170. *Lowest lying spectrum of the quantum Heisenberg ferromagnet.*

The thermodynamics of the quantum Heisenberg ferromagnet is an important open question: especially proving a phase transition in 3 dimensions and higher. We considered a property called "ferromagnetic ordering of energy levels" relating the eigenvalues of the model to the symmetry types of the eigenvectors, relative to the symmetry group of the model, SU(2). We proved that if one fixes any natural number n and considers all eigenvectors with total spin deviating from the maximum by more than n, then the minimum eigenvalue among that set of eigenvectors is greater than the minimum eigenvalue among eigenvectors whose total spin deviation is exactly n. But for each fixed n, we only prove this when the sample size is sufficiently large. I will also compare our results to a recent important work by Correggi, Giuliani and Seiringer. For thermodynamics, their result is better than ours. But our result does not appear to be subsumed by theirs because we believe we get some extra spectral information. (Received January 10, 2014)

1097-81-75 **Thomas Chen*** (tc@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 1 University Station C1200, Austin, TX 78712. *Unconditional Uniqueness and scattering for the Cubic Gross-Pitaevskii Hierarchy via Quantum de Finetti.*

The Gross-Pitaevskii (GP) hierarchy arises in the derivation of the nonlinear Schroedinger (NLS) equation from the manybody quantum dynamics of a boson gas. Proving the uniqueness of solutions to the GP hierarchy represents the most involved part in this analysis, and was achieved in a series of seminal papers of Erdoes-Schlein-Yau a few years ago. Recently, in joint work with Hainzl, Pavlovic, and Seiringer we obtained a new, simpler proof of the unconditional uniqueness of solutions to the cubic GP hierarchy in $\mathbb{R}^3$. One of the main tools in our analysis is the quantum de Finetti theorem. This method also allowed us to prove scattering in the defocusing case. (Received January 11, 2014)

1097-81-167 **Richard Rimanyi*** (rimanyi@email.unc.edu). *R-matrices acting on the cohomology of flag varieties.*

We will explore some connections between equivariant topology and physics. On the topology side we will consider singularities and fundamental cohomology classes of conormal bundles of Schubert varieties. On the physical side we will study Yangian modules. A key object in the connection of the two sides is the "weight function" introduced by Tarasov and Varchenko in order to construct q-hypergeometric solutions of qKZ equations. This is a joint work with V. Tarasov and A. Varchenko. (Received January 20, 2014)

1097-81-194 **Alexander Elgart*** (aelgart@vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061, and **Daniel Schmidt**. *Eigenvalue statistics for random block operators.*

We derive a criterion that allows us to establish an upper bound on the probability that a local Hamiltonian has at least n eigenvalues in a given energy interval. Such an estimate is known as an n-level Wegner estimate. We demonstrate its usefulness by verifying the input conditions of our criterion for random block operators that arise in the Bogoliubov-de Gennes theory of dirty superconductors. This gives a usual (1-level) Wegner estimate for these operators, as well as a weakened Minami estimate. (Received January 21, 2014)

1097-81-212 **Jacob Lewis Bourjaily*** (bourjaily@fas.harvard.edu), Harvard University, Department of Physics, 17 Oxford Street, Cambridge, MA 02138. *Scattering Amplitudes and the Positive Grassmannian.*

In the past ten years, the study of scattering amplitudes in quantum field theory has led to a revolutionary reformulation of the subject. This revolution began with the discovery, in 2005, of a recursive expansion for scattering amplitudes (to leading order) in terms of planar, two-colored, trivalent graphs—called "on-shell diagrams." Around the same time that these diagrams were first drawn by physicists, they also started to appear in the mathematical literature (for entirely independent reasons) in the context of the positroid stratification of Grassmannian manifolds. Recently, these two previously independent lines of research came together, leading to many valuable insights on both sides. In my talk, I will outline the physical ideas behind these developments, and explain the many deep connections which have been found between scattering amplitudes and the geometry and combinatorics of the positroid stratification of the Grassmannian. Although some familiarity with quantum field theory would be useful, the talk should be entirely self-contained and accessible to those without any background in physics. (Received January 22, 2014)

1097-81-304 **Jacob W Chapman*** (jchapman@wmcarey.edu), 498 Tuscan Avenue, Hattiesburg, MS 39401, and **Günter Stolz**. *Localization for Random Block Operators Related to the XY Spin Chain.*

We study a class of random block operators which appear as effective one-particle Hamiltonians for the anisotropic XY quantum spin chain in an exterior magnetic field given by an array of i.i.d. random variables. For arbitrary non-trivial single-site distribution of the magnetic field, we prove dynamical localization of these operators at non-zero energy. We also discuss a regime in which dynamical localization holds at all energies, yielding a zero-velocity-type Lieb-Robinson bound for the anisotropic XY chain. We conclude with brief remarks about our current investigation of localization properties of the Ising model and how this might help us strengthen our results on the XY chain. (Received January 25, 2014)

1097-81-314 **Clay Cordova*** (clay.cordova@gmail.com). *Deformations of Superconformal Field Theories.*

Superconformal quantum field theories frequently describe the compactification of string theory on singular manifolds. Deformations and resolutions of the singularity can then be described in field theory by supersymmetric relevant perturbations. In this talk I'll explain how to classify such perturbations from field theory. Time permitting, I will also give examples of the different types of deformations which arise. (Received January 26, 2014)

1097-81-393 **Bruno Nachtergaele** (bxn@math.ucdavis.edu), Department of Mathematics, One Shields Avenue, Davis, CA 95616, **Robert Sims*** (rsims@math.arizona.edu), Department of Mathematics, University of Arizona, 617 N. Santa Rita Avenue, Tucson, AZ 85721, and **Gunter Stolz** (stolz@math.uab.edu), Department of Mathematics, Campbell Hall, 1300 University Boulevard, Birmingham, AL 35294. *Localization for Disordered Quantum Harmonic Oscillators.*

We consider quantum harmonic oscillator models with random coefficients. Our goal is to find verifiable signatures of many-body localization in simple systems. Given certain conditions on the effective one-particle Hamiltonian, we prove results on localization of the dynamics and localization in specific states. The result on dynamical localization is expressed in terms of a zero-velocity Lieb-Robinson bound. We also prove exponential decay of correlation functions at both zero and positive temperature, demonstrating a form of localization in the ground state and in thermal states. Finally, we prove an area law for the bipartite entanglement of both the ground state and thermal states, as measured by the logarithmic negativity. The above conditions (on the one-particle Hamiltonian) are satisfied for some standard models that are almost surely gapless in the thermodynamic limit. This is joint work with Bruno Nachtergaele and Gunter Stolz. (Received January 27, 2014)

82 ► Statistical mechanics, structure of matter

1097-82-111 **Fredrik Johansson Viklund** and **Alan A Sola*** (a.sola@statslab.cam.ac.uk), Statistical Laboratory, DPMMS, University of Cambridge, Cambridge, CB3 0WB, United Kingdom, and **Amanda Turner**. *Small-particle limits in a regularized Laplacian growth model.*

We study a regularized version of the Hastings-Levitov model of Laplacian random growth. In addition to the usual feedback parameter $\alpha > 0$, this regularized version features a smoothing parameter $\sigma > 0$. Simulations of the resulting growth processes reveal non-trivial features that differ from those observed in HL(0). We prove convergence of random clusters, in the limit as the size of the individual aggregating particles tends to zero, to deterministic limits, provided the smoothing parameter does not tend to zero too fast. We also study scaling limits of the harmonic measure flow on the boundary, and show that it can be described in terms of stopped Brownian webs on the circle. In contrast to the case $\alpha = 0$, the flow does not always collapse into a single Brownian motion, which can be interpreted as a random number of infinite branches being present in the clusters. (Received January 15, 2014)

1097-82-345 **Federico Bonetto** and **Michael Loss*** (loss@math.gatech.edu), School of Mathematics, Georgia Tech, 686 Cherry Street, Atlanta, GA 303320160, and **Ranjini Vaidyanathan**. *The Kac Model coupled to a thermostat.*

We present a model of randomly colliding particles interacting with a thermal bath. Collisions between particles are modeled via the Kac master equation while the thermostat is seen as an infinite gas at thermal equilibrium at inverse temperature β. The system admits the canonical distribution at inverse temperature β as the unique equilibrium state. We prove that any initial distribution approaches the equilibrium distribution exponentially fast both by computing the gap of the generator of the evolution, in a proper function space, as well as by proving exponential decay in relative entropy. We also show that the evolution propagates chaos and that the one particle marginal, in the large system limit, satisfies an effective Boltzmann-type equation. (Received January 26, 2014)

92 ► Biology and other natural sciences

1097-92-8 **Juan B Gutierrez*** (juan@math.uga.edu), University of Georgia, Department of Mathematics, 1023 D.W. Brooks Drive, Boyd Building, Athens, GA 30602. *Systems Biology of Epidemiology: From Genes to Environment.*

Traditional epidemiological models consists of compartmentalizing hosts into susceptible, exposed, infected, recovered (SEIR), and variations of this paradigm (e.g. SIR, SIR/SI, etc.). These models are challenged when the within-host dynamics of disease is taken into account with aspects such as: (i) Simultaneous Infection: Simultaneous presence of several distinct pathogen genomes, from the same or multiple species, thus causing individual to belong to multiple compartments simultaneously. (ii) Antigenic diversity and variation: Antigenic variation, defined as the ability of a pathogen to change antigens presented to the immune system during an infection, and antigenic diversity, defined as antigenic differences between pathogens in a population, are central to the pathogen's ability to 1) infect previously exposed hosts, and 2) maintain a long-term infection in the face of the immune response. Immune evasion facilitated by this variability is a critical factor in the dynamics of pathogen growth, and therefore, transmission. This talk explores an alternate mechanistic formulation of epidemiological dynamics based upon studying the influence of within-host dynamics in environmental transmission. A basic propagation number is calculated that could guide public health policy. (Received September 26, 2013)

1097-92-27 **Jonathan Lowden**, **Rachael Miller Neilan*** (rachael.neilan@gmail.com) and **Mohammed Yahdi**. *Optimal control of vancomycin-resistant enterococci using preventive care and treatment of infections.*

The rising prevalence of vancomycin-resistant enterococci (VRE) is a major health problem in intensive care units (ICU) because of its association with increased mortality and high health care costs. We present a mathematical framework for determining cost-effective strategies for prevention and treatment of VRE in the ICU. A system of five ordinary differential equations describes the movement of ICU patients in and out of five VRE-related states. Two control variables representing the prevention and treatment of VRE are incorporated into the system. The basic reproductive number is derived and calculated for different levels of the two controls. An optimal control problem is formulated to minimize VRE-related deaths and costs associated with prevention and treatment controls over a finite time period. Numerical solutions illustrate optimal single and dual allocations of the controls for various cost values. Results show that preventive care has the greatest impact in reducing the basic reproductive number, while treatment of VRE infections has the most impact on reducing VRE-related deaths. (Received December 11, 2013)

1097-92-72 **Wandi Ding***, 1301 E Main St, MTSU Box 34, Murfreesboro, TN 37132, and **Glenn Webb**, 1326 Stevenson Center, Dept. of Mathematics, Nashville, TN 37240. *Optimal Control Applied to Hospital-acquired and Community-acquired Methicillin-resistant Staphylococcus Aureus Strains in Hospitals.*

Optimal control are applied to a deterministic mathematical model to characterize the factors contributing to the replacement of hospital-acquired MRSA with community-acquired MRSA, and quantify the effectiveness of three interventions aimed at limiting the spread of CA-MRSA in health care settings. Adjoint equations and the characterization of the optimal control strategies are established, and various numerical simulations are provided to illustrate the results. (Received January 10, 2014)

1097-92-141 **Folashade Agusto*** (fbagusto@gmail.com), Department of Mathematics and Statistics, Austin Peay State University, Clarksville,, TN 37044. *Optimal control of methicillin-resistant staphylococcus aureus transmission in hospital settings.* Preliminary report.

In this paper a deterministic model for transmission dynamics of hospital- and community-acquired methicillin-resistant *staphylococcus aureus* (MRSA) in a hospital setting is presented. MRSA infection is caused by any strain of *staphylococcus aureus* bacteria that is resistant to standard antibiotics often used in the treatment of ordinary *staphylococcus aureus* infections. The stability of the system is studied and optimal control theory is applied to investigate the goal of minimizing patients colonized and infected with MRSA as well as colonized health-care workers using as control measures decolonization of health-care workers and environmental sanitation.
(Received January 17, 2014)

1097-92-165 **Eric Numfor*** (numfor@math.utk.edu), **Souvik Bhattacharya**, **Suzanne Lenhart** and **Maia Martcheva**. *Optimal Control and Analysis of a Coupled ODE/PDE Immuno-epidemiological Model.*

We formulate an immuno-epidemiological model of coupled within-host model of ODEs and between-host model of ODE and PDE. Existence and uniqueness of solution to the between-host model is established, and an explicit expression for the basic reproduction number of the between-host model derived. Stability of disease-free and endemic equilibria is investigated. An optimal control problem with drug-treatment control on the within-host system is formulated and analyzed. Numerical simulations based on the forward-backward sweep method are obtained. (Received January 20, 2014)

1097-92-180 **Suzanne M O'Regan*** (smoregan@uga.edu), Odum School of Ecology, 140 E. Green St, Athens, GA 30602, and **Krisztian Magori**, **J Tomlin Pulliam**, **Marcus A Zokan**, **RajReni B Kaul**, **Heather D Barton** and **John M Drake**. *Multi-scale model of epidemic fadeout: Will local extirpation along geographic corridors inhibit the spread of White-nose Syndrome?*

White-nose Syndrome (WNS) in North America is an emerging infectious disease of hibernating bats. The ongoing epidemic of White-nose Syndrome is a multi-scale phenomenon because it causes local extirpations, while simultaneously spreading over large spatial scales. Previous studies have identified risk factors for propagation of WNS over local and landscape scales but none of these have tested the hypothesis that separation of spatial scales and disease-induced mortality within hibernation sites might slow or halt its spread. To test this hypothesis, we developed a mechanistic multi-scale model parameterized using WNS county and site incidence data that connects hibernaculum level Susceptible-Infectious-Removed (SIR) epidemiology to the county-scale contagion process. Our key result is that regional burnouts, caused by site-level extirpations, will not inhibit county-scale spread of WNS. Over 80% of counties of the contiguous USA are likely to become infected before the current epidemic is over and that geometry of habitat connectivity is such that host refuges are exceedingly rare. If effective control measures are not implemented, precipitous declines in bat populations are likely, particularly in cave-dense regions that constitute the main geographic corridors of the USA. (Received January 24, 2014)

1097-92-242 **Abdul-Aziz Yakubu*** (ayakubu@howard.edu), Department of Mathematics, Howard University, Washington, DC 20509, and **Avner Friedman** (afriedman@math.osu.edu), MBI and The Mathematics Department, The Ohio State University, Columbus, OH 43210. *Anthrax epizootic and migration: Persistence or extinction.*

In this talk, we will use an extension of the deterministic mathematical model of an anthrax epizootic of Hahn and Furniss to study the effects of anthrax transmission, carcass ingestion, carcass induced environmental contamination, and migration rates on the persistence or extinction of animal populations. We will demonstrate that decreasing the levels of carcass ingestion by removal of carcasses in game reserves, for example, may not always lead to a reduction in the population of animals infected with anthrax. However, increasing levels of carcass induced environmental contamination rates in an enzootic anthrax region can result in the catastrophic extinction of a persistent animal population. (Received January 23, 2014)

1097-92-283 **Joseph H Tien*** (jtien@math.ohio-state.edu), **Zhisheng Shuai**, **Marisa Eisenberg** and **Pauline van den Driessche**. *Disease invasion of community networks with environmental pathogen movement.*

Consider a set of communities (patches), connected to one another by a network. When can disease invade this network? Intuitively, this should depend upon both the properties of the communities, as well as on the network structure. Here we make this dependence explicit for a broad class of disease models with environmental pathogen movement. In particular, the rooted spanning trees of the network and a generalization of the group inverse of the graph Laplacian play fundamental roles in determining the ability of disease to invade. (Received January 24, 2014)

1097-92-289 **Sivan Leviyang*** (sr286@georgetown.edu). *Accounting for Model Uncertainty in Early HIV Infection.*

Early HIV infection is still not well understood, making construction of models and estimation of parameters difficult. I will describe an approach for dealing with this uncertainty in the context of estimating CTL escape rates. CTLs are immune system cells that kill HIV infected cells depending on the viral genotype, thereby mediating selective pressure from which HIV escapes through mutation. Quantifying the rate of this escape is valuable in understanding the role of CTL response in HIV infection. (Received January 25, 2014)

1097-92-308 **Dustin Le** (dle2@utk.edu), College Scholars, University of Tennessee, Knoxville, TN 37996, and **Vitaly V. Ganusov*** (vitaly.ganusov@gmail.com), M409 Walters Life Sciences, University of Tennessee, Knoxville, TN 37996. *Using mathematical models to discriminate between different mechanisms of viral control in influenza infection.* Preliminary report.

Influenza virus causes infection of a limited duration in humans yet mechanisms that are responsible for viral clearance are not completely understood. It has been suggested that depletion of target cells, required for virus replication, can explain influenza dynamics. We show that target cell-limited model and models involving immune response-mediated viral clearance describe with similar quality the data on influenza dynamics in human volunteers. Interestingly, if virus control is achieved by the immune response, the model predicts that the immune response follows a switch-like kinetics: little or no control until peak of viral load, and rapid increase in response efficiency to a maximum level. We extend the models to allow for the action of a commonly used influenza antiviral drug olsetamivir (tamiflu) and demonstrate that none of the models explain well viral loss in treated patients if the major function of the drug is to block virus production by infected cells. Finally, we show that mechanism of virus control has the major impact on the kinetics of generation of olsetamivir-resistant variants during treatment. Taken together, our analysis illustrates the need for experimental tests of different mechanisms of influenza virus replication in humans. (Received January 25, 2014)

1097-92-347 **Henning S Mortveit*** (hmortvei@vbi.vt.edu), NDSSL M0477, Virginia Tech, 1880 Pratt Drive, Blacksburg, VA 24060. *Large-scale interaction-based epidemic models for between- and within-host dynamics.*

In this presentation we will describe the EpiSimdemics and ENISI models. EpiSimdemics is a flexible and highly detailed model for individual-based between-host epidemic simulations that has been used to guide public health policy in several studies. Similarly, ENISI is an interaction-based simulation model used to study within-host immune system dynamics. The talk will describe these models and cover some of the challenges that they face in terms of data quality and data management. Finally, there will be some thoughts on a mathematical framework for this type of interaction-based systems. (Received January 26, 2014)

1097-92-396 **Marco V. Martinez***, mvmartinez@noctrl.edu. *Optimal Control of the gypsy moth populations.*

The gypsy moth, Lymantria dispar (L.), is probably the most destructive forest defoliator in North America. Gypsy moth outbreaks tend to be spatially synchronized over areas across hundreds of kilometers. Outbreaks can result in loss of timber and other traditional forestry products. Greater losses tend to occur to the ecosystem services that forests provide. The United States can be divided in three different areas: A generally infested area (where gypsy moth populations are established), an uninfested area (populations are not established), or a transition zone between the two. There are different management programs matching these different areas. This work focuses in optimal control techniques for models of areas where the population is established or in the invasion front.

We design an objective functional to minimize the cost generated by the defoliation caused by the population of gypsy moth and the cost of controlling the population with an aerial spray. The objective was to develop an optimal control framework and perform numerical simulations for various scenarios, that seeks to minimize the total cost due to gypsy moth (damage plus control cost). (Received January 27, 2014)

1097-92-404 **Libin Rong*** (rong2@oakland.edu), Department of Mathematics and Statistics, Oakland University, Rochester, MI 48309. *Modeling hepatitis C virus dynamics in the era of new drugs.*

Chronic hepatitis C virus (HCV) infection remains a public health problem worldwide. Traditional therapy leads to viral elimination in less than 50% of treated patients. New treatment using direct-acting antiviral agents (DAAs) has significantly increased the cure rate. These new DAA drugs directly interfere with different steps in the HCV life cycle. Thus, existing models that do not consider intracellular processes may not be optimal in analyzing data from patients treated with these drugs. In this talk, I will discuss recent advances in developing multiscale mathematical models that can study HCV dynamics under therapy with new DAAs. The models include both intracellular viral replication and extracellular cell infection. I will address model analysis, approximation, comparison with experimental data, as well as the implications for developing new treatment strategies for hepatitis C. (Received January 27, 2014)

1097-92-407 **Robert Stephen Cantrell***, Department of Mathematics, The University of Miami, Coral Gables, FL 33124, and **Daniel Ryan**. *Avoidance behavior in intraguild communities: A cross-diffusion model.*

A cross-diffusion model of an intraguild predation community where the intraguild prey employs a fitness based avoidance strategy is examined. The avoidance strategy employed is to increase motility in response to negative local fitness. Global existence of trajectories and the existence of a compact global attractor is proved. It is shown that if the intraguild prey has positive fitness at some point in the habitat when trying to invade, then it will be uniformly persistent in the system if its avoidance tendency is sufficiently strong. This type of movement strategy can lead to coexistence states in which the intraguild prey is marginalized to areas with low resource productivity while the intraguild predator maintains high densities in regions with abundant resources, a pattern observed in many real world intraguild predation systems. (Received January 27, 2014)

1097-92-410 **Sergei S. Pilyugin***, Department of Mathematics, University of Florida, Gainesville, FL 32611-8105. *Analysis of a within-host virus model with cell-to-cell transmission.*

Recent experimental studies have shown that HIV can be transmitted directly from cell to cell when structures called virological synapses form during interactions between T cells. In this talk, I will present a within-host model of HIV infection that incorporates two mechanisms: infection by free virions and the direct cell-to-cell transmission. Mathematically, the model exhibits a standard dichotomy. Namely, if the basic reproduction number R0<1, the virus is cleared and the disease dies out; if R0>1, the virus persists in the host. Under additional assumptions, the unique positive equilibrium attracts all positive solutions. (Received January 27, 2014)

1097-92-411 **Erin N. Bodine*** (bodinee@rhodes.edu), 2000 N. Parkway, Rhodes College, Memphis, TN 38119, and **Marco V. Martinez**. *Optimal Genetic Augmentation Strategies for a Threatened Population.*

One conservation method of reducing species loss is to augment a declining/threatened wild population with individuals from a captive-bred or stable, wild population. This method is known as *species augmentation*. We have modeled the change in the frequency of a detrimental allele in a threatened population using the continent-island genetic population model. We use optimal control theory to determine augmentation strategies which minimize the presence of the detrimental allele in an endangered population in minimum time while minimizing the cost of augmenting the endangered population. We present the construction of the optimal control formulation, the necessary conditions for an optimal control, the characterization of an optimal control, and some numerical simulations. Additionally, we discuss some of the challenges of systematically exploring the effects of uncertain parameters in optimal control problems, and demonstrate a new method for quantifying the sensitivity of the optimal control strategy with respect to uncertain parameter values. (Received January 27, 2014)

1097-92-416 **Jorge X. Velasco-Hernandez*** (jx.velasco@gmail.com), Blvd Juriquilla 3001, Juriquilla, 76230 Querétaro, QRO, Mexico. *Some epidemiological patterns of acute respiratory infections.* Preliminary report.

We present a mathematical model for the dynamics of the observed interaction between influenza an RSV. The model is constructed as an attempt to expalain the observed dynamics of these viruses in the pediatric population of a cetral state hospital in San Luis Potosí State, Mexico. The model is used to incorporate climate variability and R_0 is estimated from data. The superinfection hypothesis is considered valid after model analysis and discusion. (Received January 27, 2014)

1097-92-428 **Megan Olivia Powell*** (mpowell@stfrancis.edu), 500 Wilcox St., Department of Mathematics, University of St. Francis, Joliet, IL 60435, and **Buddhi R Pantha**, **Judy Day** and **Angela Reynolds**. *Modeling in vitro studies of inhalation anthrax.*

In vitro studies of various strains of *Bacillus anthracis* have produced data on the germination, phagocytosis, killing, and replication of spores and vegetative bacteria. Some *in vivo* studies have indicated that exposure to low doses of inhalation anthrax, even in multiple doses, does not inevitably lead to infection and death as exposure to high doses does. Our goal is to understand what immune system mechanisms, shortly after exposure, are playing significant roles in clearing the infection at low doses. We are using the *in vitro* data to determine parameter ranges for our model to develop understanding of the variations in data produced by *in vivo* studies. (Received January 28, 2014)

1097-92-431 **Robert Stephen Cantrell**, **Chris Cosner*** (gcc@math.miami.edu), **Yuan Lou** and **Daniel Ryan**. *Evolutionary stability of ideal free dispersal in spatial population models with nonlocal dispersal.*

The dispersal of organisms has many significant ecological effects, and hence the evolution of dispersal has been a subject of considerable interest in evolutionary ecology. An important problem in the study of the evolution of dispersal is determining what kinds of dispersal strategies are evolutionarily stable in the sense that populations using them cannot be invaded by ecologically similar populations using other strategies. A class of strategies that have been shown to be evolutionarily stable in various contexts are those that produce an ideal free distribution of the population, that is, a spatial distribution where no individual can increase its fitness by moving to another location. This talk will present results on the evolutionary stability of ideal free dispersal strategies in the context of continuous time nonlocal dispersal models. These results partially extend some recent work on the evolutionary stability of ideal free dispersal for reaction-advection-diffusion equations and discrete diffusion models to nonlocal dispersal models. They also include an extension of an inequality from matrix theory to the case of nonlocal dispersal operators, which may be of independent interest. (Received January 27, 2014)

1097-92-436 **Louis J Gross*** (gross@nimbios.org), NIMBioS - Claxton Hall, Room 106, 1122 Volunteer Blvd., University of Tennessee, Knoxville, TN 37996-3410. *Perambulations around Biology, Control and Education with Suzanne.*

This talk will cover a variety of research and education topics and projects in mostly ecological areas that were in collaboration with, motivated by, or fostered by my esteemed colleague and UTK Chancellor's Professor, Suzanne Lenhart. It will focus on our developments in the field of spatial control for resource management and note several areas that I consider fertile ground for new mathematical/computational efforts. On educational issues, I will discuss the major forces driving quantitative education for life science students today and provide suggestions for mathematically-focused educators to enhance the efforts of life science faculty to mentor "fearless biologists". (Received January 27, 2014)

1097-92-439 **Buddhi R Pantha*** (pantha@math.utk.edu), Department of Mathematics, The University of Tennessee, 208 Ayres Hall 1403 Circle Drive, Knoxville, TN 37996, and **Suzanne Lenhart**. *Optimal Control in PDE/DE Model for an Anthrax Epizootic.* Preliminary report.

Anthrax is a fatal, infectious disease which occurs in many animal species, particularly land mammals. It is a cause of population decline in several national parks worldwide such as in bison at northern Canada in 1993[1]. Due to the ability for anthrax spores to survive in soil for a long time even under harsh conditions, clearing anthrax spores from the environment is practically impossible. As infected animals die, their carcasses contribute bacteria in the surrounding environment. Proper disposal of the carcasses and effectively controlling new infections are feasible ways to help control the disease[2]. In this talk, I will present some preliminary results of these measures of controlling the spread of the disease.

References

[1] Gates, C.C. et.al *Investigation, Control, and Epizootiology of Anthrax in Geographically Isolated, Free-Roaming Bison Population in Northern Canada.* Can J Vet Res 1995; 59: 256-264.

[2] WHO, WOAH, FAOUN *Anthrax in Humans and Animals.* Fourth edition, 2008.

(Received January 27, 2014)

1097-92-476 **Holly Gaff*** (hgaff@odu.edu), Department of Biological Sciences, 110 MGB, Old Dominion University, Norfolk, VA 23529, and **Elsa Schaefer**, **Alexis White** and **Daniel Sonenshine**. *Modeling tick control through the use of a tick-killing robot.* Preliminary report.

TickBot 3.0 is a remote controlled car frame modified to follow a guide wire track while dragging a cloth treated with a chemical that kills ticks on contact. TickBot 3.0 was pilot tested at Hoffler Creek Wildlife Preserve (HC) located in Portsmouth, Virginia, USA, during May-July 2013. A series of experiments were designed to demonstrate the ability of the robot to reduce tick populations and thus reduce the threat of tick-borne diseases in a given area. TickBot uses the basics of tick biology to lure the ticks to a cloth that is treated with permethrin, which will kill the tick on contact. The goal of the system is not to eradicate ticks, but rather the goal is to control the risks in a given space and to provide the ability to create a safe space to enjoy nature. Overall, the TickBot was highly effective in reducing the overall tick densities close to zero for nearly 24 hours with the treatment that included both carbon dioxide and the treated cloth. Discussion will focus on how to use models to estimate optimal guide wire layout and frequency of treatment for future studies. (Received January 28, 2014)

1097-92-515 **Matthew T. Martin*** (mmartin42@my.apsu.edu), **Samuel N. Jator** and **Chad S. Brooks**. *Development of Mathematical Model to Understand Spread of Lyme Disease.* Preliminary report.

A model is constructed for determining the degree at which evolving disease spreads spatially and validated using Lyme disease as a case study. Lyme disease is the most prevalent disease spread by arthropods in the United States. The causative agent of Lyme disease has been found to be the bacterium *Borrelia burgdorferi*. An understanding of the spread of *B. burgdorferi* through geographical space is of importance in understanding how to best combat the disease. *B. burgdorferi* has a complex life cycle in which it is transmitted to various hosts by tick vectors and back into ticks from the same hosts. Models using a reaction-diffusion approach have been used in the past, but were limited to considering small mammals. Although small mammals are thought to be the most important reservoirs for *B. burgdorferi*, birds have also been shown to carry the disease. Migratory birds may contribute significantly to the spread of Lyme disease over long distances. In order to create a more robust model of the spread of Lyme disease, the effects of migratory birds on *B. burgdorferi* spread have been examined in a new model. (Received January 28, 2014)

93 ► Systems theory; control

1097-93-23 **Qing Zhang*** (qingz@math.uga.edu) and **Qingshuo Song**. *Pairs trading.*

Pairs trading is one of the risk-neutral or statistical arbitrary-free trading strategies. The idea is to monitor two historically correlated securities. When divergence is underway, i.e., one stock moves up while the other moves down, a pairs trade is entered which consists of a pair to short the outperforming stock and to long the underperforming one. Such a strategy bets the "spread" between the two would eventually converge. In this talk, a difference of the pair is governed by a mean-reverting model. The objective is to trade the pair so as to maximize an overall return. A fixed commission cost is charged with each transaction. In addition, a stop-loss limit is imposed as a state constraint. The associated HJB equations (quasi-variational inequalities) are used to characterize the value functions. It is shown that the solution to the optimal stopping problem can be obtained by solving a number of quasi-algebraic equations. Numerical examples are also reported to demonstrate the results. (Received December 04, 2013)

1097-93-181 **Louis Tebou*** (teboul@fiu.edu), Department of Mathematics and Statistics, Florida International University, Miami, FL 33199. *Simultaneous controllability of some uncoupled semilinear wave equations.* Preliminary report.

We consider the controllability problem for some uncoupled semilinear wave equations with proportional, but different principal operators in a bounded domain. The control is locally distributed, and its support satisfies the geometric control condition of Bardos-Lebeau-Rauch. First, we examine the case of a nonlinearity that is asymptotically linear; using a combination of the Bardos-Lebeau-Rauch observability result for a single wave equation and a new unique continuation result for uncoupled wave equations, we solve the underlying linear control problem. The linear controllability result thus established, generalizes to higher space dimensions an earlier result of Haraux established in the one-dimensional setting. Then, applying a fixed point argument, we derive the controllability of the nonlinear problem. Afterwards, we use an iterative approach to prove a local controllability result when the nonlinearity is super-linear. (Received January 21, 2014)

BALTIMORE, MD, March 29–30, 2014

Abstracts of the 1098th Meeting.

00 ► General

1098-00-2 **L. Mahadevan**, Harvard University, Pierce Hall, 29 Oxford St, Cambridge, MA. *Title to be announced.*

The range of shapes in the plant (and animal) world is "enough to drive even the sanest man mad", wrote Darwin. Motivated by qualitative and quantitative biological observations, I will show that there is a "method in the madness" - using examples of growth and form in tissues and organs such as the coiling of tendrils, the undulating fringes on a leaf or petal, the looping and patterning of the gut . In each case, we will see how a combination of biological and physical experiments, mathematical models and computations allow us to unravel the quantitative basis for the diversity and complexity of biological form, and suggest new questions in geometry and analysis. No text available. (Received April 16, 2013)

1098-00-48 **Steven J Miller*** (sjm1@williams.edu), 18 HOXSEY ST, WILLIAMSTOWN, MA 01267. *Virus Dynamics on Star Graphs.*

The field of epidemiology has presented fascinating and relevant questions for mathematicians, primarily concerning the spread of viruses in a community. The importance of this research has greatly increased over time as its applications have expanded to also include studies of electronic and social networks and the spread of information and ideas. We develop techniques to analyze in detail the evolution of the systems over time coming from star graphs. We obtain detailed descriptions of the dynamical behavior by a mix of convexity results and an analysis of partial fixed curves arising from the corresponding difference equations. Our methods supplement other techniques in the literature by describing how the system approaches its equilibrium. Specifically, we determine the path the system takes to equilibrium as a function of the cure and infection parameters and the number of spokes n. For each n we prove the existence of a critical threshold relating the two rates. Below this threshold, the virus always dies out; above this threshold, all non-trivial initial conditions iterate to a unique non-trivial steady state. We end with some generalizations to other networks. This is joint work with Thealexa Becker, Alec Greaves-Tunnell, Aryeh Kontorovich and Karen Shen. (Received December 27, 2013)

1098-00-203 **Suzanne L. Weekes*** (sweekes@wpi.edu), Dept. of Mathematical Sciences, WPI, 100 Institute Road, Worcester, MA 01609. *Undergraduate Research on Real-World Problems: Opportunities at WPI and through the PIC Math Program.*

The Center for Industrial Mathematics and Statistics (CIMS) at Worcester Polytechnic Institute (WPI) builds partnerships with business and industry to provide opportunities for our local math community to work on real-life mathematical problems that come directly from industry and that are of direct importance to the companies. We do this for WPI students during the academic year, and for other students nationwide via the NSF-supported WPI REU Program in Industrial Mathematics and Statistics. Students work under the guidance of a faculty member and a company representative to develop solutions of real value to the company.

We also describe a new national program, Preparation for Industrial Careers in the Mathematical Sciences (PIC Math) which is funded by the NSF. PIC Math is a comprehensive program which aims to increase awareness among mathematical sciences faculty and undergraduates about non-academic career options; provide students with research experience working on real problems from business, industry and government; and prepare students for industrial careers. (Received January 26, 2014)

1098-00-209 **Alexander Tovbis*** (alexander.tovbis@ucf.edu), Orlando, FL 32816, **Marco Bertola**, Montreal, Quebec , Canada, and **Alexander Katsevich**, Orlando, 32816. *Singular value decomposition of a finite Hilbert transform defined on several intervals and the interior problem of tomography with prior knowledge: the Riemann-Hilbert problem approach.*

We study the asymptotics of singular values and singular functions of a Finite Hilbert transform (FHT), which is defined on several intervals I. Transforms of this kind arise in the study of the interior problem of tomography, in particular, interior problem with the prior knowledge. We suggest a novel approach based on the technique of the matrix Riemann-Hilbert problem (RHP) and the nonlinear steepest descent method of Deift-Zhou. In particular, the SVD problem is reduced to the family of RHPs with a spectral parameter λ, and the singular values corresponds to the values of λ when the RHP has no solution. The nonlinear steepest descent method is used to calculate the asymptotics of singular values and singular functions. The answers are obtained in terms of the hyperelliptic Riemann surface $\mathcal{R}$, associated with intervals I, which include normalized holomorphic differentials and Riemann Theta function on $\mathcal{R}$. (Received January 26, 2014)

1098-00-231 **Elizabeth T Brown*** (brownet@jmu.edu), Department of Mathematics and Statistics, MSC 1911, James Madison University, Harrisonburg, VA 22807. *Closing the Circle: the Use of Meetings to Complete and Promote Undergraduate Research.*

This talk will discuss the role conferences can play in promoting and supporting undergraduate research. Conferences complete the cycle of scholarship, from question to conclusion to dissemination, with new questions arising from old. Conferences thus serve students who have conducted research whilst helping to recruit new students for the future.

We will outline the motivation, successes, and challenges of the Shenandoah Undergraduate Mathematics and Statistics (SUMS) conference. Now in its tenth year, SUMS at James Madison University is an annual event featuring undergraduate research in mathematics, statistics, and their applications. SUMS is funded by the MAA Regional Undergraduate Mathematics Conferences Program and local sources at the university, with an annual attendance of around 300.

A primary focus of discussion will be how faculty and institutions can create, sustain, and maximize conferences that disseminate undergraduate research. The key limiters of funding and human capital will be center stage. There is not one template for what a successful event looks like, but we hope that sharing our triumphs and mistakes can be useful. We conclude with a discussion of needed next steps in the mathematical community's push toward increasing undergraduate research. (Received January 26, 2014)

1098-00-275 **Xiaojun Huang**, 110 Frelinghuysen Rd., Piscataway, NJ 08854, **Xiaoshan Li**, Wuhan University, Wuhan, Hubei 430072, Peoples Rep of China, and **Ming Xiao*** (xmg512@gmail.com), 110 Frelinghuysen Rd., Piscataway, NJ 08854. *Non-embeddability into a fixed sphere for a family of compact real algebraic hypersurfaces.*

We study the holomorphic embedding problem from compact real algebraic hypersurfaces into a shpere. By our theorem, for any integer N, there is a family of compact strongly pseudoconvex hypersurfaces in $\mathbb{C}^2$, none of which can be locally holomorphically embedded into the unit sphere in $\mathbb{C}^N$. This shows that the Whitney (or Remmert) type embedding theorem in differential topology(or in the Stein space theory, respectively) does not hold in the setting above. (Received January 27, 2014)

01 ► History and biography

1098-01-149 **Deborah J Bennett*** (dbennett@njcu.edu), Mathematics Department, NJCU, 2039 Kennedy Blvd., Jersey City, NJ 07305. *Venn/Euler/Leibniz Diagrams.* Preliminary report.

Having remained unpublished for over two hundred years, the universal genius Gottfried Wilhelm Leibniz's manuscripts of 1686 illustrated the four different Aristotelian propositions by the use of drawings of groups of circles. In 1761, the much-admired master mathematician Leonhard Euler used the same diagrams without reference to Leibniz. One hundred and twenty years later, John Venn ingeniously altered what he called "Euler circles" to become the diagrams that we now attach to Venn's name. This talk will explore the history of the Venn diagram, created by Leibniz. (Received January 22, 2014)

03 ► Mathematical logic and foundations

1098-03-52 **Dr. Deepika Garg*** (deepikanit@yahoo.co.in), H.No. 1054, Matuti Kunj, Bhondsi Village ,Sohna Road, Gurgoan, Haryana 122001, India, and **Dr. Kuldeep Kumar**. *Artificial Neural Networks: Mapping Device for Availability Analysis.* Preliminary report.

In this paper algorithm based upon artificial neural networks (ANNs) approach is proposed to predict an unknown mapping i.e. availability function of a manufacturing system namely tab manufacturing plant. Data of availability testing of several years is taken from management of concern plant. This data is used to train and validate the neural network. Afterward validated neural network is used to predict the availability of concern plant. Main objective of using neural network approach is that no assumption, no explicit coding of the problem, no complete knowledge of system configuration is required, only raw data about system failure and repair is required. (Received December 30, 2013)

05 ► Combinatorics

1098-05-84 **Shiyu Li**, **Steven Miller** and **Philip Tosteson*** (ptoste@umich.edu). *Coin flips, Fibonacci numbers and the longest gap!*

A beautiful proposition of Zeckendorf states that any integer may be written uniquely as a sum of non-adjacent Fibonacci numbers. This can be generalized to any sequence defined by a recurrence relation with positive coefficients, uniting Fibonacci decompositions and binary expansions. Given these Zeckendorf representations, we consider a statistic: the longest gap between summands. Given the Zeckendorf representation for a number x, the longest gap of x is the largest space between summands in its representation. We consider the distribution of the longest gap of numbers in the interval $[G_n, G_{n+1})$ and look asymptotically for large n n. There is a direct connection between the longest gap and the longest run of heads after flipping a coin n times, given by taking the special case $G_{n+1} = 2G_n$. Extending results on the longest run of heads, we find that the distribution is strongly concentrated with finite variance about the mean, which grows on the order of $\log n$ with computable constants depending on the recurrence. We discuss the difficulties of numerically exploring our results for indices on the order of a million (it is necessary to explore such large values as the rate of convergence is at most on the order of the logarithm of the index). (Received January 12, 2014)

1098-05-105 **Brigitte Servatius*** (bservat@wpi.edu), Mathematical Sciences, WPI, 100 Institute Road, Worcester, MA 01609-2280. *Constructing finite zeolites.* Preliminary report.

In materials chemistry, a zeolite is a crystalline solid formed of units consisting of a silicon (or other tetrahedrally coordinated) atom surrounded by four covalently bonded oxygen atoms. Each oxygen has the opportunity to form another bond, but the bond angles in the unit forbids a bond between the oxygens of the same unit as well as more than one bond between oxygens of different units, so it is common for each unit to bond at the oxygens to four distinct other units. A key feature of zeolites is the presence of relatively large empty regions (pores) within the solid through which other molecules, such as water or hydrocarbons, may pass, so zeolites are useful in many applications as a micro-filter. They are usually modeled as infinite periodic structures. However, the underlying graph of a zeolite is the line graph of a 4-regular graph and there are aperiodic and finite examples. The question arises which of these combinatorial examples have geometric realizations as unit distance graphs with non-intersecting tetrahedra in 3-space and whether or not the finite examples possess the key properties of the infinite ones. (Received January 16, 2014)

1098-05-264 **Kevin T. Campbell***, 330 North Washington St., Gettysburg, PA 17325. *Covering Everything: An Exploration of h-Critical Numbers.*

Given an h, m, and a group $\mathbb{Z}_n$, $\rho(\mathbb{Z}_n, m, h)$ defines the smallest possible size of an $h-$fold sumset of A, where A is a subset of $\mathbb{Z}_n$ and A has size m. We define an $h-$fold sumset of A as the set that is given by the sum of h not necessarily distinct values in a set A, where each value is taken modulo n. An $h-$critical number is the minimum value of m such that $\rho(\mathbb{Z}_n, m, h) = n$. That is, if a subset A of a finite abelain group G is at least the size of the $h-$critical number of G, then the $h-$fold sumset of A will span G. Thus far, I have created bounds for all $h-$critical numbers, found an explicit equation for any $h-$critical number for all values of h where the ambient group has a size that is an even number or a prime, and I have a conjecture to cover all other cases. (Received January 27, 2014)

1098-05-311 **James Allen Fill***, jimfill@jhu.edu, and **Alan D. Sokal**. *The leading root of a formal power series $f(x,y) = \sum_{n=0}^{\infty} a_n(y)\, x^n$, with connections to probability.* Preliminary report.

This talk will concern the "leading root" (unique power-series root) $x_0(y)$ of a formal power series $f(x,y) = \sum_{n=0}^{\infty} a_n(y)\, x^n$, where the series $a_n(y)$ have nonzero constant terms for $n = 0, 1$ and for $n \geq 2$ satisfy modest smallness conditions such as $a_n(y) = O(y^{\alpha(n-1)})$ for some $\alpha > 0$. Problems of this type arise frequently in combinatorics, statistical mechanics, number theory, and analysis.

A prominent example is the "deformed exponential function" (DE)

$$f(x,y) = \sum_{n=0}^{\infty} \frac{y^{n(n-1)/2}}{n!} x^n.$$

For this example, let $U(y) := -x_0(y)$. Extensive numerical computations lead to the conjecture that $U(y)$ has all strictly positive coefficients; and, even more strongly, that $F(y) := 1 - [1/U(y)]$ has all strictly positive coefficients after the vanishing constant term. This is just the proverbial tip of the iceberg, in that similar positivity properties, both for the leading root and for approximations to the leading root used for efficient computation of its coefficients, are conjectured for wide families of examples that include DE.

There are almost no proofs available yet for these conjectures, but I will discuss exceptions. I will also discuss several connections of these problems with probability. (Received January 28, 2014)

11 ► Number theory

1098-11-157 **A. Bourla***, American University, Washington, DC 20016. *Diophantine Approximation on Continued Fraction-like Expansions.*

We establish arithmetic and geometric properties for bi-sequences of approximation coefficients associated with the naturalextension of maps, leading to continued fraction-like expansions. These maps are realized as the fractional part of Möbius transformations which carry the end points of the unit interval to zero and infinity. Results will also apply to the classical regular and backwards continued fractions expansions, which are realized as special cases. These include a formula for the recovery of the entire bi-sequence from a pair of consecutive terms. (Received January 23, 2014)

1098-11-299 **Robert Erdahl*** (robert.erdahl@queensu.ca), Department of Mathematics, Queen's University, Kingston, Ontario K7L 3N6, Canada. *Parity centres and dual lattice polytopes for parallelohedra.* Preliminary report.

If a d-dimensional polytope P has the property that a selection of translates fit together facet-to-facet to tile space, then P is called a parallelohedron. We use the notation T(P) to denote such tilings by parallelohedra. In such cases P must be centrally symmetric, and the centers of the tiles form a lattice L(P). If two tiles touch, the midpoint of the lattice vector between centers lies on the boundary of both. We will refer to such points on the boundary of P, and on the boundary of all other tiles in T(P), as parity centers. The tiling T(P) is invariant with respect to inversion through all such parity centers.

Associated with the tiling T(P) is a dual tiling D(P) that I will define during the course of my lecture. There are many open questions regarding the structure of this tiling that are currently under investigation, but some very basic facts are known: It is known that the cells of this tiling are convex lattice polytopes, and that the dual tiling D(P) is invariant with respect to inversion through all parity centers. Using these basic features I will show how all 4-dimensional dual lattice polytopes can be enumerated. (Received January 28, 2014)

15 ► Linear and multilinear algebra; matrix theory

1098-15-25 **Nakhila Mistry*** (nmistry@elon.edu), 5732 Campus Box, Elon, NC 27244, and **Crista Arangala**. *Music Genomics: Applying Seriation Algorithms to Billboard #1 Hits.*

Music plays a prominent role in society and companies have even started studying its aspects for commercial purposes. It is only natural to ask what are the characteristics that make certain songs appealing. While much research has been conducted on the mathematical principles of sound, there has been less focus on analyzing the structure of popular songs from a mathematical perspective. One mathematical tool that researchers have used to study this is seriation, ordering. Seriation algorithms are frequently used for companies with an online presence, including Google, Facebook, Amazon, and Pandora, to understand the traits of what users like in order to attract more consumers. We will use these types of seriation algorithms to conduct a mathematical analysis of the structural qualities of music. We will test whether the same structural traits appear in an artist's songs as the songs of the artists that they cite as musical influences. In order to musically link the chosen artists, we will use applied linear algebra methods. Results show that an artist's songs have a higher quantitatively measured connection with the artists they cite as influences rather than the artists who they never mention as musical influences. (Received November 25, 2013)

1098-15-215 **Jiyuan Tao***, 4501 North Charles Street, Baltimore, MD 21210. *Thompson's triangle inequality in Euclidean Jordan algebras.* Preliminary report.

In this talk, we present Thompson's triangle inequality in Euclidean Jordan algebras and its applications. (Received January 26, 2014)

16 ► Associative rings and algebras

1098-16-239 **Bernd Souvignier*** (souvi@math.ru.nl), IMAPP, Faculty of Science, Radboud University Nijmegen, Postbus 9010, 6500 GL Nijmegen, Netherlands, 6500 GL Nijmegen, Netherlands. *Relations between icosahedral polytopes induced by group ring elements.*

The symmetry operations considered in classical crystallography are isometries which preserve lengths and angles. In some situations, however, it is beneficial to consider a larger class of operations. It is well-known that scalings play an important role in the analysis of quasicrystals via inflation rules, but they also occur naturally in the description of biomacromolecules, relating an inner channel to the outer hull of the molecule.

It was observed by A. Janner that the enclosing forms of macromolecules can often be described by star polygons which explain that the scalings found take special values related e.g. to the golden ratio (in case of 5- or 10-fold symmetry) or $\sqrt{2}$ (in case of 8-fold symmetry). A closer analysis of the intersection points of the different star polygons in a regular n-gon shows that the ratios between the radii of these points often correspond to units in the integral group ring of the corresponding cyclic group.

This immediately raises the question whether units in group rings of other groups also give rise to interesting geometric relations. We give an affirmative answer by demonstrating that the group ring of the icosahedral group provides a wealth of relations between various polytopes with icosahedral symmetry. (Received January 27, 2014)

20 ► Group theory and generalizations

1098-20-45 **Sang-hyun Kim** and **Thomas Koberda***, PO Box 208283, New Haven, CT 06520-8283. *Anti-trees and right-angled Artin subgroups of planar braid groups.*

We discuss a new result which shows that every right-angled Artin group quasi–isometrically embeds in a planar pure braid group. As a consequence, we obtain examples of quasi–isometrically embedded closed hyperbolic manifold subgroups of pure braid groups up to dimension eight. (Received December 26, 2013)

1098-20-63 **Mladen Bestvina**, Math Dept, University of Utah, SLC, UT 84112, and **Mark Feighn***, Math Dept, Rutgers University, Newark, NJ 07102. *The geometry of Out(F_n).* Preliminary report.

I will discuss work with Mladen Bestvina using the geometry of Culler-Vogtmann's Outer space to explore outer automorphism groups of free groups. (Received January 07, 2014)

1098-20-64 **Richard P Kent*** (rkent@math.wisc.edu), 480 Lincoln Drive, Madison, WI 53706. *Congruence subgroup problems.*

It is a theorem of Bass, Lazard, and Serre, and, independently, Mennicke, that the special linear group $\mathrm{SL}(n;\mathbb{Z})$ enjoys the congruence subgroup property when n is at least 3. This property is most quickly described by saying that the profinite completion of the special linear group injects into the special linear group of the profinite completion of Z. There is a natural analog of this property for mapping class groups of surfaces. Namely, one may ask if the profinite completion of the mapping class group embeds in the outer automorphism group of the profinite completion of the surface group. I'll discuss what's known about this problem, including a reduction to a question about centralizers. (Received January 07, 2014)

1098-20-74 **Massimo Nespolo*** (massimo.nespolo@crm2.uhp-nancy.fr), BP 70239, Boulevard des Aiguillettes, 54506 Vandoeuvre-les-Nancy, France, **Mohamed Amine Marzouki** (mohamed-amine.marzouki@crm2.uhp-nancy.fr), BP 70239, Boulevard des Aiguillettes, 54506 Vandoeuvre-les-Nancy, France, and **Bernd Souvignier** (souvi@math.ru.nl), Toernooiveld 1, 6525 ED Nijmegen, Netherlands. *The staurolite enigma solved through the analysis of the pseudo-eigensymmetry of crystallographic orbits.* Preliminary report.

Staurolite is an enigmatic mineral characterized by a high degree of pseudo-symmetry, which frequently occurs twinned. It gives two twins with different occurrence frequency, the Greek cross (lower frequency) and the Saint Andrews cross (higher frequency) but to date no explanation has been found for their different occurrence frequency. We have analyzed the structure of staurolite in terms of the pseudo-eigensymmetry of the crystallographic orbits building this structure and found that: 1) the set of oxygen atoms has a pseudo-cubic eigensymmetry which contains the twin operations of both twins, which justifies the high frequency of twinning of this mineral; 2) a subset of the tetrahedral cations has an eigensymmetry which contains the twin operation of the Saint Andrews cross, but not that of the Greek cross; 3) a subset of the octahedral cations has an eigensymmetry which contains the twin operation of the Greek cross and a larger subset has an eigensymmetry

which contains the twin operation of the Saint Andrews. The substructure approximately restored by the twin operation is thus more important for the Saint Andrews cross, which justifies its higher occurrence frequency (Received January 10, 2014)

1098-20-87 **Yago Antolin*** (yago.antolin.pichel@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *Residual finiteness of some outer automorphism groups.*

In this talk I will present my work together with Minasyan and Sisto on commensurating endomorphism of acylindrically hyperbolic groups. We show that any commensurating endomorphism of an acylindrically hyperbolic groups is inner modulo a small perturbation. We use this result to prove that the outer automorphism group of a virtually special group or the fundamental group of some compact 3-manifold is residually finite. (Received January 13, 2014)

1098-20-95 **Asaf Hadari*** (asaf.hadari@yale.edu), 10 Hillhouse Ave. C/O Dept. Of Mathematics, New Haven, CT 06517. *Homological shadows and mapping tori.*

Suppose $f \in \mathrm{Aut}(F_n)$ is a fully irreducible automorphism, $x \in F_n$ is a word, and $k \gg 0$. We will discuss the set $\{ab(w)\}$, where ab is the abelianization map, and w ranges over all subwords of $f^k(x)$. Then, we will discuss the connections between this set and mapping tori. (Received January 15, 2014)

1098-20-117 **Richard D Canary**, **Michelle Lee** and **Matthew Stover***, Department of Mathematics, Temple University, 1805 N. Broad Street, Philadelphia, PA 19122. *Amalgam Anosov representations.*

Let Γ be a torsion-free hyperbolic group, G a real semisimple Lie group with finite center, and X the character variety of representations of Γ into G. I will discuss joint work with Dick Canary and Michelle Lee on the action of $\mathrm{Out}(\Gamma)$ on X. When Γ is a surface group and G is $\mathrm{PSL}_2(\mathbb{R})$ this already includes the mapping class group action on Teichmüller space. There the action is properly discontinuous, and Goldman conjectured that the action is ergodic on the other components of X. For general Γ and G, Labourie and Guichard–Weinhard introduced the subset X_A of Anosov representations in X, and X_A shares many of the well-known properties of Teichmüller space, including proper discontinuity of the $\mathrm{Out}(\Gamma)$-action. Using Sela's structure theory for hyperbolic groups, I will explain how to build larger domains of discontinuity, which indicate that the dynamics of $\mathrm{Out}(\Gamma)$ on X can be much more complicated than the classical setting. (Received January 19, 2014)

1098-20-127 **Spencer Dowdall*** (dowdall@illinois.edu), Department of Mathematics, 1409 W Green Street, Urbana, IL 61801, and **Ilya Kapovich** and **Christopher J. Leininger**. *Fibrations and polynomial invariants for free-by-cyclic groups.*

The beautiful theory developed by Thurston, Fried and McMullen provides a near complete picture of the various ways a hyperbolic 3–manifold M can fiber over the circle. Namely, there are distinguished convex cones in the first cohomology $H^1(M;\mathbb{R})$ whose integral points all correspond to fibrations of M, and the dynamical features of these fibrations are all encoded by McMullen's "Teichmüller polynomial."

This talk will describe recent work developing aspects of this picture in the setting of a free-by-cyclic group G. Specifically, I will introduce a polynomial invariant that determines a convex polygonal cone $\mathcal{C}$ in the first cohomology of G whose integral points all correspond to algebraically interesting splittings of G. The polynomial invariant additionally provides a wealth of dynamical information about these splittings. This is joint work with Ilya Kapovich and Christopher J. Leininger. (Received January 20, 2014)

1098-20-191 **Mathieu Carette*** (mathieu.carette@uclouvain.be), Department of Mathematics, McGill University, 805, Sherbrooke Street West, Montreal, Quebec H3A 2K6, Canada. *Quasi-isometry and commability for groups acting on trees.*

Commability was recently introduced as an intermediate notion between commensurability and quasi-isometry. I will describe the first examples of finitely generated groups which are quasi-isometric but not commable. I will also discuss the commability class of F_2 among locally compact groups. This is joint work with Romain Tessera. (Received January 25, 2014)

1098-20-246 **Matt Clay**, **Johanna Mangahas*** (mangahas@math.brown.edu) and **Alexandra Pettet**. *Volume of periodic free factors and an algorithm to detect full irreducibility.*

We provide an effective algorithm for determining whether an element ϕ of the outer automorphism group of a free group is fully irreducible. Our method produces a finite list which can be checked for periodic proper free factors. (Received January 27, 2014)

1098-20-290 **Aaron Abrams*** (abramsa@wlu.edu), Mathematics Department, Washington and Lee University, Lexington, VA 24450, and **Noel Brady**, **Pallavi Dani** and **Robert Young**. *Homological and homotopical Dehn functions are different.*

The usual (homotopical) Dehn function of a group measures the difficulty of filling curves with disks in (a model space for) the group. The homological Dehn function measures the difficulty of filling curves with chains rather than with disks. I will describe examples of finitely presented groups whose homological Dehn functions are much smaller than their usual Dehn functions. These examples were recently published in joint work with Noel Brady, Pallavi Dani, and Robert Young. (Received January 28, 2014)

22 ► Topological groups, Lie groups

1098-22-3 **Nimish A. Shah*** (shah@math.osu.edu), The Ohio State University, 100 Math Tower, 231 West 18th Ave., Columbus, OH 43210-1174. *Homogeneous dynamics and its interactions with number theory.*

Several questions about Diophantine approximation or counting of integral or rational points associated to geometric objects involve two types of groups of symmetries - an infinite discrete group Γ associated to the arithmetic quantities, and a continuous group H associated to the geometric side. These groups may arise as subgroups of a Lie group $G = \mathrm{SL}(n, \mathbf{R})$. The study of dynamical properties of the left action of H on G/Γ, namely *homogeneous dynamics*, provides deep insights into the original number theoretic problem.

Margulis' resolution of Oppenheim conjecture in the late eighties attracted great attention to the power of this method. Ratner's theorems on algebraic rigidity of unipotent dynamics in the early nineties, and the work of Lindenstrauss on rigidity properties of the diagonal group actions in the last decade have lead to tremendous growth of techniques and scope of applications of this field.

In this talk we will explore some examples of important number theoretic questions answered via homogeneous dynamics. We will then describe more recent developments on this theme. (Received January 29, 2014)

1098-22-68 **Gregory S Chirikjian*** (gregc@jhu.edu), Prof. Gregory Chirikjian, Department of Mechanical Engineering, Johns Hopkins University, Baltimore, MD 21218. *Motion-Space Manifolds in Macromolecular Crystallography.*

X-ray crystallography is a powerful experimental method that has been used to determine the atomic structure of almost one-hundred-thousand protein and nucleic-acid structures. A computational approach called molecular replacement (MR) is a well established method for phasing of x-ray diffraction patterns for crystals composed of biological macromolecules. In MR, a search is performed over possible positions and orientations of a biomolecular structure within a model of the crystallographic asymmetric unit, or, equivalently, multiple symmetry-related molecules in the unit cell. Whereas the set of motions of a rigid-body freely moving in space forms a group, i.e., the group of proper rigid-body transformations, SE(3), and the chiral crystallographic symmetry group of a macromolecular crystal is a subgroup of SE(3), the coset space resulting from the quotient of SE(3) by its crystallographic subgroups have not been studied extensively in the past. This is quite surprising for two reasons: (1) these coset spaces are in fact the natural configuration spaces for MR searches; (2) there is mention of the compactness of similar spaces in the statement of Hilbert's 18th Problem, 100 years ago. Properties of these 'motion space' manifolds are investigated in this presentation. (Received January 08, 2014)

1098-22-193 **Jonathan Novak*** (jnovak@math.mit.edu), 77 Massachusetts Avenue, Cambridge, MA 02139. *How to integrate on U(N).*

Suppose f is a regular function on the unitary group $U(N)$. How can one compute the integral of this function against Haar measure? I'll explain a representation-theoretic method to accomplish this, which reduces the problem to counting certain walks on the Cayley graph of the symmetric group. This technique has applications in random matrix theory and asymptotic representation theory, which I will also explain if time permits. Extending these methods to non-uniform measures on $U(N)$, e.g. those coming from heat kernels, is an open problem which seems to be in reach. (Received January 25, 2014)

30 ► Functions of a complex variable

1098-30-153 **Khim Raj Shrestha***, 115 Carnegie Building, Syracuse University, Syracuse, NY 13244.
Weighted Hardy Spaces.

The classical notion of Hardy spaces has a long and venerable history. In 2008 Poletsky and Stessin introduced such spaces on hyperconvex domains in the paper *Hardy and Bergman spaces on hyperconvex domains and their composition operators*. In their definition Hardy space depends on (pluri)subharmonic exhaustion function of a domain and this new definition of Hardy space subsumes the old definition. For example for the classical case the exhaustion function is $\log|z|$ or $|z|^2-1$. So even on the disc there is an abundance of Hardy Spaces. In our talk we will present their definition and show that most of the classical properties stay true for new spaces. (Received January 22, 2014)

1098-30-252 **Dan Volok*** (danvolok@math.ksu.edu), 138 Cardwell Hall, Kansas State University, Manhattan, KS 66506. *Rational discrete analytic functions.*

One of the peculiarities of discrete complex analysis is that the usual point-wise product of two discrete analytic functions is not discrete analytic, in general. For example, on the integer lattice in the complex plane the finctions z and z^2 are discrete analytic, but the function z^3 is not. We shall discuss a suitable product of Cauchy-Kovalevskaya type, which preserves the discrete analyticity, and the structure of discrete analytic functions, which are rational with respect to this product.

This is joint work with Daniel Alpay (Ben Gurion University of the Negev), Palle Jorgensen (University of Iowa), Fernando Roman (Kansas State University) and Ron Seager (Kansas State University). (Received January 27, 2014)

1098-30-254 **Arash Karami*** (akarami@math.jhu.edu), 2735 saint paul street, Apt 5, Baltimore, MD 21218. *Asymptotics of the partial Szegö kernels and zeros of random polynomials on Reinhardt domains.* Preliminary report.

For a strictly pseudoconvex Reinhardt domain Ω with smooth boundary in $\mathbb{C}^{m+1}$ and a positive smooth measure μ on the boundary of Ω , we consider the ensemble $\mathcal{P}_N$ of polynomials of degree N with the Gaussian probability measure γ_N which is induced by $L^2(\partial\Omega, d\mu)$. Our aim is to compute the scaling limit distribution function and scaling limit pair correlation function for zeros near a point $z \in \partial\Omega$. First, we apply the stationary phase method to the Boutet de Monvel-Sjöstrand Theorem to get the asymptotic for the scaling limit partial Szegö kernel around $z \in \Omega$. Then by using the Kac-Rice formula, we compute the scaling limit distribution and pair correlation functions. (Received January 27, 2014)

32 ► Several complex variables and analytic spaces

1098-32-14 **Bingyuan Liu*** (bingyuan@math.wustl.edu), Saint Louis, MO 63130. *Recent results on noncompact automorphism groups.*

Let $\mathbb{C}^n$ be a bounded domain. It was a long time ago when mathematicians started to consider a group of automorphisms $\phi_j \in Aut(\Omega)$ which is not compact. Greene and Krantz gave a conjecture that the orbit accumulation point is finite type in the early 90s. We are going to review some relative results over the past 20 years and problems remaining to be solved. As the second part of this talk, we consider the property of noncompact automorphism groups from another aspect, namely, to check whether the domain is globally pseudoconvex. Some partial results have been studied in various papers under the hypothesis of local pseudoconvexity around orbit accumulation point. At the last, we introduce a brand new result in case of $\mathbb{C}^2$. With an assumption in regularity of the boundary of the domain in $\mathbb{C}^2$, if there is at least one hyperbolic orbit accumulation point p, the domain will be globally pseudoconvex. If there is time, more further results will also be introduced. (Received October 19, 2013)

1098-32-114 **Ozcan Yazici*** (oyazici@syr.edu), Mathematics Department, 215 Carnegie Building, Syracuse, NY 13244. *Extension of plurisubharmonic functions with logarithmic growth.*

Let X be an algebraic subvariety of $\mathbb{C}^n$ and $\overline{X}$ be its closure in $\mathbb{P}^n$. Coman-Guedj-Zeriahi proved that any plurisubharmonic function with logarithmic growth on X extends to a plurisubharmonic function with logarithmic growth on $\mathbb{C}^n$ when the germs $(\overline{X}, a)$ in $\mathbb{P}^n$ are irreducible for all $a \in \overline{X} \setminus X$. In this talk we will consider X for which the germ $(\overline{X}, a)$ is reducible for some $a \in \overline{X} \setminus X$ and we give a necessary and sufficient condition for X so that any plurisubharmonic function with logarithmic growth on X extends to a plurisubharmonic function with logarithmic growth on $\mathbb{C}^n$. (Received January 18, 2014)

1098-32-169 **Jeffrey S Case***, jscase@math.princeton.edu, and **Paul Yang**. *A Paneitz-type operator for CR pluriharmonic functions.*

We introduce a new fourth order CR invariant operator on pluriharmonic functions on a three-dimensional CR manifold, generalizing to the abstract setting the operator discovered by Branson, Fontana and Morpurgo. For a distinguished class of contact forms, all of which have vanishing Hirachi-Q curvature, these operators determine a new scalar invariant with properties analogous to the usual Q-curvature. We discuss how these are similar to the (conformal) Paneitz operator and Q-curvature of a four-manifold, and describe its relation to some problems for three-dimensional CR manifolds. (Received January 24, 2014)

1098-32-240 **Richard Alan Wentworth*** (raw@umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742, and **Benjamin Sibley** (bsibley@math.umd.edu), Max Planck Institute for Mathematics, Vivatsgasse 7, 53111 Bonn, Germany. *A singular Bott-Chern formula and gauge theory.*

This talk will present a formula relating the second Chern character of a hermitian holomorphic vector bundle to that of the associated graded sheaf with respect to a filtration by reflexive subsheaves. This generalizes the classical Bott-Chern formula when the subsheaves are holomorphic subbundles. The proof relies on a monotonicity formula and the gauge fixing theorems of Uhlenbeck. (Received January 27, 2014)

1098-32-249 **Junyan Zhu*** (jyzhu@math.jhu.edu), 3400 N. Charles St., Krieger 404, Baltimore, MD 21218. *Asymptotics of Hole Probability for $SU(m+1)$ Gaussian Random Polynomials.*

We gave a way to compute the asymptotics of the hole probability that an $SU(m+1)$ Gaussian random polynomial never vanishes on a polydisk of radius $r \geq 1$. This is analogous to A. Nishry's result on Gaussian entire functions. In the case of $m = 1$, we compute the hole probability for all $r > 0$ and the probability that an $SU(2)$ Gaussian random polynomial has no more than k zeros in a disk of radius r, for each k finite. (Received January 27, 2014)

34 ► Ordinary differential equations

1098-34-126 **Tracy Weyand*** (tweyand@math.tamu.edu) and **Gregory Berkolaiko**. *Stability of Eigenvalues of Quantum Graphs with Respect to Magnetic Perturbation.*

We consider the eigenvalues of the magnetic Schrödinger operator on a quantum graph as functions of the magnetic potential. We establish a simple relation between the Morse index of the magnetic eigenvalue and the number of zeros of the corresponding non-magnetic eigenfunction. This highlights an intricate relationship between the zeros of an eigenfunction and the stability of the corresponding eigenvalue under magnetic perturbation.

In particular, let $\{\sigma_j\}_{j=1}^{\beta}$ be a set of generators of the fundamental group of a quantum graph Γ. The eigenvalues of the magnetic Schrödinger operator may be considered as functions of the magnetic flux $\boldsymbol{\alpha} = (\alpha_1, \ldots, \alpha_\beta)$ where $A(x)$ is the magnetic potential on Γ and

$$\alpha_i = \oint_{\sigma_j} A(x)\, dx.$$

Let ψ be the n-th eigenfunction of the ordinary Schrödinger operator (no magnetic potential) and let ϕ denote the number of zeros of ψ on Γ. We demonstrate that $\boldsymbol{\alpha} = (0, \ldots, 0)$ is a non-degenerate critical point of $\lambda_n(\boldsymbol{\alpha})$ with Morse index equal to the nodal surplus of ψ, which is $\phi - (n-1)$. (Received January 26, 2014)

1098-34-259 **Maria E Markovich*** (mm0283@ship.edu) and **Luis Melara** (lamelara@ship.edu). *Modeling the Cellular Dynamics of Multiple Sclerosis.* Preliminary report.

Multiple Sclerosis is an autoimmune disease that targets the central nervous system, specifically the myelin sheath. Symptoms of this disease include loss of muscle control, dizziness, and visual impairment. Because of the autoimmune nature of Multiple Sclerosis, all of the cells involved are self-cells. We develop a simple system of ordinary differential equations describing the interactions of leukocytes, oligodendroglia, and myelin. Our model can yield insight into the deterioration of the myelin sheath. This degradation may eventually result in Multiple Sclerosis. (Received January 27, 2014)

35 ► Partial differential equations

1098-35-54 **Alexandra Lynn Zeller** (azeller@masonlive.gmu.edu), 6178 Otter Run Ct., Clifton, VA 20124, and **Padmanabhan Seshaiyer*** (pseshaiy@gmu.edu), 4400 University Dr, Fairfax, VA 22030. *Mathematical Modeling of Dynamic Social Processes.*

This project models the social interactions of human immigration and emigration within regions. Distinctive scenarios are proposed to impact the population movements between locations. Potential applications are discussed and include disease outbreaks, regulatory influences, and language differences. Mathematical modeling is combined with quantitative sociology in a system of differential equations that accurately projects a dynamic social process. This project also projects ways to estimate the various parameters involved in this model. The model then estimates values for both equivalent and different population sizes. In terms of future work, a specific application will be chosen and then usable data will be collected regarding the population movements. Specifically, this project hopes to address a number of new ideas including making the regulatory parameters dynamic. Also, the project will continue the parameter estimation process, eventually using real data to evaluate the error for this model. Finally, we would like to perform stability analysis on the model. Then, this will be used to better the model even further. (Received January 01, 2014)

1098-35-106 **Adekunle Ademola Araromi*** (adekunle_yem@yahoo.ca), P. O. Box 491, Oyo, Oyo State, Nigeria. *The solution of linear Klein-Gordon equatios using Reduced Differential Transform method (RDTM).*

In this research, the Reduced Differential Transform Method (RDTM) is used to solve linear Klein-Gordon equations. Examples are presented to show the ability of the method for solving and obtaining the exact solutions of these equations. The results reveal that the method is very effective, efficient and simple. It is also consistent with the method of variational iteration method (VIM) (Received January 17, 2014)

1098-35-147 **Julian Edward*** (edwardj@fiu.edu), Department of Mathematics, Florida International University, Miami, FL 33199, and **Nina Avdonina**, Department of Mathematics, University of Alaska at Fairbanks, Fairbanks, AK. *Inverse problem for networks of strings with attached masses.*

We consider the inverse problem of a non-homogeneous string with a mass attached. Suppose one is given as data the dynamical Dirichlet to Neumann map for a sufficiently large time interval. The boundary control method is adapted to use this data to determine the length of the string, the mass and its location, and the density function of the string. The method is then extended to trees-like networks of strings with masses located at the nodes. An application to biology is also discussed. (Received January 23, 2014)

1098-35-152 **Lorena Bociu*** (lvbociu@ncsu.edu), Department of Mathematics, Box 8205, NC State University, Raleigh, NC 27695, and **Jean-Paul Zolesio**. *Optimal Control in a Free Boundary Fluid-Elasticity Interaction.* Preliminary report.

The talk addresses the problem of minimizing turbulence inside fluid flow in the case of a free boundary interaction between a viscous fluid (described by the 3D Navier-Stokes equations) and a moving and deforming elastic body (modeled by the nonlinear equations of elastodynamics.). This is particularly relevant in the design of small-scale unmanned aircrafts and the problem of reducing turbulence in blood flow in stenosed or stented arteries. The issue is addressed from the point of view of optimal control, i.e. determining the optimal action upon the system in order to minimize turbulence within the flow. (Received January 22, 2014)

1098-35-175 **John Matthews*** (matt-matthews@utc.edu), 615 McCallie Ave, Dept 6956, Chattanooga, TN 37363, **Boris P Belinskiy** (boris-belinskiy@utc.edu), 615 McCallie Ave, Dept 6956, Chattanooga, TN 37363, and **Sergei A Avdonin** (saavdonin@alaska.edu), Fairbanks, AK 99775. *Local Approaches to Reconstruction on the Semi-Axis.*

The reconstruction of the potential for a wave equation on a semi-axis is demonstrated with local versions of the Gelfand-Levitan and Krein equations and the linear version of Simon's approach. In all cases the problem is reduced to a Fredholm integral equation of the second kind. The resulting problems are then resolved numerically with a second order accurate scheme, and the efficacy of these local approaches is demonstrated. Construction of accurate data from the forward problem is also described. (Received January 24, 2014)

1098-35-188 **Sergei Avdonin*** (s.avdonin@alaska.edu), Department of Mathematics and Statistics, Fairbanks, AK 99775-6660. *Source Identification for the Wave Equation on Graphs.*

In this talk we consider source identification problems for the wave equation on trees and graphs with cycles. The main advantage of our approach is its locality: to recover unknown coefficients on a part of the graph we use an information relevant only to this subgraph. This feature of our method allows us to propose a very efficient identification algorithm which is new even for an interval and much more simple than known algorithms.

The talk is based on join work with Serge Nicaise. (Received January 25, 2014)

1098-35-190 **Charles L. Epstein** (cle@math.upenn.edu), 209 South 33rd Street, Philadelphia, PA 19104-6395, and **Camelia A. Pop*** (cpop@math.upenn.edu), 209 South 33rd Street, Philadelphia, PA 19104-6395. *Smoothness of solutions and Harnack inequality for Kimura diffusion operators.*

Motivated by applications to population genetics, we consider a boundary-degenerate elliptic operator, the so-called Kimura diffusion operator. We prove that the solutions of the homogeneous initial-value parabolic problem defined by the Kimura operator with continuous initial data, become smooth up to the boundary of the domain. In addition, we prove that the nonnegative solutions satisfy the Harnack inequality. The difficulty of studying the smoothness of solutions and the Harnack inequality comes from the degeneracy of the operator. Our method of the proof is based on arguments specific to stochastic analysis. (Received January 25, 2014)

1098-35-224 **Abdon Eddy Choque Rivero*** (abdon.ifm@gmail.com), Universidad Michoacana de San Nicolas de Hida, CU Edificio C3A, IFM, 58000 Morelia, Morelia, Mexico. *The boundary control method applied to two velocity tree—like graph inverse problem.* Preliminary report.

We investigate the inverse problem of a two–velocity wave equation on a tree—like graph. A two component vector displacement is assumed to hold on each edge of the studied graph. Physical properties of the graph as the densities and lengths of each string, and also the topology of the tree as well as the angles between branching edges are recovered from the given data.

We extend the approach and result of the paper: (S. Avdonin, G. Leugering and V. Mikhaylov, *On an inverse problem for tree-like networks of elastic strings*, Zeit. Angew. Math. Mech., **90** (2010), 136–150) to the case of variable velocities. It is shown that the inverse problem can be uniquely solved by applying measurements at all, or at all but one, boundary vertices.

This is a preliminary result based on a joint work with S. Avdonin and V. Mikhaylov.
(Received January 26, 2014)

1098-35-229 **Kurt E. Anderson**, **Scott Manifold** and **Jonathan Sarhad*** (jonathan.sarhad@ucr.edu). *Reaction-diffusion-advection in stochastically generated tree graphs.* Preliminary report.

A reaction-diffusion-advection equation is used to model population persistence in rivers. Persistence is given by the instability of the zero steady-state (i.e., persistence requires that a population be able to grow at low density). We use a principal eigenvalue analysis to determine stability. Previous work extended this type of analysis to compact metric trees, providing insight into how geometric features of trees affect the principal eigenvalue, and hence persistence. In the current work, we apply this model to stochastically generated metric trees in the service of comparing the robustness of various geometric features as indicators of persistence. The Dirichlet condition is used for the root boundary, while upstream boundaries and junctions are assumed to be zero flux. Our model features sectional areas, representing available habitat, assigned to graph edges. We have identified a distance, CM, related to the distribution of volume in a tree, as a promising indicator of persistence: Numerical results for stochastic trees show that CM out performs other metrics which have been considered, such as maximum (or minimum) distance from root to upstream boundary and the total volume of a tree. (Received January 26, 2014)

1098-35-267 **Kamran Sadiq**, 4000 Central Florida Blvd., Orlando, FL 32816, and **Alexandru Tamasan*** (tamasan@math.ucf.edu), 4000 Central Florida Blvd., Orlando, FL 32816. *Range characterization of the attenuated Radon transform of symmetric tensors in the plane.* Preliminary report.

In this talk I will address the range conditions on the (attenuated) Radon data of symmetric tensors in the plane. The conditions are based on a Hilbert transform (see the talk of K.Sadiq in this session) associated with the A-analytic maps a la Bukhgeim. This is a preliminary work report. (Received January 27, 2014)

1098-35-292 **Kamran Sadiq*** (ksadiq@knights.ucf.edu), 4000 Central Florida Blvd., Orlando, FL 32816, and **Alexandru Tamasan** (tamasan@math.ucf.edu), 4000 Central Florida Blvd., Orlando, FL 32816. *The Range of the Radon Transform of a compactly supported function.*

We present new necessary and sufficient conditions for a function on $\partial\Omega \times \mathbb{S}^1$ to be in the range of the (non) attenuated Radon transform of a sufficiently smooth function support in the convex set $\overline{\Omega} \subset \mathbb{R}^2$. The approach is based on an explicit Hilbert Transform associated with A-analytic functions in the sense of Bukhgeim. (Received January 28, 2014)

1098-35-312 **Chi Li*** (chi.li@stonybrook.edu). *A Pohozaev identity and critical exponents of some complex Hessian equations.*

We prove some non-existence results for Dirichlet problems of complex Hessian equations. The non-existence results are proved using the Pohozaev method. We also prove existence results for radially symmetric solutions. The main difference of the complex case from the real case is that we don't know if a priori radially symmetric property holds in the complex case. (Received January 28, 2014)

37 ► Dynamical systems and ergodic theory

1098-37-28 **Madhura Joglekar***, madhura@math.umd.edu, and **James Yorke**, yorke@umd.edu. *Periodic windows within windows within windows.*

For a dynamical system $x_{n+1} = f_C(x_n)$, there are often infinitely many periodic windows, that is, intervals in the parameter C in which there is stable periodic behavior, followed by period-doubling to chaos, followed by the merging of chaotic attractors, followed by a boundary crisis. The windows display a fractal structure, wherein each window has windows of higher orders. Fortunately there is one situation where these nested windows can be studied effectively, the quadratic map $f_C(x) = C - x^2$. For a given small $\epsilon > 0$, we say C is ϵ-uncertain if there is a periodic attractor for exactly one of the values C and $C + \epsilon$. The other presumably has chaotic behavior. We find that for ϵ very small, for the great majority of ϵ-uncertain pairs, one of the two parameters is in a very high order window, that is, a window within a window within a window ... N times for large N. (Received December 03, 2013)

1098-37-31 **Suddhasattwa Das*** (sdas11@umd.edu), 6100 44TH Place, Riverdale, MD 20737, and **James A Yorke**. *Avoiding extremes in chaotic systems.*

In chaotic dynamical systems subjected to disturbances which are stronger than the the available control, it is not possible to follow a particular trajectory but the system can be partially controlled to avoid extreme values by staying confined within some compact set. Economic models can be prone to crashes due to the presence of chaotic dynamics. This paper explains for a toy economic model how a general 1-dimensional system can be regulated by the application of relatively weak control, even in the presence of strong external disturbances, thereby avoiding severe downturns in the economy. This partial controllability is defined through the concepts of safe sets. We describe how the safe set varies with parameters, sometimes continuously or discontinuously. (Received January 23, 2014)

1098-37-102 **Lorenzo Sadun*** (sadun@math.utexas.edu), Department of Mathematics C1200, 2515 Dean Keaton, Austin, TX 78712. *Rigidity of Model Sets.* Preliminary report.

Many properties of tilings are defined by the combinatorics of the tiling (or an associated point pattern), while others are computed from the associated dynamical systems. So which combinatorial properties are preserved by topological conjugacies? It turns out the the property of being a model set, or even a Meyer set, is NOT preserved.

Suppose that Λ is a model set (aka cut-and-project pattern with a reasonably nice window), and suppose that Λ' is another point pattern, of finite local complexity, such that the dynamical systems defined by Λ and Λ' are topologically conjugate. Then either (a) Λ' is MLD to a reprojection of Λ, or (b) Λ' is not a model set, and is not even a Meyer set. I'll give an example of the second possibility. This is joint work with Johannes Kellendonk. (Received January 16, 2014)

1098-37-128 **Reem Yassawi*** (ryassawi@trenu.ca), Department of Mathematics, Trent University, 1600 West Bank Drive, Peterborough, Ontario K9J7B8, Canada, and **Eric Rowland**. *Using constant length substitutions to compute congruences of algebraic sequences.*

A sequence of integers $(a_k)_{k\in\mathbb{N}}$ is *algebraic* if its generating function $y = \sum_k a_k x^k$ is the root of a polynomial $P(x, y)$ with integer coefficients. Many combinatorial sequences, such as the Motzkin numbers or the Fibonacci numbers, are algebraic. A result of Christol, and also Denef and Lipshitz, tells us that given for any prime p and natural number m, the sequence $(a_k \mod p^m)_{k\in\mathbb{N}}$ is the letter to letter projection of a constant length p substitution. We apply this result to show that, for any such algebraic sequence (a_k), and any p and m, there is a constructive procedure to compute this sequence modulo p^m . We compute several examples, reproving several results in the combinatorics literature, and we also compute new congruences, such as for the Apéry numbers, which are not algebraic, but which are "diagonals" of higher dimensional algebraic arrays. We also discuss how these algebraic sequences naturally lead to a definition of a constant length substitution and corresponding subshift, on infinitely many letters. This is joint work with Eric Rowland. (Received January 20, 2014)

1098-37-133 **Natalie Priebe Frank**, **Samuel B.G. Webster*** (sbgwebster@gmail.com) and **Michael Whittaker**. *Fractal substitution tilings.*

Under mild hypotheses on a substitution tiling system, we may associate infinitely many new substitution tilings in which each tile has fractal boundary. We show that the new tilings constructed force the border and are MLD from the initial tiling. (Received January 21, 2014)

1098-37-142 **Aminur Rahman*** (ar276@njit.edu), 345 Belgrove Drive, Floor 1 (left door), Kearny, NJ 07032. *A Scheme for Modeling and Analyzing the Dynamics of Logical Circuits.*

It is shown how logical circuits can be modeled by discrete dynamical systems that preserve the qualitative behavior observed in physical realizations. While continuous dynamical systems provide quite accurate mechanistic models, they can become extremely computationally expensive to simulate. In contrast, simulating a discrete dynamical system is relatively inexpensive. A model for the RS flip-flop circuit, made with chaotic NOR gates, is found in an ad-hoc manner. This is shown to replicate the qualitative features of the physical realization. Next, a systematic - algorithmic - first principles based approach is developed in order for such dynamical models to more accurately reflect observed behavior and facilitate further investigation. Also, it is demonstrated how this fundamental algorithmic approach can, with similar ease, be used to obtain discrete dynamical models of other more complicated logical circuits. (Received January 21, 2014)

1098-37-160 **Uwe Grimm*** (uwe.grimm@open.ac.uk), Department of Mathematics and Statistics, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom, and **Michael Baake** (mbaake@math.uni-bielefeld.de), Faculty of Mathematics, University of Bielefeld, Postfach 100131, 33501 Bielefeld, Germany. *Squirals and lattice substitutions with singular continuous spectrum.*

The squiral tiling from Grünbaum and Shephard's monograph is equivalent to a binary bijective lattice substitution in the plane. In fact, it is a genuinely two-dimensional analogue of the classic Thue-Morse substitution. It is shown how the constructive approach due to Mahler and Wiener, as well as Kakutani, can be extended to prove that this system has purely singular continuous diffraction. The methods extend to higher dimensions and provide an alternative approach to results previously discussed by Natalie Frank. (Received January 23, 2014)

1098-37-164 **Terrence M Adams*** (tma4321@gmail.com) and **Andrew B Nobel**. *Slow weak mixing.*

We give a procedure for combining two ergodic measure preserving transformations, defined on the same Lebesgue probability space. Given any rigid ergodic transformation and corresponding rigidity sequence, we use this procedure to construct a weak mixing transformation with the same rigidity sequence. (Received January 23, 2014)

1098-37-167 **Christian Huck*** (huck@math.uni-bielefeld.de), Fakultät für Mathematik, Universität Bielefeld, Postfach 100131, D-33501 Bielefeld, Germany. *Dynamical properties of k-free lattice points.*

We revisit the visible points of a lattice in Euclidean n-space together with their generalisations, the kth-power-free points of a lattice, and study the corresponding dynamical system that arises via the closure of the lattice translation orbit. This is joint work with Michael Baake. (Received January 24, 2014)

1098-37-171 **Daniel J Thompson*** (thompson@math.osu.edu). *Entropy for generalized β-transformations.* Preliminary report.

Generalized β-transformations are the class of piecewise continuous interval maps given by taking the β-transformation $x \mapsto \beta x \pmod 1$, where $\beta > 1$, and replacing some of the branches with branches of constant negative slope. If the orbit of 1 is finite, then the map is Markov, and we call the map a PCF (post-critically finite) generalized β-transformation. We would like to describe the set of β for which these maps can be PCF. We know that β (which is the exponential of the entropy of the map) must be an algebraic number. Our main result is that the Galois conjugates of such β have modulus less than 2. This extends an analysis of Solomyak for the case of β-transformations, who obtained a sharp bound of the golden mean in that setting. (Received January 24, 2014)

1098-37-199 **Tyler M. White*** (tmwhite@nvcc.edu). *Topological Mixing Tilings of $\mathbb{R}^2$ Generated by a Generalized Substitution.*

Kenyon, in his 1996 paper, gave a class of examples of tilings of $\mathbb{R}^2$ constructed from generalized substitutions. These examples are topologically conjugate to self-similar tilings of the plane (with fractal boundaries). I have proven that an infinite sub-family of Kenyon's examples are topologically mixing. These are the first known examples of topologically mixing substitution tiling dynamical systems of $\mathbb{R}^2$. (Received January 25, 2014)

1098-37-213 **Amitabha Bose*** (bose@njit.edu), Dept. Mathematical Sciences, NJIT, Newark, NJ 07102. *Phase locking in coupled networks.*

In many prior studies, phase locking has been studied in weakly coupled networks. Here we consider a pair of cells coupled by inhibition in which the synapses are frequency dependent and not necessarily weak. We derive a 2-dim map to determine existence and stability of periodic phase locked solutions. Mathematical methods for the analysis of higher dimensional maps are introduced. (Received January 26, 2014)

1098-37-223 **Lloyd W West*** (lwest@gc.cuny.edu). *The moduli space of cubic rational maps.*

Rational maps on the projective line have long been studied from a dynamical point of view. The moduli space M_2 of quadratic rational maps has been explicitly described by Milnor and Silverman.

In this talk, we give an explicit description of the moduli space M_3 of cubic rational maps on $\mathbb{P}^1$. Moreover, using classical invariant theory, we solve the problem of field-of-moduli vs field-of-definition for this moduli space. (Received January 26, 2014)

1098-37-232 **Boris Solomyak** and **Konstantin Medynets*** (medynets@usna.edu). *A Second Order Ergodic Theorem for Self-Similar Tiling Systems.*

We consider infinite measure-preserving non-primitive self-similar tiling systems in Euclidean space $\mathbb{R}^l$. We establish the second-order ergodic theorem for such systems. The speed of convergence is determined by the Hausdorff dimension of a graph-directed set associated to the substitution rule. (Received January 26, 2014)

1098-37-245 **Michael Baake*** (mbaake@math.uni-bielefeld.de), Dept. of Mathematics, Bielefeld University, Bielefeld, Germany, and **Franz Gaehler** (gaehler@math.uni-bielefeld.de). *An exact renormalisation approach to primitive substitution rules.* Preliminary report.

The classic Fibonacci substitution is revisited from the point of view of constructing its autocorrelation via the solution of an exact renormalisation equation. This leads to an independent interpretation of pure point diffraction and dynamical spectrum. We discuss first steps how to extend this approach to more general substitution rules. (Received January 27, 2014)

1098-37-250 **Franz Gähler*** (gaehler@math.uni-bielefeld.de). *Decorated silver mean chain with mixed spectrum.*

We present a decorated version of the silver mean chain (SMC), which has a mixed diffraction spectrum with a pure point and a singular continuous component. This decorated SMC is generated by a primitive substitution rule. Geometrically, the tiles are the same as for the usual SMC, but tiles come now in two colors each. If tiles of opposite color are decorated with weights of opposite sign, a structure with a continuous diffraction spectrum is obtained, which is at least partially singular. Conversely, if tiles of opposite color are decorated the same way, the usual SMC is recovered, which has pure point spectrum. A generic decoration thus leads to a structure with mixed spectrum.

Examples of this kind can be constructed in a systematic way, also in higher dimensions. Starting with a substitution tiling known to be pure-point diffractive, we can split each tile into two subtypes, a barred and an unbarred variant. The two variants are then coupled by a suitable twist in the substitution rule, so that the twisted rule commutes with the bar operation. Under certain conditions, which we shall discuss and which are frequently met, a substitution tiling with mixed spectrum is obtained. (Received January 27, 2014)

1098-37-253 **Franz Gähler*** (gaehler@math.uni-bielefeld.de) and **Johan Nilsson**. *Primitive substitutions for higher-dimensional paper-folding structures.*

Paper-folding sequences are one of the well-known examples of aperiodically ordered structures. Some are known to be generated by a primitive substitution, which allows to prove important properties like unique ergodicity or pure point spectrum of the associated dynamical systems.

Recently, also higher-dimensional analogues of paper-folding structures have been proposed [S.I. Ben-Abraham et al., Acta Cryst. (2013) A69, 123-130], constructed via a recursive procedure (not a substitution). We show here that, in any dimension, these structures can also be generated by a primitive substitution. This allows us to prove that they give rise to dynamical systems (via the translation action on the hull) which are uniquely ergodic and have pure point spectrum. Knowledge of a generating substitution also allows to compute topological and dynamical invariants, as well as the complexity of these higher-dimensional paper-folding structures. (Received January 27, 2014)

1098-37-260 **Eric Forgoston*** (eric.forgoston@montclair.edu), **Lora Billings**, **M. Ani Hsieh**, **Ira B. Schwartz** and **Philip Yecko**. *Collaborative tracking and control in stochastic dynamical systems.*

We consider the problem of stochastic prediction and control in a time-dependent stochastic environment, such as the ocean, where escape from an almost invariant region occurs due to random fluctuations. Lagrangian Coherent Structures (LCS) are found using collaborative tracking, and a control policy is formulated that utilizes knowledge of the LCS. The control strategy is evaluated with experimental and ocean data. (Received January 27, 2014)

1098-37-265 **Joseph L Herning*** (jherning@nvcc.edu). *Bijective substitutions without pure discrete subshift factors.*

We show how to construct bijective substitutions which do not admit topological subshift factors with infinite pure discrete spectrum. We first show how in the case of certain constant-length substitutions it is possible to realize all non-trivial such factors as substitutions. Then, we find among bijective substitutions examples for which the process can never yield a coincident substitution. Finally I will show show some interesting visualizations of the spectra of substitution systems. (Received January 27, 2014)

1098-37-294 **Michael Marcondes de Freitas*** (marcfrei@math.rutgers.edu) and **Eduardo D. Sontag**. *Existence and uniqueness of an invariant point, and global attractiveness for a class of nonlinear, random difference equations.* Preliminary report.

We present a decomposition-based approach to the study of the asymptotic behavior of solutions of autonomous random difference equations of the form

$$x_{n+1} = g(\theta_n \omega, x_n)\,,$$

where $\theta : \Omega \times \mathbb{Z}_{\geqslant 0} \to \Omega$ is a stationary noise process. When this system can be realized as the "closed-loop" of the "random difference equation with inputs and outputs"

$$\begin{aligned} x_{n+1} &= f(\theta_n \omega, x_n, u_n(\omega)) \\ u_n(\omega) &= h(\theta_n \omega, x_n)\,, \end{aligned}$$

we may apply the stochastic "Small-Gain" Theorem proven for our newly developed concept of random dynamical systems with inputs and outputs (MMF & EDS, 2013) to establish global attractiveness for a class of monotone righthand-sides f and anti-monotone output functions h.

(MMF & EDS, 2013) Michael Marcondes de Freitas and Eduardo D. Sontag. **Random dynamical systems with inputs**. In Christian Poetzsche and Peter E. Kloeden, editors, *Nonautonomous Dynamical Systems in the Life Sciences*, volume 1202 of *Lecture Notes in Mathematics, Mathematical Biosciences Subseries*, chapter 2, pages 41–87. Springer, 2013.

(Received January 29, 2014)

1098-37-302 **Erblin Mehmetaj*** (erblinm@gwu.edu), Department of Mathematics, 2115 G Street, NW, Washington, DC 20052. *Generalized Continued Fraction Expansions.* Preliminary report.

I will consider generalized continued fraction expansions generated via the map $T_r : [0, 1) \to [0, 1)$ defined by

$$T_r(x) = \frac{r}{x} - \left\lfloor \frac{r}{x} \right\rfloor \quad \text{if} \quad x \neq 0 \quad \text{and} \quad T_r(0) = 0.$$

We call these expansions $r-$expansions. Every real number has an $r-$expansion. Also, for an $r-$expansion not all sequences of digits $(a_1, a_2, ...)$ are admissible. So, I will show that a sequence $(a_1, a_2, ...)$ is admissible if and only if the sequence itself and all of its shifts are alternating-lexicographically less than the $r-$expansion of 1. (Received January 28, 2014)

1098-37-333 **Jane Hawkins*** (jhawkins@nsf.gov), Division of Math Sciences, National Science Foundation, 4201 Wilson Blvd, Arlington, VA 22230. *Complex dynamics and symbolic dynamics.*

We give an overview of complex dynamics and symbolic dynamics, focussing on post critically finite rational maps. We discuss the classical Lattes examples and the symbolic dynamics that shows the isomorphism to Bernoulli shifts. We also mention a connection to tilings and work of others that sets the stage for the current study. (Received January 29, 2014)

1098-37-334 **Cesar E Silva*** (csilva@williams.edu), Mathematics Department, Williams College, Williamstown, MA 01267. *Weak mixing notions and examples for infinite measure-preserving transformations.* Preliminary report.

We will discuss various notions of weak mixing and examples for infinite measure-preserving transformations. (Received January 31, 2014)

39 ► Difference and functional equations

1098-39-83 **Harold M Hastings*** (hastingsmail@earthlink.net) and **Michael Radin**. *Time Scales, Switching, Control, Survival and Extinction in a Population Dynamics Model with Time-Varying Carrying Capacity.*

The Basener-Ross (2004) model is a system of two coupled logistic equations, one for a resource population and a second for a population which is harvesting that resource. This model has been used to model the collapse of the Easter Island population (Basener, Brooks, Radin, Wiandt 2008). We added a third equation to model a declining carrying capacity for the resource population, which might arise, for example, as a result of climate change. The resulting model displays a sharp transition between survival and extinction, depending upon how fast the harvesting population responds to the decline in resource production. Although this result is not of itself surprising, the surprising sharpness of the transition to extinction in finite time as the harvester time scale increases calls for an explanation. Further examination shows that increasing the harvester time scale shifts control from the resource population (reminiscent of a fishery model at low levels of effort) to virtually sole control by the harvester population (an analogue of extreme overfishing). We shall also briefly discuss extensions and generalizations. (Received January 12, 2014)

1098-39-115 **Daniel W. Cranston*** (dcranston@vcu.edu) and **Candace M. Kent**. *On the boundedness of positive solutions of the reciprocal max-type difference equation $x_n = \max_{1\le i\le t}\left\{\frac{A^i_{n-i}}{x_{n-i}}\right\}$ with periodic parameters.*

We investigate the boundedness of positive solutions of the reciprocal max-type difference equation

$$x_n = \max\left\{\frac{A^1_{n-1}}{x_{n-1}}, \frac{A^2_{n-1}}{x_{n-2}}, \ldots, \frac{A^t_{n-1}}{x_{n-t}}\right\}, \quad n = 1, 2, \ldots,$$

where, for each value of i, the sequence $\{A^i_n\}_{n=0}^{\infty}$ of positive numbers is periodic with period p_i. We give both sufficient conditions on the p_i's for the boundedness of all solutions and sufficient conditions for all solutions to be unbounded. This work essentially complements the work by Bidwell and Franke, who showed that as long as every positive solution of our equation is *bounded*, then every positive solution is eventually periodic, thereby leaving open the question as to when solutions are bounded. (Received January 19, 2014)

1098-39-144 **H. Sedaghat*** (hsedagha@vcu.edu). *Folding planar systems into second-order difference equations.*

We show how a planar system of difference equations may be folded into a second-order difference equation. Special cases are presented where useful global results are obtained by folding. (Received January 21, 2014)

1098-39-166 **Michael A. Radin*** (michael.radin@rit.edu), Rochester Institute of Technology, College of Science, School of Mathematical Sciences, Rochester, NY 14623, **Bernard P. Brooks** (bpbsma@rit.edu), Rochester Institute of Technology, College of Science, School of Mathematical Sciences, Rochester, NY 14623, and **Tamas I. Wiandt** (tiwsma@rit.edu), Rochester Institute of Technology, College of Science, School of Mathematical Sciences, Rochester, NY 14623. *Dynamics of a Discrete Population Model for Extinction and Sustainability in Ancient Civilizations.*

We start off with the Basener Ross-Model of Easter Island and then proceed with the progress on other models of Easter Island; in particular, the emphasis on the Logistic component in the model and its vital role. Furthermore, we will investigate how the introduction of rats on Easter Island accelerated the extinction process. Moreover,we will analyze the differences between the continuous and discrete models. (Received January 23, 2014)

1098-39-183 **Candace M. Kent*** (cmkent@vcu.edu), 3510 Hanover Avenue, Richmond, VA 23221-2208, and **Michael A. Radin**. *On the Boundedness of Positive Solutions of the Reciprocal Max-Type Difference Equation* $\max\left\{\frac{A_n}{x_{n-k}}, \frac{B_n}{x_{n-\ell}}\right\}$ *with Periodic Parameters.*

We investigate the unbounded behavior of positive solutions of the reciprocal max-type difference equation

$$\max\left\{\frac{A_n}{x_{n-k}}, \frac{B_n}{x_{n-\ell}}\right\}, \quad n = 0, 1, \ldots,$$

with positive periodic parameters and arbitrary delays. We give sufficient conditions on parameters and their periods for every solution to be unbounded. We also introduce the notion of *extended periodicity* of unbounded solutions, and then give sufficient conditions on the delays such that particular patterns of extended periodicity of unbounded solutions are attained. (Received January 25, 2014)

41 ► Approximations and expansions

1098-41-41 **Palle E Jorgensen*** (palle-jorgensen@uiowa.edu), MLH 14, Dept of Matheamtics, University of Iowa, Iowa City, IA 52242. *Harmonic analysis of non-overlapping frequency bands and representations.*

We study subdivision of analogue-signals into frequency bands in signal/image-processing. Motivated by applications to digital filters we suggest a new representation theoretic framework. We build particular representations creating both Hilbert space H and algebra representing digital subdivisions. This leads to a filtered system of closed subspaces in H such that "non-overlapping frequency bands" correspond to orthogonal subspaces in H; or equivalently to systems of orthogonal projections. Since the different frequency bands must exhaust the signals for the entire system, one looks for orthogonal projections which add to the identity operator in H. Since time/frequency analysis is non-commutative, one is further faced with a selection of special families of commuting orthogonal projections. From this and repeated subdivision sequences we generate recursive algorithms for new bases and frames including wavelet families. (Received December 24, 2013)

1098-41-131 **Dr. Atma Sahu*** (asahu@coppin.edu), 7704 Mystic River Terrace, Glenn Dale, MD 20769. *Using linguistic variables in approximating Fuzzy-logic smart-reasoning to extend the binary sense.*

This presentation will walk the fuzzy logic users from its' inception story by Lotfi Zadeh, a professor at the University of California at Berkley to today's fuzzy logic approaches as applied to control nonlinear systems that would be difficult or impossible to model mathematically. Additionally, this fuzzy logic methodology discourse will show conference attendees, some engineering applications, such as fuzzy logic thermostats system 's usage to control the heating and cooling, fuzzy logic methodology use in industrial automation; and later illustrate it's usage in decision making process and in data mining that uses, to some extent, many machine learning methods. (Received January 20, 2014)

1098-41-187 **Richard P. Pembroke*** (richpemb@yahoo.com), Richard Pembroke, Baltimore, MD 21210-1932. *Mapping the Regular Polygons onto the Circle.*

We consider the Schwarz- christofel integral which maps the circle onto the Nth order regular polygon. I propose to invert the mapping by a power series inversion of the integral. It appears that a 3 term inversion can map each regular polygon onto the circle to within 1 part in 1000. (Received January 25, 2014)

1098-41-258 **Marco Bertola*** (marco.bertola@concordia.ca), 1455 de Maisonneuve W., LB 901-29, Montreal, Quebec H3G 1M8, Canada, and **Alexander Katsevich** and **Alex Tovbis**. *Application of Theta functions to the singular value decomposition of a finite Hilbert transform and the interior problem of tomography.*

The study of asymptotic behaviour of singular values of the Finite Hilbert Transform (FHT) on several intervals is instrumental to the study of stability of the reconstruction problem.

Via the "nonlinear steepest descent method" we obtained rigorous asymptotic estimates (including bounds on the error terms) for both the singular functions and the singular values. These expressions use a class of special functions that generalize the Jacobi theta function $\vartheta(z;\tau)$ and are called Riemann-Theta functions. The talk will try to recall briefly how these functions are defined and how the zeroes of a suitably chosen Theta functions are related to the asymptotic behavior of the singular values. (Received January 27, 2014)

1098-41-308 **Kasso Okoudjou*** (kasso@math.umd.edu), University of Maryland, College Park, MD 20742, **Alexander Barg** (abarg@umd.edu), University of Maryland, College Park, MD 20742, and **Wei-Hsuan Yu** (mathyu@math.umd.edu), University of Maryland, College Park, MD 20742. *Two distance sets and finite unit norm tight frames.* Preliminary report.

In this talk I will present a characterization of the intersection of the set of two distance sets of N unit norm vectors in $\mathbb{R}^d$ and the class of finite unit norm tight frames. As a consequence we show that two distance sets can be constructed when a strongly regular graph with certain parameters exist. I will also present some new examples of two distance sets and describe the special case of equiangular lines. This is a joint work with A. Barg and W-H Yu. (Received January 28, 2014)

1098-41-314 **Julia Dobrosotskaya*** (jxd365@case.edu). *Variational imaging methods based on sparse representations.*

Replacing differential operators with the diffusive operators based on multiscale sparse representation systems, such as wavelets or composite wavelets (including shearlets), leads to the design of a new class of adaptively anisotropic operators.

Such operators are not meant to approximate the differential operators directly, but rather replace them in a variety of applied signal processing settings, such as diffuse interface approximations to the Total Variation functional - in such applications as inpainting, superresolution and more. Discrete transforms has been successfully used in this context as well.

This ongoing research aims at merging the knowledge and experience of the sparse systems, compressive sensing and PDE communities to create qualitatively new and highly adaptable methods for image analysis and reconstruction. (Received January 28, 2014)

42 ► Fourier analysis

1098-42-47 **Alex Iosevich*** (iosevich@math.rochester.edu), 145 Dunrovin Lane, Rochester, NY 14618. *Random walks, exponential sums and fractal sets.*

We shall discuss random walks in discrete and continuous settings and spectral properties of certain operators. (Received December 26, 2013)

1098-42-58 **Dorin Ervin Dutkay***, ddutkay@gmail.com. *Fuglede's conjecture in one dimension.*

Fuglede's conjecture states that a measurable set has an orthonormal Fourier basis if and only if it tiles the real line by translations. It connects the geometry of tiles to the harmonic analysis of spectral sets.

The conjecture is still open in dimension one. We will present some equivalent formulations and reductions to tiles and spectral sets in the integers. (Received January 04, 2014)

1098-42-66 **Deguang Han***, Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Matrix Fourier Multipliers for Parseval Multi-wavelet Frames.*

Matrix Fourier multipliers are matrices with L^∞-function entries that map Parseval multi-wavelet frames to Parseval multi-wavelet frames. Like Fourier wavelet multiplier, matrix Fourier multipliers can be used to derive new multi-wavelet frames and can help us better understand the basic theory of multi-wavelet frames. In this talk I will discuss a characterization of such matrix Fourier multipliers. This is a joint work with Z. Li. (Received January 08, 2014)

1098-42-108 **Marcin Bownik** and **Darrin Speegle***, speegled@slu.edu. *Linear independence of time-frequency translates in $\mathbb{R}^d$ of functions with decay.*

The HRT conjecture states that time-frequency translates of function in $L^2(\mathbb{R})$ are linearly independent. Previous work of the authors established that functions on $\mathbb{R}$ with sufficiently good one-sided decay have linearly independent translates. In this talk, we review the known results, and establish the linear independence of time-frequency translates for functions f on $\mathbb{R}^d$ having one sided decay $\lim_{x\in H,\ |x|\to\infty} |f(x)|e^{c|x|\log|x|} = 0$ for all $c > 0$, which do not vanish on a half-space $H \subset \mathbb{R}^d$. (Received January 17, 2014)

1098-42-121 **Susanna Spektor*** (sanaspek@gmail.com), University of Alberta CAB 632, Edmonton, Alberta T6G 2G1, Canada, and **Ron Kerman**, Brock University, St. Catharines, Ontario L2R 1H5, Canada. *Approximation of almost time and band limited functions by finite Hermite series.*

We prove that a function that is almost time and band limited is well represented by a certain truncation of its expansion in the Hermite basis. (Received January 20, 2014)

1098-42-163 **Linh Viet Nguyen*** (lnguyen@uidaho.edu), Department of Mathematics, University of Idaho, 875 Perimeter Drive MS 1103, Moscow, ID 83844-1103. *On A Reconstruction Formula for Spherical Radon Transform : A Microlocal Analytic Point of View.*

Let $\mathcal{R}$ be the restriction of the spherical Radon transform to the set of spheres centered on a hypersurface $\mathcal{S}$. In this talk, we discuss the construction of a function f from $\mathcal{R}(f)$ by a closed-form formula. We approach the problem by studying an oscillatory integral, which depends on the observation surface $\mathcal{S}$ as a parameter. We then derive various microlocal analytic properties of the associated closed-form reconstruction formula. (Received January 23, 2014)

43 ► Abstract harmonic analysis

1098-43-29 **Vignon Oussa***, 131 Summer Street, Bridgewater, MA 02325. *An Abstract harmonic analysis approach to Gabor analysis.* Preliminary report.

Let Γ be a discrete group generated by translation and modulation operators on $\mathbb{R}^d$. Precisely, let B be an invertible rational matrix and assume that translation and modulation operators are parametrized by $\mathbb{Z}^d$ and $B\mathbb{Z}^d$ respectively. Let π be the corresponding unitary representation of Γ. In this talk, we provide an explicit decomposition of π into its irreducible components. We will discuss the applications of this decomposition in Gabor analysis. This work extends some previous results of Fuhr proved for the particular case where $d = 1$. (Received December 05, 2013)

1098-43-119 **Isaac Z. Pesenson*** (pesenson@temple.edu). *Sampling formulas for one-parameter groups of operators in Banach spaces.*

Some results about sampling of entire functions of exponential type extended to one-parameter groups of isometries acting in Banach spaces. By using generator D of one-parameter group e^{tD} of isometries of a Banach space E we introduce Bernstein subspaces $\mathbf{B}_\sigma(D)$, $\sigma > 0$, of vectors f in E for which trajectories $e^{tD}f$ are abstract-valued functions of exponential type which are bounded on the real line. This property allows to reduce sampling problems for $e^{tD}f$ with $f \in \mathbf{B}_\sigma(D)$ to known sampling results for regular functions of exponential type σ. (Received January 19, 2014)

1098-43-140 **Jens Gerlach Christensen*** (jchristensen@colgate.edu), **Karlheinz Gröchenig** (karlheinz.groechenig@univie.ac.at) and **Gestur Ólafsson** (olafsson@math.lsu.edu). *Representation theoretic approach to atomic decompositions of Bergman spaces on the unit ball.* Preliminary report.

We will present a representation theoretic approach to atomic decompositions of Bergman spaces on the unit ball. The representations in question are the discrete series representations of $SU(n, 1)$, and sampling results on reproducing kernel Banach function spaces on this group provide atomic decompositions. This is joint work with Karlheinz Gröchenig and Gestur Ólafsson. (Received January 21, 2014)

1098-43-207 **Dorin Dutkay** and **John Haussermann*** (jhaussermann@knights.ucf.edu). *Tiling properties of spectra of measures.*

We investigate tiling properties of spectra of measures, i.e., sets Λ in $\mathbb{R}$ such that $\{e^{2\pi i\lambda x} : \lambda \in \Lambda\}$ forms an orthogonal basis in $L^2(\mu)$, where μ is some finite Borel measure on $\mathbb{R}$. Such measures include Lebesgue measure on bounded Borel subsets, finite atomic measures and some fractal Hausdorff measures. We show that various classes of such spectra of measures have translational tiling properties. This lead to some surprising tiling properties for spectra of fractal measures, the existence of complementing sets and spectra for finite sets with the Coven-Meyerowitz property, the existence of complementing Hadamard pairs in the case of Hadamard pairs of size 2,3,4 or 5. In the context of the Fuglede conjecture, we prove that any spectral set is a tile, if the period of the spectrum is 2,3,4 or 5. (Received January 26, 2014)

1098-43-303 **Benjamin Manning*** (manning5@math.umd.edu), University of Maryland, Mathematics Building, College Park, MD 20742. *Subspaces of $L^2(\mathbb{R})$ Invariant Under Crystallographic Shifts.*

We present a generalization of the theory of translation-invariant subspaces to a class of subspaces invariant under shifts from a crystallographic group. Since these groups are non-commutative, operator valued brackets replace scalar valued brackets to prove various classifications of shift-invariant subspaces that are analogous to well known classifications of translation-invariant subspaces. Additionally, we demonstrate how our tools developed from this shift-invariant subspace theory apply to the theory of Composite-Dilation Wavelets. (Received January 28, 2014)

44 ► Integral transforms, operational calculus

1098-44-135 **Alexander Katsevich*** (alexander.katsevich@ucf.edu). *Broken ray transform: inversion and a range condition.*

In this talk we study a class of Broken-Ray transforms (BRT), which can be implemented with flat and/or curved detectors. In the case of two detectors we obtain an inversion formula, which involves a second order derivative of the data and integration along characteristics. In the case of three detectors, we obtain an inversion formula, which is purely local and involves only the first order derivatives of the data. Hence the formula solves the interior problem. Neither the object nor the source and detectors require to be rotated in order to obtain a complete data set. We also prove a theorem, which describes the range of the BRT in the case of three detectors. Finally, the results of numerical experiments are presented. (Received January 21, 2014)

1098-44-198 **Gaik Ambartsoumian***, gambarts@uta.edu, and **Rim Gouia-Zarrad** and **Sunghwan Moon**. *Inversions of the V-line and conical Radon transforms with a fixed opening angle.*

We present exact inversion formulas for two related generalized Radon transforms. The first one, called V-line Radon transform, integrates a 2D function along V-shaped piecewise linear trajectories with a fixed angle between two rays. The second one, called a conical Radon transform, integrates a 3D function over circular cones with a fixed opening angle. Such transforms appear in various mathematical models in medical imaging, nuclear industry and homeland security. (Received January 25, 2014)

45 ► Integral equations

1098-45-39 **Mark Hubenthal*** (hubenjm@math.uh.edu), University of Houston, Department of Mathematics, 651 PGH, Houston, TX 77204-3008. *The Broken Ray Transform in n Dimensions with Flat Reflecting Boundary.*

This article is concerned with the broken ray transform on n-dimensional Euclidean domains where the reflecting parts of the boundary are flat. In particular, given a subset E of the boundary $\partial\Omega$ such that $\partial\Omega \setminus E$ is itself flat (contained in a union of hyperplanes), we measure the attenuation of all broken rays starting and ending at E with the standard optical reflection rule applied to $\partial\Omega \setminus E$. The main technique is to localize the measurement operator around broken rays which reflect off a fixed sequence of hyperplanes and then to apply the analytic microlocal approach of Frigyik, Stefanov, and Uhlmann for the ordinary X-ray transform via a path unfolding. We can then establish injectivity and stability under certain conditions. This generalizes the author's previous result for the square, although we can no longer treat reflections from corner points. (Received December 23, 2013)

1098-45-234 **Michael Horst*** (michael.horst@asu.edu), **R A Renaut** (rosie.renaut@asu.edu) and **Yang Wang** (ywang@math.msu.edu). *Validity of down-sampling data for regularization parameter estimation when solving large scale ill-posed inverse problems.*

Many physical systems are modeled using solutions to integral inverse problems. These solutions are found using some form of regularization, which requires one to determine the best regularization parameter, but this can be computationally expensive for problems with large data sets. One method for finding the regularization parameter is the Generalized Discrepancy Principle (GDP). For an integral kernel which is square integrable the discrete Singular Value Decomposition for the discrete kernel reveals information about the continuous Singular Value Expansion (SVE). With this information, convergence of the GDP parameter estimate with increasing resolution can be obtained. Hence one can down-sample the data and use the GDP to find a regularization parameter that will solve the full-scale problem. (Received January 27, 2014)

46 ► Functional analysis

1098-46-79 **Peter G. Casazza*** (casazzap@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Non-orthogonal Fusion Frames.*

We consider some results of J. Cahill, P.G. Casazza, M. Ehler and S. Li on non-orthogonal fusion frames. Fusion frames are one of the most applied subjects but have the serious drawback that they rarely exist in the form they are needed. Given a self-adjoint operator T, we classify those projections P for which T=P*P. Using this and related results we will see how to construct tight non-orthogonal fusion frames and discover they exist most of the time. This takes care of a critical problem with fusion frames in that we know they very rarely exist if we construct them using orthogonal projections. (Received January 11, 2014)

1098-46-235 **Judith A. Packer*** (packer@colorado.edu), Department of Mathematics, Campus Box 395, University of Colorado, Boulder, Boulder, CO 80309. *Using p-adic wavelets to analyze equivalence bimodules between noncommutative solenoids.* Preliminary report.

Let p be a prime number, and consider a noncommutative solenoid $C^*(\mathbb{Z}[\frac{1}{p}] \times \mathbb{Z}[\frac{1}{p}], \Psi_\alpha) = \mathcal{A}_\alpha$ where Ψ_α is a multiplier on $\mathbb{Z}[\frac{1}{p}] \times \mathbb{Z}[\frac{1}{p}]$. The speaker together with F. Latrémolière constructed a Morita equivalence bimodule between $\mathcal{A}_\alpha$ and $\mathcal{A}_\beta$ for a different multiplier Ψ_β on $\mathbb{Z}[\frac{1}{p}] \times \mathbb{Z}[\frac{1}{p}]$ using a Heisenberg equivalence bimodule of Rieffel. The bimodule was constructed using the locally compact abelian group $M = [\mathbb{Q}_p \times \mathbb{R}]$, which suggested that p-adic harmonic analysis might have additional applications in this situation. This talk will use p-adic wavelets to investigate the question of whether the corresponding Hilbert module Ξ between $\mathcal{A}_\alpha$ and $\mathcal{A}_\alpha$ can be viewed as a nested sequence of countably generated Hilbert modules over rotation algebras. (Received January 27, 2014)

1098-46-244 **Lindsey M. Woodland*** (lmwvh4@mail.missouri.edu), Mathematics Department, 202 Mathematical Sciences Bldg, University of Missouri, Columbia, MO 65211. *Phase Retrieval by Projections.*

Signal reconstruction has been a longstanding problem in engineering with numerous applications, such as: X-ray crystallography, electron microscopy and much more. More recently the mathematical study of signal reconstruction without phase or phase retrieval has shown that in some instances a signal can be retrieved using the norms of one-dimensional projections and in other scenarios higher dimensional projections are necessary. Such is the case in crystal twinning. Surprisingly, new results show that the bound for phase retrieval with vectors is the upper bound for phase retrieval by projections. Also, numerous other new results regarding phase retrieval by projections will be discussed. (Received January 27, 2014)

1098-46-321 **David R. Larson***, Department of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Sam Scholze**, Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Spectral bridging of omissions in frame theory.* Preliminary report.

Let $\{f_j\}$ be a Parseval frame for a Hilbert space H, or more generally $\{f_j, g_j\}$ be a dual pair of frames. let f be a vector in H, and let Λ be a subset of the index set. If f is analysed with $\{g_j\}$ and if the frame coefficients for Λ are erased or omitted, then by bridging the omissions we mean replacing the omitted coefficients with appropriate weighted averages of the other non-omitted coefficients. By spectral bridging we mean bridging in such a way that the resulting error operator has significantly reduced spectral radius. We show that in many (in fact most) cases bridging can be done to make the error operator nilpotent, so the spectral radius is zero, using a bridge set of indices no greater than the cardinality of the omission set. In fact, the error operator can be made nilpotent of index 2, which really surprised us, leading to a new method of perfect reconstruction from frame ommisions in finitely many computational steps, and to improved partial reconstruction when perfect reconstruction is not the goal. (Received January 28, 2014)

49 ► Calculus of variations and optimal control; optimization

1098-49-27 **Daniel P Robinson*** (daniel.p.robinson@gmail.com), **Nick I. M. Gould**, **Frank E. Curtis** and **Philippe Toint**. *An Interior-Point Trust-Funnel Algorithm for Nonlinear Optimization.* Preliminary report.

I present an interior-point trust-funnel algorithm for solving extreme-scale nonlinear optimization problems. Our method, which is designed to solve problems with both equality and inequality constraints, achieves global convergence guarantees by combining a trust-region methodology with a funnel mechanism. The prominent features of our algorithm are that (i) the subproblems that define each search direction may be solved approximately, (ii) criticality measures for feasibility and optimality aid in determining which subset of computations will be performed during each iteration, (iii) no merit function or filter is used, (iv) inexact sequential quadratic optimization steps may be computed when advantageous, and (v) it may be implemented matrix-free so that derivative matrices need not be formed or factorized so long as matrix-vector products with them can be performed. (Received December 01, 2013)

1098-49-59 **Fatma Kilinc-Karzan*** (fkilinc@andrew.cmu.edu), 5000 Forbes Ave, Tepper School of Business, Pittsburgh, PA 15213. *Understanding Structure in Conic Mixed Integer Programs: From Minimal Inequalities to Conic Disjunctive Cuts.* Preliminary report.

We study nonlinear mixed integer sets involving a general regular (closed, convex, full dimensional, and pointed) cone K and introduce the class of K-minimal valid linear inequalities. Under mild assumptions, we show that these inequalities together with the trivial cone-implied inequalities are sufficient to describe the convex hull. We characterize these inequalities by identifying necessary, and sufficient conditions for an inequality to be K-minimal. By establishing strong connections with the support functions of sets with certain structure, we obtain efficient ways of showing whether a given inequality is K-minimal or not.

This framework and the notion of K-minimality, naturally generalizes the corresponding results for Mixed Integer Linear Programs (MILPs), which have received a lot of interest recently. In particular, our results recover that the minimal inequalities for MILPs are generated by sublinear functions that are piecewise linear. However, our study also reveals that such a cut generating function view is not possible for the general conic case even when the cone involved is the Lorentz cone. Finally, we will conclude by introducing a new technique on deriving conic valid inequalities for sets involving a Lorentz cone via a disjunctive argument. (Received January 04, 2014)

1098-49-165 **R O Moore*** (rmoore@njit.edu), New Jersey Institute of Technology, Newark, NJ 07102, and **D McDougall** (damon@ices.utexas.edu), ICES, 201 E. 24th St., Stop C0200, The University of Texas at, Austin, TX 78712-1229. *Optimal control in Lagrangian data assimilation.* Preliminary report.

Inferring the state of an ocean flow is an integral part of environmental monitoring, whether it be for improved preparedness for extreme weather events; better understanding of marine animal migrations; or as part of a general climate model for the planet. Autonomous vehicles with a limited capacity for locomotion are increasingly being used for data assimilation of various quantities of interest in the ocean, including the underlying time-independent velocity field. We assess the efficacy of optimal control techniques to guide Lagrangian data assimilation in 1- and 2-dimensional flows, focusing on assimilation of the velocity field itself. (Received January 24, 2014)

1098-49-194 **Tor G. J. Myklebust** (tmyklebu@csclub.uwaterloo.ca), Dept. of Combinatorics and Optimization, Faculty of Mathematics, 200 University Avenue West, Waterloo, Ontario N2L3G1, Canada, and **Levent Tunçel*** (ltuncel@math.uwaterloo.ca), Dept. of Combinatorics and Optimization, Faculty of Mathematics, 200 University Avenue West, Waterloo, Ontario N2L3G1, Canada. *Elements of Primal-Dual Interior-Point Methods for Hyperbolic Cone Programming and Beyond.*

I will first discuss some of the fundamental ingredients of primal-dual interior-point methods for convex optimization in conic form. Then, I will focus on those convex optimization problems which can be formulated by utilizing convex cones which are hyperbolicity cones of some hyperbolic polynomials. Then, I will present some interior-point algorithms and their theoretical features including their iteration complexity analyses. (Received January 25, 2014)

1098-49-205 **Florian A Potra*** (potra@umbc.edu), University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250. *Weighted Complementarity Problems.*

The weighted complementarity problem (wCP) is a new paradigm in applied mathematics that provides a unifying framework for analyzing and solving a variety of equilibrium problems in economics, multibody dynamics, atmospheric chemistry and other areas in science and technology. It represents a far reaching generalization of the notion of a complementarity problem (CP). Since many of the very powerful CP solvers developed over the past two decades can be extended to wCP, formulating an equilibrium problem as a wCP opens the possibility of devising highly eficient algorithms for its numerical solution. For example, the Fisher competitive market equilibrium model can be formulated as a wCP, while the Arrow-Debreu competitive market equilibrium problem (due to Nobel prize laureates Kenneth Joseph Arrow and Gerard Debreu) can be formulated as a self-dual wCP. (Received January 26, 2014)

1098-49-305 **Alberto Bressan** and **DONGMEI ZHANG*** (zhang_d@math.psu.edu), Penn State University, University Part, PA 16802. *Control Problems for a Class of Set Valued Evolutions.*

This work studies controllability problems for the reachable set of a differential inclusion. These were originally motivated by models of control of a flock of animals. Conditions are derived for the existence or nonexistence of a strategy which confines the reachable set within a given bounded region, at all sufficiently large times. Steering problems and the asymptotic shape of the reachable set are also investigated. (Received January 28, 2014)

1098-49-313 **Ming Tse P. Laiu*** (mtlaiu@umd.edu), Dept of Electrical and Computer Engineering, and Institute for Systems Research, University of Maryland, College Park, MD 20742, **Cory D. Hauck** (hauckc@ornl.gov), Computational Mathematics Group, Computer Science and Mathematics Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, **Dianne P. O'Leary** (oleary@cs.umd.edu), Department of Computer Science, University of Maryland, College Park, MD 20742, and **Andre L. Tits** (andre@umd.edu), Dept of Electrical and Computer Engineering, and Institute for Systems Research, University of Maryland, College Park, MD 20742. *Constraint Reduction in Filtered Positive P_N Closures for Kinetic Equations.*

We apply a constraint-reduced primal-dual interior-point method to the solution of quadratic programs arising from filtered positive P_N closures for linear kinetic equations. Solving kinetic equations numerically is difficult due to the large state space; moment methods are often used to reduce the size of the state space by tracking a finite number of moments of the distributions. Our filtered positive P_N closure closes moment systems with a non-negative and smooth velocity distribution by filtering the partially negative, oscillatory standard P_N distribution (degree N polynomial approximation that matches moments up to order N). The filter is formulated as a finely discretized semi-infinite quadratic program. The resulting distribution no longer exactly matches the given moments, but essential properties are preserved.

At each iteration of an interior-point algorithm, constraint reduction (a technique that has gained popularity in recent years) constructs a search direction based on a set of constraints deemed most critical. On problems with a large number of inequality constraints, this technique significantly lowers the CPU cost. We demonstrate the approach on the 2D line source benchmark problem. (Received January 28, 2014)

51 ► Geometry

1098-51-4 **Daniel T. Wise*** (wise@math.mcgill.ca). *Cube Complexes.*

Cube complexes have come to play an increasingly central role within geometric group theory, as their connection to right-angled Artin groups provides a powerful combinatorial bridge between geometry and algebra. This talk will primarily aim to introduce nonpositively curved cube complexes, and then describe some of the developments that have recently culminated in the resolution of the virtual Haken conjecture for 3-manifolds, and simultaneously dramatically extended our understanding of many infinite groups. (Received January 22, 2014)

1098-51-20 **Derege Haileselassie Mussa*** (derege.mussa@tamuc.edu/dhm2114@columbia.edu), Departemnt of Mathematics, Texas A & M University Commerce, Commerce, TX 75428. *Twenty-Five partition Types of Tetrahedra.* Preliminary report.

Tetrahedron (plural Tetrahedra) is a three dimensional solid having four vertices, four triangular faces and six edges which don't lie in a single plane. We classify the Tetrahedra according as what the partitions of edge lengths are present and without regard to the relative lengths of the edges. The partitions of n are the ways of writing n as the sum of positive integers .Since the tetrahedron has 6 edges then there are 11 such partitions and all exists as 3D type but not as a degenerate 2D type. We can also consider the partition for a particular tetrahedron based on congruence of triangles.This system can be further refined to take into account whether the triangles are equilateral, isosceles or scalene. The refined approach taking some geometric information into account leads to potentially 25 classes (D.Mussa, Doctoral Dissertation, Columbia University, 2013). Theorem(Derege Mussa): There are 25different partition classes of Tetrahedra taking into account graph theoretical aspects of the position of the edges, and all 25types exist. The paper discusses new mathematical questions: 1. How to determine the 25 partition types of Tetrahedra. 2. The 25 partition types of Tetrahedra (Received November 10, 2013)

1098-51-76 **Lara Simone Suárez*** (suarez@dms.umontreal.ca). *Exact Lagrangian cobordism and pseudoisotopy.*

Lagrangian submanifolds are central objects in the study of symplectic manifolds. Given two Lagrangian submanifolds L_0, L_1 in the symplectic manifold (M, ω), a Lagrangian cobordism between them is a cobordism $(W; L_0, L_1)$, that can be embedded as a Lagrangian submanifold in $(([0,1] \times \mathbb{R}) \times M, dx \wedge dy \oplus \omega)$, with the property that near the boundary it looks like the products $[0,\epsilon) \times 1 \times L_0$ and $(1-\epsilon, 1] \times 1 \times L_1$ for some $\epsilon > 0$. In recent work Biran and Cornea proposed the following conjecture: Exact Lagrangian cobordism implies pseudoisotopy. In this talk we give partial results towards this conjecture. (Received January 10, 2014)

1098-51-116 **Ciprian S. Borcea*** (borcea@rider.edu), Rider University, Lawrenceville, NJ 08648, and **Ileana Streinu**. *Geometric auxetics.*

We present a purely geometric notion of auxetic one-parameter deformation of a periodic framework. In materials science and elasticity theory, auxetic behavior is an expression of negative Poisson's ratios. Simply phrased, auxetic behavior means becoming laterally wider when stretched and thinner when compressed. Our geometric approach relies on the evolution of the periodicity lattice. A deformation path will be auxetic when the Gram metrix for a basis of periods gives a curve with all tangents in the positive semidefinite cone, analogous to a causal line in special relativity. (Received January 19, 2014)

1098-51-138 **Genevieve S. Walsh*** (genevieve.walsh@gmail.com). *Subgroups of Coxeter Groups.*

We will discuss some subgroups of some 3-dimensional Coxeter Groups. In our situation, the Coxeter groups are hyperbolic reflection groups. (Received January 21, 2014)

1098-51-176 **Ian P Biringer*** (ianbiringer@gmail.com) and **Miklos Abert**. *Random limits of hyperbolic 3-manifolds.*

We'll discuss a probabilistic limit object associated to a sequence of closed Riemannian manifolds. A consequence is that a sequence of closed hyperbolic 3-manifolds can only develop large volume by creating either unbounded topology, large injectivity radius, or product regions around nearly all of its points. (Received January 24, 2014)

1098-51-226 **Christopher J Leininger*** (clein@math.uiuc.edu), 1409 W. Green St., Urbana, IL 61801, and **Anna Lenzhen** and **Kasra Rafi**. *Limit sets of Teichmueller geodesics with minimal non-uniquely ergodic vertical foliations.*

We describe a method for constructing Teichmüller geodesics where the vertical measured foliation ν is minimal but is not uniquely ergodic and where we have a good understanding of the behavior of the Teichmüller geodesic. The construction depends on various parameters, and we show that one can adjust the parameters to ensure that the set of accumulation points of such a geodesic in the Thurston boundary is exactly the set of all possible measured foliations in the homotopy class of ν. With further adjustment of the parameters, one can even take ν to be an ergodic measure on a non-uniquely ergodic foliation. (Received January 26, 2014)

52 ► Convex and discrete geometry

1098-52-42 **Alexander Koldobsky*** (koldobskiya@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Hyperplane inequalities for measures of convex bodies.*

The hyperplane problem asks whether there exists an absolute constant C so that for any origin-symmetric convex body K in R^n

$$|K|^{\frac{n-1}{n}} \le C \max_{\xi \in S^{n-1}} |K \cap \xi^\perp|,$$

where $\xi^\perp$ is the central hyperplane in R^n perpendicular to ξ, and $|K|$ stands for volume of proper dimension. The problem is still open, with the best-to-date estimate $C \sim n^{1/4}$ established by Klartag, who slightly improved the previous estimate of Bourgain. It is much easier to get a weaker estimate with $C = \sqrt{n}$.

In this talk we show that the $\sqrt{n}$ estimate holds for arbitrary measure in place of volume. Namely, if L is an origin-symmetric convex body in R^n and μ is a measure with non-negative even continuous density on L, then

$$\mu(L) \ \le \ \sqrt{n}\frac{n}{n-1} c_n \max_{\xi \in S^{n-1}} \mu(L \cap \xi^\perp) \ |L|^{1/n} \ ,$$

where $c_n = \left|B_2^n\right|^{\frac{n-1}{n}} / \left|B_2^{n-1}\right| < 1$, and B_2^n is the unit Euclidean ball in R^n. We deduce this inequality from a stability result for intersection bodies. We also present lower dimensional and complex versions of this inequality, and prove that $\sqrt{n}$ can be replaced by an absolute constant for some special classes of convex bodies. (Received December 24, 2013)

1098-52-73 **Marjorie Senechal*** (senechal@smith.edu). *From $\aleph_0$ to ϵ – and back again?*

This special session is timely: 2014 is the International Year of Crystallography, celebrating a century of structure-determination, from salt and diamond to DNA and proteins to once-unimagined synthetic materials. I will describe the role discrete geometry has played – and will play – in these developments, from the classificaiton of infinite patterns (crystallographic groups) at the turn of the twentieth century to nanostructures today and tomorrow. (Received January 10, 2014)

1098-52-75 **Barry Monson*** (bmonson@unb.ca), Dept. Math/Stat, UNB, Box 4400, Fredericton, NB E3B 5A3, Canada, and **Leah Berman**, **Mark Mixer**, **Deborah Oliveros** and **Gordon Williams**. *Pyramids in 3-space and Crystallographic Groups in 4-space.*

The monodromy group $M(\mathcal{P})$ for a polyhedron $\mathcal{P}$ (or indeed for any convex, even abstract, d-polytope $\mathcal{P}$) is a combinatorial invariant of $\mathcal{P}$. This group somehow encodes the essential structural features of the polytope. Intuitively, $M(\mathcal{P})$ describes how an abstract set $\mathcal{F}$ of *flags* can be assembled to produce $\mathcal{P}$.

Recently (*Discrete Mathematics*, in press) we have completely described $M(\mathcal{P})$ when $\mathcal{P}$ is an ordinary pyramid over an n-gonal base. Though $\mathcal{P}$ itself is very familiar, $M(\mathcal{P})$ has some interesting features.

Here we focus on the extreme cases $n = 2$ and ∞. In the first instance, when $\mathcal{P}$ is the rather modest pyramid over the digon, $M(\mathcal{P})$ is, surprisingly, isomorphic to the symmetry group of a 4-cube. And, at the other extreme, when $n = \infty$, $M(\mathcal{P})$ acts, in a natural way, as a crystallographic group in real 4-space.

But why dimension 4? Well, look at a pyramid and count flag orbits under the action of the automorphism group of the base. (Received January 10, 2014)

1098-52-85 **Gregory McColm*** (mccolm@usf.edu), Department of Mathematics, University of South Florida, 4202 E. Fowler Ave., CMC342, Tampa, FL 33620. *Generating Crystal Nets in Euclidean Space.*

A *crystal net* is an infinite graph whose vertices form a uniformly discrete subset of a Euclidean space, with an upper bound on edgelength, and whose symmetry group contains translations by vectors spanning that Euclidean space. Such a net admits finitely many orbits of vertices and edges. These nets are used as models of the molecular structure of valent crystals, and the computer generation and analysis of these nets is a growing field in theoretical materials science. For each integer $n > 0$, there is a fixed set of affine transformations (two for $n = 2$ or $n = 3$) such that the following is true. Every crystal net in n-dimensional Euclidean space is isomorphic to a crystal net of at least comparable symmetry whose vertices are at integer points (modulo one of these affine transformations). This result enables the representation of such isomorphism classes as boolean combinations of parametrized ensembles of vector spaces. (Received January 13, 2014)

1098-52-99 **Chaim Goodman-Strauss*** (strauss@uark.edu), SCEN 301, 1 University of Arkansas, Fayetteville, AR 72701, and **Matthew J. Patitiz**, JBHT 517, 1 University of Arkansas, Fayetteville, AR 72701. *Self-assembly of hierarchical non-periodic tilings.*

Aperiodic sets of tiles have been known for nearly fifty years— such sets of tiles do admit tilings of the plane, but remarkably, only admit non-periodic tilings, tilings in which, somehow, translational symmetry is disrupted at all scales. The most famous example, the Penrose tiles bears a more than passing resemblance to many physical "quasicrystals", first discovered by Schechtman in 1982. However, local-assembly procedures, which presumably govern physical examples, proved elusive and this line of inquiry appeared closed with Dworkin and Shieh's 1995 result that any tiling with the "local isomorphism property" must include tilings of with "deceptions" of arbitrary size. This result was widely interpreted as proving that local assembly procedures could *never* exist for *any* aperiodic set of tiles.

In fact this is far from the case. We give, for any tiling substitution system satisfying mild and general conditions, and any regular language of hierarchies of supertiles arising in this system, a set of tiles in the well-studied "Abstract Tile Assembly Model" such that every infinite configuration these tiles assemble into reduces to such a hierarchy and every hierarchy arises as such an infinite self-assembled configuration. (Received January 16, 2014)

1098-52-118 **Ciprian S. Borcea** and **Ileana Streinu*** (istreinu@smith.edu), Smith College, Northampton, MA 01063. *Expansive periodic frameworks and pseudo-triangulations.*

We characterize two-dimensional periodic frameworks which admit an expansive deformation, defined by the property that the distance between any pair of vertices increases or stays the same. The proof uses our generalization to the periodic setting of Maxwell's theorem on lifting and stresses. Since expansive implies auxetic, we obtain an endless resource for auxetic designs. (Received January 19, 2014)

1098-52-143 **Abigail Williams*** (abigail.williams13@gmail.com). *Uniform Skeletal Polyhedra.*

In this talk, I will discuss uniform skeletal polyhedra. When looking at skeletal polyhedra, we consider each face to be a set of edges which is not spanned by a membrane. The faces, and indeed the polyhedra themselves, are then hollow. The uniformity condition signifies that the polyhedra are vertex transitive and have regular faces. I will focus on the relationship between different uniform skeletal polyhedra from the same point group. (Received January 21, 2014)

1098-52-173 **Elissa Ross*** (eross2@wpi.edu), Department of Mathematical Sciences, Stratton Hall, WPI, 100 Institute Road, Worcester, MA 01609, and **Anthony Nixon**. *Modelling Infinite Periodic Frameworks with a Variable Lattice Using Inductive Constructions.*

Zeolites are a type of micro-porus crystalline material which are frequently modelled as fragments of infinite periodic graphs. A topic of interest is to determine the rigidity of zeolite-type structures, since their utility for applications may depend on it. We examine the more general problem of infinite periodic frameworks, and discuss a recursive characterization of generic rigidity for infinite frameworks that are periodic in the plane with respect to a partially variable lattice. We follow the approach of modelling periodic frameworks as frameworks on a torus, and define periodic adapted Henneberg type inductive graph constructions for this setting. (Received January 24, 2014)

1098-52-184 **Undine Leopold*** (leopold.u@husky.neu.edu). *Vertex-Transitive Polyhedra of Higher Genus.* Preliminary report.

Regular and chiral maps successfully generalize the combinatorial structure of the Platonic solids. While it is hopeless for their higher genus examples to exist as symmetric polyhedra in 3-space (with flat, non-self-intersecting faces tiling an embedded surface), an interesting related problem is that of combinatorially uniform, or geometrically vertex-transitive, polyhedra. Indeed, an infinite family of genus one and a few higher genus examples of these highly symmetric polyhedra exist in 3-space, but the completeness of the list has never been established. In this talk, I will present an overview of the topic and outline the solution for the case of tetrahedral rotation symmetry. (Received January 25, 2014)

1098-52-221 **Egon Schulte*** (schulte@neu.edu), Northeastern University, Department of Mathematics, Boston, MA 02115. *Skeletal Polyhedra, Complexes, and Nets.* Preliminary report.

Skeletal polyhedra and complexes are finite, or infinite periodic, geometric edge graphs in space that are equipped with additional polyhedra-like structure determined by faces (simply closed planar or skew polygons, zig-zag polygons, or helical polygons). The edge graphs of the infinite skeletal polyhedra and complexes are periodic nets. We discuss classification results for skeletal polyhedra and complexes by distinguished transitivity properties of the symmetry group, as well as their relevance for the classification of crystal nets. (Received January 26, 2014)

1098-52-237 **N. Jonoska*** (jonoska@mail.usf.edu), **M. Krajcevski** and **G. McColm**. *Crystallographic Structures and Intersection Hierarchy of Context-free Languages.* Preliminary report.

We establish a relationship between periodic graphs representing crystallographic structures and an infinite hierarchy of intersection languages $\mathcal{DCL}_d$, $d = 0, 1, 2, \ldots$, within the intersection classes of deterministic context-free languages. An intersection of d languages in $\mathcal{DCL}_1$ defines $\mathcal{DCL}_d$. A crystallographic structure can be represented by a periodic (di)graph, i.e., a graph whose group of automorphisms has a translational subgroup of finite index acting freely on a unit cell of the structure. We prove that there is a one-to-one correspondence between sets of walks starting and ending in the same unit of a d-dimensional periodic (di)graph and the class of languages in $\mathcal{DCL}_d$. The proof uses the following result: given a digraph Δ and a group G there is a unique digraph Γ such that $G \leq \mathrm{Aut}\,\Gamma$ and $\Gamma/G \cong \Delta$. (Received January 27, 2014)

1098-52-238 **Michael Baake** (mbaake@math.uni-bielefeld.de), Faculty of Mathematics, University of Bielefeld, Postfach 100131, 33501 Bielefeld, Germany, **Franz Gähler** (gaehler@math.uni-bielefeld.de), Faculty of Mathematics, University of Bielefeld, Postfach 100131, 33501 Bielefeld, Germany, and **Uwe Grimm*** (uwe.grimm@open.ac.uk), Department of Mathematics and Statistics, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom. *Aperiodic hexagon tilings and some of their relations.*

The recently discovered hexagon tilings due to Taylor and to Socolar/Taylor are of interest, because they are the presently best answers to the planar aperiodic monotile quest. They are closely related to an earlier hexagon tiling by Penrose, which gives rise to a weak functional monotile. We review some of the properties and some of the relations between these tilings. In particular, we present a common ancestor (with respect to local derivation), which sheds some light on the differences between the above hexagon tilings. (Received January 27, 2014)

1098-52-241 **Michael Baake*** (mbaake@math.uni-bielefeld.de), Dept. of Mathematics, Bielefeld University, 33739 Bielefeld, Germany, and **Markus Moll** (mmoll@math.uni-bielefeld.de). *Random noble means substitutions.*

While the structure and geometry of primitive substitution rules is rather well understood, this is less so for random substitutions. We revisit an old example due to Godréche and Luck (from 1987), the random Fibonacci substitution, and extend it to the class of random noble means substitutions. Each family leads to a hull with positive entropy, although every member of the hull turns out to be a Meyer set. There is a canonical invariant measure on the hull, and the Meyer property guarantees that the pure point part of the spectrum is non-trivial. (Received January 27, 2014)

1098-52-248 **Nikolai P. Dolbilin*** (dolbilin@mi.ras.ru), Gubkin street 8, Moscow, 119991, Russia. *Local Criteria for Regular Sets.*

A Delone (r, R)-set $X \subset \mathbb{R}^d$ is called *regular* if its symmetry group is transitive. Regular sets serve model of crystal. L.Pauling, R.Feynmann believed that long-range order in crystal comes out identity of patterns of nearby atoms.

In 1970's Delone initiated a problem to find link between local identity and global order, Dolbilin and Stogrin developed basics of local theory of crystals.

Given (r, R)-set $X, \rho > 0$, $\rho - cluster$ at point $x \in X$ is called set $X_x(\rho)$ of points $x' \in X$ s.t. $|xx'| \le \rho$. Let $S_x(\rho)$ denote a group of $X_x(\rho)$ and $N_x(\rho)$ the number of classes of ρ-clusters in X.

We will discuss the following statements:

I. X is regular iff for some ρ s.t. two conditions hold:

(1) $N(\rho + 2R) = 1$; (2) $S_x(\rho) = S_x(\rho + 2R)$.

II. For $\forall\, \varepsilon > 0\ \exists$ set X s.t. $N(4R - \varepsilon) = 1$ but X is not regular.

III. If $N(2R) = 1$ and $X_x(2R)$ is centrally symmetrical about x then the X is centrally symmetrical about x.

IV. If $X \subset \mathbb{R}^3$, $N(10R) = 1$ then X is regular. (Received January 27, 2014)

1098-52-270 **Karoly Bezdek*** (bezdek@math.ucalgary.ca), University of Calgary, Dept. of Math. and Stats., Calgary, Canada. *Separable sphere packings revisited.*

We survey some old as well as new results on unit sphere packings that are separable including lattice (resp., periodic) sphere packings. (Received January 27, 2014)

1098-52-274 **Vlad Yaskin*** (yaskin@ualberta.ca). *Counterexamples to convexity of k-intersection bodies.*

It is a well-known result due to Busemann that the intersection body of an origin-symmetric convex body is also convex. Koldobsky introduced the notion of k-intersection bodies. We show that the k-intersection body of an origin-symmetric convex body is not necessarily convex if $k > 1$. (Received January 27, 2014)

53 ► Differential geometry

1098-53-22 **Oscar M Perdomo*** (perdomoosm@ccsu.edu), Deparment of Mathematics, Marcus White 111, 1615 Stanley Street, New Britain, CT 06119. *Rotating drops with helicoidal symmetry (Joint work with Bennett Palmer).*

In this talk we will consider rotating drops in the Euclidean space. This is, we will consider surfaces with the property that $2H = b - (a/2)R^2$ where a and b are constants, H is the mean curvature of the surface and R is the distance from points in the surface to the z-axis. We will classify all rotating drops that have helicoidal symmetry and we will show an explicit way to describe them. We will also show embedded examples. This is joint work with Bennett Palmer. (Received November 11, 2013)

1098-53-49 **Virginie Charette**, **Todd A. Drumm** and **William M. Goldman*** (wmg@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Proper affine deformations of two-generator Fuchsian groups.* Preliminary report.

Just as W. Thurston exploited ideal triangulations of hyperbolic surfaces to analyze hyperbolic structures in dimension 2, we develop an analogous theory using crooked planes to study affine 3-manifolds. Our earlier work used the crooked analog of ideal triangles in the hyperbolic plane to classify flat Lorentzian 3-manifolds ("Margulis spacetimes") associated to the 3-holed sphere and 2-holed cross-surface. We complete this classification for all surfaces whose fundamental group is free of rank two. The proof involves navigating in the pants complex of these surfaces. I will also report on joint work with Greg Laun relating this to 3-generator Coxeter groups, illustrated with interactive visualization tools developed with J.-P. Burelle. (Received December 28, 2013)

1098-53-192 **Peter Connor*** (pconnor@iusb.edu), **Kevin Li** and **Matthias Weber**. *The Gauss-Bonnet formula for harmonic surfaces.*

We consider harmonic immersions in $\mathbb{R}^d$ of compact Riemann surfaces with finitely many punctures where the harmonic coordinate functions are given as real parts of meromorphic functions. We prove that such surfaces have finite total Gauss curvature. The contribution of each end is a multiple of 2π, determined by the maximal pole order of the meromorphic functions. This generalizes the well known Gackstatter-Jorge-Meeks formula for minimal surfaces. The situation is complicated as the ends are generally not conformally equivalent to punctured disks, nor does the surface have limit tangent planes. (Received January 25, 2014)

1098-53-217 **Yingying Zhang*** (yiz308@lehigh.edu), 14 E. Packer Ave, Department of Mathematics, Bethlehem, PA 18015. *Geometric Quantization of Weil-Petersson Metric of the Moduli Space of Fano Kähler-Einstein manifolds.*

Based on Kodaira-Spencer's complex deformation theory, I will talk about the geometric quantization of the Weil-Petersson metric on the moduli space of compact Fano kähler-Einstein manifolds. As a result, we can show that after normalization, the convergence behavior of the Ricci Curvature of the L^2 metric on the direct image sheaf can be related to the Weil-Petersson metric on the moduli space. (This is the joint work with Huai-Dong Cao and Xiaofeng Sun) (Received January 26, 2014)

1098-53-230 **SONG SUN*** (song.sun@stonybrook.edu), Department of Mathematics, SUNY Stony Brook, Stony Brook, NY 11794. *Kahler-Einstein metrics on Fano manifolds.*

I will talk about joint work with Xiuxiong Chen and Simon Donaldson on the resolution of Yau's conjecture that a Fano manifold admits a Kahler-Einstien metric if and only if it is K-stable. (Received January 26, 2014)

1098-53-273 **Bernard Shiffman*** (shiffman@math.jhu.edu). *Sup norms of holomorphic sections on complex manifolds.*

We state some old and new results and conjectures on L^∞ bounds of holomorphic sections of powers of a positive line bundle on a compact Kähler manifold.

In particular, we show the existence of sequences of orthonormal bases of sections of all powers of a positive holomorphic line bundle that contain a uniformly bounded subsequence of positive density. (Received January 27, 2014)

54 ► General topology

1098-54-289 **Jonathan Hanselman*** (jhansel@math.columbia.edu), Mathematics Department, 2990 Broadway, New York, NY 10027. *Heegaard Floer homology of graph manifolds.*

A graph manifold is a 3-manifold that decomposes along tori into S^1 bundles over surfaces. This class of manifolds includes all non-hyperbolic geometric manifolds. I will show how the Heegaard Floer homology of graph manifolds can be computed by finding the bordered Heegaard Floer invariants of the pieces in the S^1 bundle decomposition. (Received January 28, 2014)

55 ► Algebraic topology

1098-55-19 **Michael A Abel*** (maabel@live.unc.edu) and **Lev Rozansky** (rozansky@email.unc.edu). *A filtration on HOMFLY-PT homology via virtual crossings.* Preliminary report.

In 2006, Khovanov gave a construction of HOMFLY-PT homology in the homotopy category of Soergel bimodules. Soergel bimodules can be naturally filtered by bimodules representing virtual crossings, known as standard bimodules. We show that, by choosing the proper filtrations by virtual crossings, we get a filtration on HOMFLY-PT homology which is a link invariant. The grading induced by this filtration is independent of the three preexisting gradings, turning HOMFLY-PT homology into a quadruply-graded theory. (Received November 02, 2013)

1098-55-269 **Carl Hammarsten*** (chammar@gwu.edu). *Combinatorial Heegaard Floer Homology and Branched Spines.*

A 3-dimensional closed manifold Y represented by its branched spine has a canonical Heegaard decomposition. We present this decomposition graphically in the form of a Strip Diagram. We show that strip diagrams have nice properties which greatly simplify the calculation of Heegaard Floer homology for "most" manifolds. Motivated by this work, we present a combinatorial definition of a chain complex which we expect to be homotopically equivalent to the Heegaard Floer one, yet significantly smaller. Finally, we consider the presentation of a branched spine by its O-graph and show how to reformulate our definition in these terms. (Received January 27, 2014)

1098-55-277 **Kristen Hendricks***, hendricks@math.ucla.edu. *Spectral sequences for the link Floer homology of doubly-periodic knots.*

We construct localization spectral sequences for the link Floer homology of doubly-periodic knots, and discuss how they give a simultaneous generalization of two classical results of Kunio Murasugi and Allan Edmonds concerning, respectively, the Alexander polynomial and genus of the knot. We give an example of a knot $\widetilde{K}$ which is not obstructed from being two-periodic with specific quotient knot K by Edmonds' and Murasugi's conditions, but for which our spectral sequences cannot exist. (Received January 28, 2014)

1098-55-280 **Seung Yeop Yang*** (syyang@gwmail.gwu.edu) and **Jozef Przytycki** (przytyck@gwu.edu). *Knot Spinning and Rack Coloring.*

Carter and Ishii introduced in 2012 a notion of a knotted 2-dimensional foam which is a generalization of a knotted sphere in the same sense as a trivalent graph generalizes a classical knot. Although Zeeman proved in 1965 that the 1-twist spin of any classical knot is unknotted, Carter and I found a knotted trivalent graph for which 1-twist spinning is knotted.

We relate this work on spinning of knotted trivalent graphs with Greg Friedman's approach to knot spinning. This is a joint work with Jozef Przytycki. (Received January 28, 2014)

57 ► Manifolds and cell complexes

1098-57-17 **Benjamin Cooper*** (cooper.ben.j@gmail.com) and **Anna Beliakova**. *Steenrod structures on quantum groups.*

(joint with A. Beliakova) The Steenrod algebra is essential element in the study of the algebraic topology of spaces. The structures which underly the construction of categorified quantum groups are modules over this algebra in a natural way. This observation leads to a study which enriches the categorified quantum groups and associated constructions. In particular, knot homology theories. (Received October 27, 2013)

1098-57-23 **Prayat Poudel*** (p.prayat@gmail.com), 6900 SW 44th St, Unit 214, Miami, FL 33155. *Lescop's Invariant and Gauge Theory.*

Taubes proved that the Casson invariant of an integral homology 3-sphere equals half the Euler characteristic of its instanton Floer homology. We extend this result to all closed oriented 3-manifolds with positive first Betti number by establishing a similar relationship between the Lescop invariant of the manifold and its instanton Floer homology. The proof uses surgery techniques. (Received November 13, 2013)

1098-57-44 **Samuel J Lomonaco*** (lomonaco@umbc.edu), University of Maryland Baltimore County (UMBC, 1000 Hilltop Circle, Baltimore, MD 21250. *The Geometry of Fox's Free Calculus with Applications to Higher Dimension Knots.*

In this talk, we discuss the geometry hidden within Fox's free calculus, and its application to higher dimensional knot theory. (Received December 26, 2013)

1098-57-46 **Alexander Lubotzky**, **Joseph Maher*** (joseph.maher@csi.cuny.edu) and **Conan Wu**. *Casson invariants of random Heegaard splittings.*

The mapping class group element resulting from a finite length random walk on the mapping class group of a closed surface may be used as the gluing map for a Heegaard splitting, and the resulting 3-manifold is known as a random Heegaard splitting. We use these to show the existence of infinitely many closed hyperbolic 3-manifolds with any given value of the Casson invariant. (Received December 26, 2013)

1098-57-67 **Samuel J Taylor*** (staylor@math.utexas.edu) and **Alexander Zupan**. *Totally geodesic subgraphs of the pants graph.*

For a compact surface S, the pants graph P(S) captures the combinatorics of pants decompositions of S and has important connections to hyperbolic structures on surfaces and 3-manifolds. Motivated by the Weil-Petersson geometry of Teichmüller space, Aramayona, Parlier, and Shackleton conjecture that the full subgraph G of P(S) determined by fixing a multicurve is totally geodesic in P(S). We resolve this conjecture in the case that G is a product of Farey graphs. This is joint work with Alex Zupan. (Received January 08, 2014)

1098-57-69 **Adam S Levine*** (asl2@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544. *Non-surjective satellite operators on the smooth concordance group.*

We provide an example of a satellite operator P with winding number 1 (i.e. a knot in $S^1 \times D^2$ representing a generator of first homology) such that for any knot $K \subset S^3$, the satellite knot $P(K)$ is not slice in any homology 4-ball. As a corollary, we obtain a new proof of a conjecture of Zeeman from the 1960s, originally proven by Akbulut, that a knot in the boundary of a contractible 4-manifold need not bound a piecewise-linear disk. The proof makes use of bordered Heegaard Floer homology and the concordance invariants τ and ϵ. (Received January 08, 2014)

1098-57-72 **Michael Brandenbursky*** (brandenm@crm.umontreal.ca), Centre de recherches mathematiques, Universite de Montreal, Montreal, Quebec , Canada. *Braid concordance classes and stable commutator length.* Preliminary report.

I this talk I will define a quasihomomorphism from braid groups to the concordance group of knots in the 3-sphere. As a consequence of this construction, I will provide a relation between the stable four ball genus of a knot K and the stable commutator length of a braid in the preimage of the concordance class of K.

In addition, for a knot K I will define a new knot invariant, that may be seen as a refinement of a braid index of K, and will show that it bounds from above the four ball genus of K.

This is a joint work with J. Kedra from U. Aberdeen. (Received January 09, 2014)

1098-57-122 **Brian Rushton*** (brian.rushton@temple.edu). *Geometry of groups through subdivision rules.*

Subdivision rules are a relatively new way of studying large-scale geometry of groups. We show how many geometric properties have simple descriptions in terms of subdivision rules, and use these to characterize subdivision rules for various classes of groups. We discuss applications to right-angled Artin groups and special cube complexes. (Received January 20, 2014)

1098-57-129 **Tarik Aougab*** (tarik.aougab@yale.edu), 1275 Chapel Street, Apt. 5, New Haven, CT 06511, and **Shinnyih Huang**. *Minimally intersecting filling pairs.*

Let S_g denote the closed orientable surface of genus g, $\mathcal{M}_g$ the moduli space of hyperbolic metrics on S_g, and $\mathrm{Mod}(S_g)$ the mapping class group. A filling pair is a pair of simple closed curves (α, β) on S_g such that no essential simple closed curve is disjoint from both α and β. As a function of g, we construct exponentially many $\mathrm{Mod}(S_g)$-orbits of filling pairs on S_g which intersect minimally.

As an application, we characterize the global minima of the function $\mathrm{MFill} : \mathcal{M}_g \to \mathbb{R}$ which given a metric σ, outputs the length of the shortest minimally intersecting filling pair on σ and show that there are exponentially many minima; we also show the existence of some uniform constant K (independent of g) such that all such minima are in the K-thick part of $\mathcal{M}_g$. Time permitting, we'll also discuss applications of these filling pairs to studying the coarse geometry of the curve complex. (Received January 20, 2014)

1098-57-130 **Christian R Millichap*** (christian.millichap@gmail.com), 506 Shelbourne Road, Havertown, PA 19083. *Hyperbolic pretzel knots with the same volume and systole length.*

The volume and systole length of a hyperbolic 3-manifold are two of the most commonly studied geometric invariants. It is natural to ask how often such manifolds can have the same volume, the same systole length, or perhaps even both. In this talk, we shall construct large families of hyperbolic pretzel knots whose complements have both the same volume and systole length. In particular, we shall show that the number of hyperbolic knot complements with the same volume and systole length grows at least factorially fast with the volume and the number of twist regions. This proof relies on Ruberman's work on mutations along Conway spheres in least area form that preserve volume, and expanding this analysis to see when these Conway spheres could intersect short geodesics in a hyperbolic 3-manifold. (Received January 20, 2014)

1098-57-136 **Laura Starkston*** (lstarkston@math.utexas.edu). *Symplectic fillings and exotic 4-manifolds.*

This talk will show how some very well understood invariants of manifolds can be used to understand complicated geometry and invariants. We will discuss how some powerful tools from symplectic geometry together with simple homology computations, can classify and suggest constructions of symplectic manifolds with a particular fixed boundary (in these cases certain Seifert fibered spaces with a canonical contact structure). We will then describe how these constructions can be used to build exotic 4-manifolds. The exoticness can be detected by Seiberg-Witten invariants, but the computation of the Seiberg-Witten invariants comes down, again, to computations on the homology of the 4-manifold. This is based on joint work with Cagri Karakurt. (Received January 21, 2014)

1098-57-139 **Jeffrey Danciger**, **Sara Maloni*** (sara_maloni@brown.edu) and **Jean-Marc Schlenker**. *Polyhedra inscribed in a hyperboloid and anti-de Sitter geometry.*

Let Γ be a 3–connected graph embedded in $\mathbb{S}^2$. In this talk we will show that Γ is the 1–skeleton of a Euclidean polyhedron inscribed in a hyperboloid if and only if it is the 1–skeleton of a polyhedron inscribed in a sphere and has a Hamiltonian cycle.

That result originates in statements on the geometry of ideal AdS polyhedra. Any hyperbolic metric on the sphere with n labelled cusps, and a distinguished "equator" and "top" and "bottom" polygon, can be uniquely realized as the induced metric on a convex ideal polyhedron in the anti-de Sitter space $\mathbb{A}\mathrm{d}\mathbb{S}^3$. Moreover we characterize the possible dihedral angles of those ideal AdS polyhedra, and show that each ideal polyhedron is characterised by its angles.

(This is a joint work with J Danciger and J-M Schlenker.) (Received January 21, 2014)

1098-57-151 **Louis H. Kauffman*** (kauffman@uic.edu), Math UIC, 851 South Morgan Street, Chicago, IL 60607-7045. *The Virtual Quandle.* Preliminary report.

We define a virtual quandle invariant for virtual knots and links that is stronger than the standard quandle. The virtual quandle, VQ(K), for a knot or link K is defined by the usual quandle relations at classical crossings and a new relation at the virtual crossings defined by operating on incoming elements with a special element of the quandle. The resulting invariant is stronger than the standard quandle and, and for classical knots and links it is the free product of the standard quandle with a one-generator free quandle. There is a group associated with the virtual quandle in analogy with the association of the fundamental group with the standard quandle. We will discuss representations and applications of this structure. (Received January 22, 2014)

1098-57-170 **Peter D Horn***, 215 Carnegie Building, Syracuse, NY 13244, and **Margaret I Doig**. *Homology cobordism of graph manifolds.* Preliminary report.

Livingston proved every 3-manifold is homology cobordant to an irreducible manifold. Meyer proved every 3-manifold is homology cobordant to a hyperbolic manifold. Recently Cochran-Tanner proved that not every 3-manifold is homology cobordant to a Seifert fibered space. We take up the question for the class of graph manifolds. Our first task is to compute the cohomology ring for an arbitrary graph manifold and investigate whether this can obstruct a given manifold from being homology cobordant to a graph manifold. We will discuss some initial progress and examples. (Received January 24, 2014)

1098-57-177 **Igor Rivin***, rivin@temple.edu. *Statistics of random 3-manifold.*

We describe some proved and some conjectured results on the geometry and topology of *random* three-dimensional manifolds., (Received January 24, 2014)

1098-57-179 **Nataša Jonoska** and **Masahico Saito*** (saito@usf.edu). *Modeling DNA assembly by 4-regular rigid vertex graphs.*

DNA assembly in certain kinds of ciliates can be modeled by graphs with 4-valent rigid vertices, possibly with end points. Such a graph can be described by double occurrence words (unsigned Gauss codes), that are used in knot theory. Assembled DNA segments are modeled by certain types of paths in graphs called Hamiltonian polygonal paths, and the recombination is modeled by smoothings of vertices. Some properties of such graphs motivated from DNA assembly are discussed, such as the minimum number of polygonal paths, genus ranges, and word reductions. (Received January 24, 2014)

1098-57-185 **Ilya Kofman*** (ikofman@math.csi.cuny.edu), **Abhijit Champanerkar** and **Jessica Purcell**. *Geometrically and diagrammatically maximal knots.* Preliminary report.

Let W be the infinite alternating square lattice weave. For any sequence of alternating links $K_n \to W$ (with convergence precisely defined), we show that

$$\lim_{n\to\infty} \frac{\mathrm{vol}(K_n)}{c(K_n)} = \lim_{n\to\infty} \frac{2\pi \log \det(K_n)}{c(K_n)} = v_8,$$

where v_8 is the hyperbolic volume of the regular ideal octahedron. In this talk, we focus on related graph theory, and use these results to motivate an Asymptotic Volume Conjecture for $K_n \to W$. (Received January 25, 2014)

1098-57-186 **Cagatay Kutluhan** and **Steven Sivek***, Fine Hall, Washington Road, Princeton, NJ 08544. *Sutured embedded contact homology is an invariant.*

Embedded contact homology (ECH) is an invariant of a closed contact 3-manifold, but proving its invariance is not so straightforward: the only known proof (due to Taubes) is to show that it is isomorphic to monopole Floer homology, which only depends on the underlying manifold. Colin, Ghiggini, Honda, and Hutchings defined a version of ECH for contact 3-manifolds with boundary, which are naturally sutured manifolds, and conjectured that this is also an invariant of the underlying sutured manifold. In this talk I will show that sutured ECH is indeed an invariant and discuss how it can be made into a natural one. (Received January 25, 2014)

1098-57-195 **Charles Livingston** and **Cornelia A. Van Cott*** (cvancott@usfca.edu). *Concordance and boundary genus of satellite links.*

In this talk, we will consider several families of satellite links and discuss the minimal genus surfaces which the links bound in S^3. We will also discuss the surfaces which these links bound in B^4. Specifically, we consider whether the links are slice. We prove that for most knots K, the iterated Bing doubles of K are in fact very far from being slice. In particular, suppose that K has nontrivial signature σ. Then, if the components of the n^{th}-iterated Bing double of K bound disjoint surfaces in B^4, the genus of each of these surfaces is at least $2^{n-1}\sigma$. The same result holds with σ replaced by 2τ, twice the Ozsváth-Szabó knot concordance invariant. (Received January 25, 2014)

1098-57-206 **Abhijit Champanerkar*** (abhijit@math.csi.cuny.edu), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Blvd, Staten Island, NY 10314, and **Ilya Kofman** and **Jessica Purcell**. *Geometrically maximal knots.*

We present new results and conjectures about geometrically maximal sequences of knots, which maximize hyperbolic volume per crossing in the limit. A weaving knot is an alternating knot with the same projection as a torus knot. We prove that weaving knots are geometrically maximal by providing asymptotically correct lower volume bounds, and show that the infinite alternating square lattice weave is their geometric limit. We will discuss a result, known to I. Agol, about generating families of geometrically maximal knots. (Received January 26, 2014)

1098-57-208 **Jennifer Hom**, **Tye Lidman** and **Nicholas Zufelt*** (nzufelt@math.utexas.edu). *Reducible surgeries and Heegaard Floer homology.*

In this talk, we'll discuss the use of Heegaard Floer homology to study reducible surgeries. In particular, suppose K is a non-cable knot in the three-sphere with an L-space surgery. If p-surgery on K is reducible, we show that p equals 2g(K)-1. This implies that any knot with an L-space surgery has at most one reducible surgery, a fact that we show additionally for any knot of genus at most two. (Received January 26, 2014)

1098-57-219 **Margaret I Doig***, midoig@syr.edu. *Homology cobordism classification of lens spaces.* Preliminary report.

We will discuss an effort to classify the lens spaces that are rational homology cobordant. If p is odd, it is known that two lens spaces L(p,q) and L(p,q') are cobordant iff they are diffeomorphic under an orientation-preserving diffeomorphism. We will discuss efforts to extend this result for all lens spaces using the Heegaard Floer d-invariants or correction terms, which are invariants of spin-c manifolds under rational homology cobordism. (Received January 26, 2014)

1098-57-228 **Oliver T Dasbach***, Department of Mathematics, LSU, Baton Rouge, LA 70803, and **Anastasiia Tsvietkova**. *Estimates for the hyperbolic volume of knot complements.*

We discuss bounds for the hyperbolic volume of the complement of an alternating link in terms of coefficients of its colored Jones polynomial. (Received January 26, 2014)

1098-57-243 **Thomas Mark*** (tmark@virginia.edu), PO Box 400137, University of Virginia, Charlottesville, VA 22904. *How (not) to classify Stein fillings of planar contact structures.*

I will outline a strategy for studying the diffeomorphism type of Stein 4-manifolds that are fillings of contact structures on 3-manifolds, where the contact structure is supported by an open book of genus 0. The method gives rise to some interesting conjectures and partial results that I'll describe, but I'll also indicate what seems to be a serious obstacle to using this strategy to prove the conjectures in general. (Received January 27, 2014)

1098-57-247 **Hao Wu*** (haowu@gwu.edu). *Transverse Khovanov-Rozansky Homologies.*

For $N \geq 1$, the Khovanov-Rozansky homology with potential ax^{N+1} is an invariant for transverse links in the standard contact S^3. I'll discuss the $\mathbb{Q}[a]$-module structure of this homology and its behavior under stabilization. (Received January 27, 2014)

1098-57-261 **Corrin Clarkson*** (clarkson@math.columbia.edu), Columbia University, Dept of Math MC4406, 2990 Broadway, New York, NY 10027. *Three-manifold mutations detected by 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 January 27, 2014)

1098-57-266 **Christopher W Scaduto*** (scaduto@math.ucla.edu), University of California, Department of Mathematics, 520 Portola Plaza, Los Angeles, CA 90095-1555. *Framed Instantons and Khovanov homology.* Preliminary report.

In the past several years, much has been discovered towards a structural relationship between Floer-theoretic invariants of 3-manifolds and combinatorial link invariants. A first step was in the form of a spectral sequence from the reduced Khovanov homology of a link to the Heegaard Floer homology of the double branched cover of the link, done by Ozsváth and Szabó. In this talk we discuss how this story carries through in the setting of instanton Floer homology. (Received January 27, 2014)

1098-57-268 **Amey Kaloti***, 686 Cherry ST NW, Atlanta, GA 30332, and **Youlin Li**, liyoulin@sjtu.edu.cn. *Stein fillings of contact 3 manifolds.*

The purpose of this talk is to present results on classification of Stein fillings of contact 3-manifolds. Some contact 3-manifolds in this family can be obtained by Legendrian surgeries on (S^3, ξ_{std}) along certain Legendrian 2-bridge knots. Results to be presented also classify Stein fillings, up to symplectic deformation, of an infinite family of contact 3-manifolds which can be obtained by Legendrian surgeries on (S^3, ξ_{std}) along certain Legendrian twist knots. As a corollary, we obtain a classification of Stein fillings of an infinite family of contact hyperbolic 3-manifolds up to symplectic deformation. Joint work with Youlin Li (Received January 27, 2014)

1098-57-276 **Shelly Harvey*** (shelly@rice.edu) and **Tim Cochran**. *Metric Aspects of Knot Concordance.*

We are interested in the set of knots up to concordance, denoted C. C is an abelian group but its structure is not very well understood. We propose a new approach to understanding C, namely considering C as a metric space on which there exists many natural operators. One example of such an operator is connected-sum with a fixed knot, this approach is arguably more general than focusing on C as an abelian group. In fact, it was previously suggested by the authors along with C. Leidy that C is a fractal space and the proposed self-similarities of C are classical satellite operators. Very recently, Cochran-Davis-Ray proved that many of these satellite operators (strong winding number 1) are indeed injective, modulo the smooth 4-dimensional Poincare Conjecture. We show that that these operators are, in fact, isometric embeddings while winding number zero satellite operators are, by contrast, approximate contractions. This is joint work with Tim Cochran. (Received January 28, 2014)

1098-57-278 **Jing Wang*** (jxfzwangjing@gmail.com) and **Jozef H Przytycki**. *Khovanov type graph homology for non-commutative algebras.*

Our work is motivated by homology of abstract simplicial complex with functor coefficients. For non-commutative algebras, we introduce a Khovanov type definition of graph homology. This is an alternative approach to Paul Turner and Emmanuel Wagner's work. We discuss the relation between these two approaches. (Received January 28, 2014)

1098-57-286 **Heather M Russell*** (hrussell2@washcoll.edu) and **Hoel Queffelec**. *Oriented skein modules and the Frohman-Gelca formula.*

Using an oriented skein module of curves in thickened surfaces, we offer an alternative proof of the product-to-sum result of Frohman and Gelca that relates the Kauffman bracket skein module of the cylinder over the torus to a certain canonical subalgebra of the non-commutative torus. (Received January 28, 2014)

1098-57-297 **Uwe Kaiser*** (ukaiser@boisestate.edu), Department of Mathematics, Boise State University, 1910 University Drive, Boise, ID 83725-1555. *Alexander type invariants of fusions of links.* Preliminary report.

In 1991 we proved in unpublished work that there exist exact sequences relating Alexander modules of strong fusions of links (add a trivial circle linking the fusion band) with the modules of the original link and certain Alexander modules of a string link defined from the band. From this we concluded a quite practical explicit formula (in terms of the Alexander polynomials of the two knots and the band) for a band sum of two knots, suggesting a ribbon concordance to the connected sum. This ribbon concordance was proved by K. Miyazaki in 1998. The band information in our formula is deduced from a so called *longitudinal polynomial* (discussed by Hillman and Levine in 1981) of the two-component strong fusion. The more recent progress due to knot, link and string link homologies suggests to revisit some of the old results, which will be the main focus of the talk. But there are obvious questions we want to touch on like: (i) the quasi-alternating property of fusions, (ii) the categorification of longitudinal polynomials, and (iii) the calculation of knot homology of strong fusions of links and of band sums of knots. (Received January 28, 2014)

1098-57-300 **Tim D Cochran*** (cochran@rice.edu) and **Arunima Ray** (arunima.ray@rice.edu). *Shake concordant knots that are not concordant.* Preliminary report.

If K is a knot in $S^3 = \partial\mathbb{B}^4$, then the 4-manifold W_K obtained by adding a single two-handle along K with framing zero, has $H_2 \cong \mathbb{Z}$. The **shake genus of K** is the minimum genus of an embedded surface representing a generator of $H_2(W_K)$. The question was asked whether the shake genus is equal to the slice genus of K. In particular if the shake genus is zero then the knot is called shake slice. There has been no progress since 1976 on the question: is every shake slice knot a slice knot? We answer , in the negative, a relative version of this question. Specifically we show that there are many shake-concordant knots that are not concordant. We also show that none of the invariants τ, s, slice genus, is invariant under shake concordance. (Received January 28, 2014)

1098-57-301 **Radmila Sazdanovic*** (rsazdanovic@math.ncsu.edu), Department of Mathematics, NCSU, 3120 SAS Hall, PO Box 8205, 2311 Stintson Drive, Raleigh, NC 27696-8205, and **Jozef H. Przytycki**. *Torsion in Khovanov homology of semi-adequate links.*

We analyze torsion in Khovanov homology using the correspondence between Khovanov link homology and well developed theory of Hochschild homology for algebras via chromatic graph homology. We extend A. Shumakovitch's conjecture about the existence of Z_2-torsion in Khovanov link homology to semi-adequate links, and conjecture existence of higher 2-torsion. (Received January 28, 2014)

1098-57-304 **Peter Lambert-Cole*** (plambe7@lsu.edu), **Michaela Stone** and **David Shea Vela-Vick**. *Computation of knot Floer homology via braids.*

Knot Floer homology is a powerful invariant of knots in 3-manifolds that is computationally intensive to obtain. In this talk, I will discuss a new approach to computing this invariant in terms of braids and discuss some of the algorithmic strengths of this approach. (Received January 28, 2014)

1098-57-310 **J. Scott Carter***, Dept. of Math. and Stat., ILB 325, University of South Alabama, Mobile, AL 36688. *Braided manifolds of dimension* 3 *and* 4..

This is joint work with Seiichi Kamada. The idea of a surface braid was introduced by Kamada, Viro, and Rudolph as a method of studying knotted surfaces in 4-dimensional space. Kamada's braid charts are a method of encoding these surface braids. They consist of a labeled oriented graph with specific types of vertices that represent relations in the braid group or branch points of the surface. A sequence of charts can be used to define embeddings and immersions of 3-manifolds in 5-space which have the property that canonical projections induce branched coverings. Similarly, for small covering indices, we can generalize this construct embeddings and immersions of branched coverings of the 4-space branched over orientable surfaces.

The talk will illustrate the ideas via as many examples as possible. (Received January 28, 2014)

1098-57-315 **Prudence Heck*** (prudence.heck@gmail.com). *Topology and data.* Preliminary report.

We use tools from topological data analysis to observe well-known patterns in natural gas supply and demand. (Received January 28, 2014)

1098-57-316 **John Etnyre** and **David Shea Vela-Vick*** (shea@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70808, and **Rumen Zarev**. *Contact structures and knot Floer homology.*

Using contact-geometric techniques, we present an alternate formulation of the plus and minus versions of knot Floer homology. We further show how natural constructions in the realm of contact geometry give rise to many of the formal algebraic structures present in Heegaard Floer theory. Finally, to a Legendrian or transverse knot $K \subset (S^3, \xi_{std})$, we associate distinguished classes in HFK^+ and HFK^- which are invariants of either the Legendrian or transverse knot type of K. (Received January 28, 2014)

1098-57-318 **Christopher R Cornwell*** (cornwell@math.duke.edu) and **David Hemminger**. *Knot contact homology and a question of Cappell and Shaneson.* Preliminary report.

An open question raised by Cappell and Shaneson asks whether the minimal number of meridians needed to generate the group of a knot is equal to the bridge number of that knot. Knot contact homology gives a new approach to studying this question, which we will show behaves well for certain satellites. This gives an affirmative answer to Cappell and Shaneson's question for many satellite knots, including iterated torus knots. (Received January 28, 2014)

1098-57-320 **Charles D. Frohman** and **Joanna Kania-Bartoszynska*** (jkaniaba@nsf.gov). *Structure of the Kauffman bracket skein module of a connected sum of copies of a product of a circle with a sphere.*

We describe the structure of the Kauffman bracket skein module of a 3-manifold which is a connected sum of copies of $S^1 \times S^2$. We discuss its relationship to the SL(2,C)-characters of the fundamental group of the manifold. (Received January 28, 2014)

1098-57-324 **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. *Odd homological operations on Khovanov homology.* Preliminary report.

We discuss homological operations between even and odd Khovanov homology theories. These operations are defined via the unified even/odd Khovanov homology theory developed by Putyra and give rise to new knot invariants with interesting properties. (Received January 28, 2014)

1098-57-325 **Tim D Cochran** and **Eamonn Tweedy*** (eamonn@rice.edu). *On an inequality for concordance classes.*

Cochran and Gompf defined an inequality for concordance classes of knots and links in the three-sphere. We'll discuss this notion and relate it to some classical and modern concordance invariants. This is joint work with Tim Cochran. (Received January 28, 2014)

1098-57-326 **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20 052. *Progress in Yang-Baxter homology.*

We describe the progress made in the last half a year in the quest to connect distributive homology and Khovanov homology, via Yang Baxter operators. (Received January 28, 2014)

1098-57-330 **Kenneth L. Baker** and **Allison H. Moore*** (allison.h.moore@rice.edu). *Montesinos knots and contact structures.*

A rational homology sphere whose Heegaard Floer homology is the same as that of a lens space is called an L-space. We will classify Montesinos knots admitting L-space surgeries by studying fibered Montesinos knots which support tight contact structures. (Received January 29, 2014)

58 ► Global analysis, analysis on manifolds

1098-58-71 **Radu Balan*** (rvbalan@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *On Lipschitz inversion of Nonlinear Redundant Representations.*

In this talk we show that reconstruction from magnitudes of frame coefficients (the so called "phase retrieval problem") can be performed using Lipschitz continuous maps. Specifically we show that when the nonlinear analysis map $\alpha : H \to \mathbb{R}^m$ is injective, with $(\alpha(x))_k = |\langle x, f_k \rangle|^2$, where $\{f_1, \ldots, f_m\}$ is a frame for the Hilbert space H, then there exists a left inverse map $\omega : \mathbb{R}^m \to H$ that is Lipschitz continuous. Additionally we obtain the Lipschitz constant of this inverse map is at most 12 divided by the lower Lipschitz constant of α. This is a joint work with Dongmian Zou (UMD). (Received January 09, 2014)

1098-58-80 **Ved V Datar*** (veddatar@math.rutgers.edu), 110 Frelinghuysen Road, Hill Center, Busch Campus, Dept. of Math, Rutgers University, Piscataway, NJ 08904. *Conical soliton metrics on Kähler manifolds.*

Recently there has been a lot of interest in conical Kähler metrics culminating in the breakthrough on the Kähler-Einstein problem, independently by Chen-Donaldson-Sun and Tian. I will first talk about some joint work with Guo,Song and Wang on the existence of conical soliton metrics on toric manifolds and connecting toric manifolds by conical Kähler-Einstein metrics. If time permits, I will then talk about some recent work of mine on the greatest lower bound for Bakry-Emery Ricci curvature on Fano manifolds. (Received January 11, 2014)

1098-58-137 **Renjie Feng*** (renjie@math.umd.edu), Mathematics Building, University of Maryland, College Park, MD 20742. *The supremum of L^2 normalized random holomorphic fields.*

We prove that the expected value and median of the supremum of L^2 normalized random holomorphic fields of degree n on m-dimensional Kähler manifolds are asymptotically of order $\sqrt{m \log n}$. The estimates are based on the entropy methods of Dudley and Sudakov combined with a precise analysis of the relevant distance functions and covering numbers using off-diagonal asymptotics of Bergman kernels. This is the joint work with S. Zelditch. (Received January 21, 2014)

1098-58-156 **Don Colladay**, **Leon Kaganovskiy** and **Patrick McDonald*** (mcdonald@ncf.edu). *Isospectrality, torsional rigidity and heat content for metric graphs.*

The isospectral problem for metric graphs is well studied and the associated literature includes a number of positive results. For example, it is known that for metric graphs with natural boundary conditions and rationally independent edge lengths, the graph is determined by the spectrum of the corresponding Laplace operator. When the edge lengths are permitted to be rationally dependent, simple constructions going back to Sunada provide examples of pairs of isospectral, non-isometric metric graphs. The results we discuss involve the construction of natural geometric invariants which distinguish pairs of isospectral metric graphs arising via a Sunada-like construction. In particular, we provide explicit examples of isosepctral non-isometric metric graphs which are distinguished by their torsional rigidity and by their heat content. (Received January 23, 2014)

1098-58-296 **Ian M. Anderson** and **Zhaohu Nie*** (zhaohu.nie@usu.edu), Department of Mathematics and Statistics, Utah State University, Logan, UT 84322-3900, and **Pawel Nurowski**. *Non-rigid parabolic geometries of Monge type.*

A parabolic geometry, with the classical examples of conformal geometry, projective geometry and CR-geometry, is defined by a choice of a parabolic subalgebra in a simple Lie algebra. In particular, the geometry of the (2, 3, 5) distributions on a 5-manifold is the parabolic geometry associated to the simple Lie algebra $\mathfrak{g}_2$ with the parabolic subalgebra defined by the first simple root. Associated with the flat model for this geometry there is a natural underetermined ODE, the celebrated Hilbert-Cartan equation $\frac{dz}{dx} = \left(\frac{d^2y}{dx^2}\right)^2$. In this talk, we will generalize the above example of parabolic geometry to all simple Lie algebras in the framework of non-rigid parabolic geometry of Monge type. The differential equations for the corresponding flat models are all underdetermined systems of ODE's. A parabolic geometry is called non-rigid if it allows curved analogs, and the non-rigidity is characterized by the second Lie algebra cohomology. For the non-rigid parabolic geometries of Monge type, the ODE systems have particularly simple forms. We will also mention work in progress on the underlying geometric structures to define the curved analogs of these geometries. (Received January 28, 2014)

1098-58-306 **Eric L Grinberg*** (eric.grinberg@umb.edu), Department of Mathematics, University of Massachusetts Boston, Boston, MA 02125, and **Steven G Jackson** (jackson@math.umb.edu), Department of Mathematics, University of Massachusetts Boston, Boston, MA 02446. *The Flat Torus Transform on Symmetric Spaces of Compact Type.* Preliminary report.

In a 1913 paper Paul Funk proved that a suitable function on the sphere S^2 is odd if and only if its integrals over great circles (closed geodesics) vanish, and that an even function is determined by such integrals. We replace the sphere S^2 by a symmetric space of compact type, e.g., a grassmann manifold, and great circles by maximal totally geodesic flat tori, and consider the transform that integrates over these. We show that, when the symmetric space is the "universal covered space" in its class, the torus transform is injective, and otherwise the transform is non- injective, with a kernel that is directly linked to deck transformations of the appropriate symmetric cover. This gives one of the direct extensions of Funk's transform and its injectivity properties. (Received January 28, 2014)

60 ► Probability theory and stochastic processes

1098-60-1 **Maria Gordina*** (maria.gordina@uconn.edu), Department of Mathematics, Storrs, CT 06269. *Stochastic analysis and geometric functional inequalities.*

Our starting point is the heat flow operator which is used to describe a number of physical phenomena. Recall that its generator is the Laplace operator. In particular, a well-known connection between the spectrum of the Laplacian and the speed of heat diffusion leads to several functional inequalities such as Poincare, Nash etc. The geometry of the underlying space plays an important role in such an analysis. Another example of a functional inequality is the log-Sobolev inequality which is used to describe entropic convergence of the heat flow to an equilibrium. A probabilistic point of view comes from a path integral representation of the heat flow for stochastic differential equations driven by a Brownian motion. The talk will review recent advances in the field including elliptic and hypo-elliptic settings over both finite- and infinite-dimensional spaces. (Received January 22, 2014)

1098-60-21 **Triet Pham*** (triet.pham@rutgers.edu). *Non-Markovian zero-sum stochastic differential games and path dependent Bellman-Isaacs equations.*

The connection between a partial differential equation and its stochastic representation has always been an important topic in mathematical finance. For example, the connection between Backward Stochastic Differential Equations and semi-linear PDEs is classical, which opens the door for many applications, including numerical solutions via Monte Carlo methods. More recently, the notion of Second-order Backward Stochastic Differential equations (2BSDEs), proposed by Soner, Touzi and Zhang (2011) has received considerable attention by giving the stochastic representation for the HJB equation. In an attempt to generalize the notion of 2BSDEs to derive the stochastic representation for the Bellman-Isaacs equations, we study the problem of non-Markovian zero-sum stochastic differential games. Our contributions here is to show the existence of the game value in the control versus control setting (in contrast to the strategy versus control setting, which is popular in the literature), via the notion of viscosity solutions to path-dependent Bellman-Isaac equations. We will also mention the remaining difficulties that still need to be overcome to develop a theory of generalized 2BSDEs. This is joint work with Jianfeng Zhang. (Received November 11, 2013)

1098-60-37 **Xiang Yu*** (xymath@umich.edu) and **Erhan Bayraktar**. *On the Market Viability under Proportional Transaction Costs.*

We consider a notion of weak no arbitrage condition known as Robust No Unbounded Profit with Bounded Risk (RNUPBR) in the context of continuous time markets with small proportional transaction costs. We show that the RNUPBR condition on terminal liquidation value holds if and only if there exists a strictly consistent local martingale system (SCLMS). Moreover, we show that RNUPBR condition implies the existence of optimal solution of the utility maximization problem defined on the terminal liquidation value. (Received December 22, 2013)

1098-60-38 **Duy Nguyen*** (d.nguyen@mcla.edu), Department of Mathematics, Massachusetts college of Liberal Arts, 375 Church street, North Adams, MA 01247, and **Qing Zhang** and **George Yin**. *A Stochastic Approximation Approach for Trend-Following Trading.*

This talk develops a feasible computation procedure for trend-following trading under a bull-bear switching market model. In this talk, stock prices are modeled by a regime switching model. The drift of the stock price switches between two parameters corresponding to an uptrend (bull market) and a downtrend (bear market) according to a partially observable Markov chain. The objective is to buy and sell the underlying stock to maximize an expected return. It was shown that an optimal trading strategy can be obtained in terms of two threshold levels. Finding the threshold levels turns out to be a difficult task. In this talk, we develop a stochastic approximation algorithm to approximate the threshold levels. One of the main advantages of this approach is that one need not solve the associated HJB equations. We also establish the convergence of the algorithm and provide numerical examples to illustrate the results.

(Joint work with Q. Zhang and G. Yin) (Received December 23, 2013)

1098-60-43 **Michael Carlisle** and **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu), 2900 Bedford ave, Brooklyn, NY 11210, and **Ioannis Stamos**. *Trends and trades.*

We present a trend following algorithm based on the sequential statistical rule known as the cumulative sum (CUSUM). We draw connections between these statistics and the problem of online statistical surveillance and quality control. We build a trading strategy based on the CUSUM stopping rule and apply it to high-frequency tick data from 5-year and 30-year US Treasury notes sold at auction. We analyze the performance of the proposed trend following strategy in detail. In particular, it is seen that the proposed trading rule is most profitable during times of market instability and long trends. We further calculate in closed form the expected value of the gain of the proposed strategy for a class of random walk models. Not surprisingly, it is seen that the suggested strategy is most profitable in biased random walks but is indifferent to the direction of the bias. We also examine the performance of the proposed strategy in simulated data from a variety of random walk models and analyze this behavior in relation to the analytical results and the results of the performance of the strategy on the actual data. We finally discuss other statistics of interest and the way in which they can help us improve the performance of our proposed algorithm. (Received December 25, 2013)

1098-60-55 **Konstantinos Spiliopoulos*** (kspiliop@math.bu.edu), Department of Mathemtics and Statistics, Boston University, Boston, MA 02215. *Systemic risk in large financial networks.*

The past several years have made clear the need to better understand the behavior of risk in large interconnected financial networks. Interconnections often make a system robust, but they can act as conduits for risk. In this talk, I will present recent results on modeling the dynamics of correlated default events in the financial market. An empirically motivated system of interacting point processes is introduced and we study how different types of risk, like contagion and exposure to systematic risk, compete and interact in large-scale systems. A law of large numbers for the loss from default is proven and used for approximating the distribution of the loss from default in large, potentially heterogeneous portfolios. Fluctuation analysis and conditional Gaussian approximations are used to improve the approximations. Finally large deviations theory is developed to approximate probabilities of large losses and the most likely path to failure in large portfolios. Numerical results illustrate the accuracy of the approximation. The results give insights into how different sources of default correlation interact to generate typical and atypical portfolio losses. (Received January 02, 2014)

1098-60-89 **Paul Feehan**, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, **Ruoting Gong***, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, and **Jian Song**. *Feynman-Kac formulae for solutions to degenerate elliptic boundary value and obstacle problems with Dirichlet boundary conditions.*

We prove stochastic representation formulae for solutions to the elliptic boundary value and obstacle problems associated with a degenerate Markov diffusion process. The degeneracy in the diffusion coefficient is proportional to the α-power of the distance to the boundary of the half-space, where $\alpha \in (0,1)$. This generalizes the well-known Heston stochastic volatility process, which is widely used as an asset price model in mathematical finance and a paradigm for a degenerate diffusion process. The generator of this degenerate diffusion process with killing, is a second-order, degenerate-elliptic partial differential operator where the degeneracy in the operator symbol is proportional to the 2α-power of the distance to the boundary of the half-plane. Our stochastic representation formulae provide the unique solutions to the elliptic boundary value and obstacle problems, when we seek solutions which are suitably smooth up to the boundary portion Γ_0 contained in the boundary of the half-plane. In the case when the full Dirichlet condition is given, our stochastic representation formulae provide the unique solutions which are not guaranteed to be any more than continuous up to the boundary portion Γ_0. (Received January 13, 2014)

1098-60-92 **Jay Rosen*** (jrosen30@optimum.net), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Boulevard, Staten Island, NY 10314. *Loop measures and loop soups.*

We discuss loop measures and loop soups for general Markov processes. We explain various constructions and applications. We also discuss some open problems. (Received January 14, 2014)

1098-60-100 **Ilie Grigorescu** (igrigore@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33146, and **Min Kang*** (kang@math.ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695. *Stochastic Processes with Catalyst and Quasi-Stationary Distribution.*

A general class of stochastic processes with catalyst is considered. The process changes its behavior upon contact with a catalyst in the state space. Examples of such particle systems include so-called Fleming-Viot process on a bounded domain, Bak-Sneppen fitness evolution model and many others. In the Fleming-Viot case of the diffusions equipped with hard catalyst consisting of the boundary of the domain, the condition to prevent explosion of the processes is discussed. Also the connection between the limiting empirical measure associated with this particle system and the quasi-stationary distribution for the underlying process will be clarified. (Received January 16, 2014)

1098-60-103 **Vadim Gorin*** (vadicgor@gmail.com). *Gaussian Free Field in random matrices and 2d statistical mechanics.*

The Gaussian Free Field (GFF) is a distinguished conformally invariant generalized $2d$ random field. The aim of my talk will be to discuss the universal appearance of GFF as a scaling limit describing global fluctuations of statistical mechanics models and random matrices. (Received January 16, 2014)

1098-60-107 **Brian Rider*** (brian.rider@temple.edu). *On continuum limits of random matrices.*

In the last few years, several important distributions from random matrix theory have been characterized in terms of random differential equations. A guiding principle is that the large dimensional limit of certain random matrix ensembles can (and should) be viewed as the continuum limit of the underlying discrete operators. An advantage of the method is that it applies simultaneously well to the so-called "beta ensembles", one parameter families of models which generalize the classical real symmetric, complex Hermitian, and quaternion self-dual Gaussian matrices.

I will attempt summarize the current state of affairs, and then point out various directions for future research. (Received January 17, 2014)

1098-60-112 **Christoph Frei*** (cfrei@ualberta.ca) and **Nicholas Westray**. *VWAP order execution and dynamic trading volume estimation.*

We consider the optimal liquidation of a position of stock (long or short) where trading has a temporary market impact on the price. The aim is to minimize both the mean and variance of the order slippage with respect to a benchmark given by the market VWAP (volume weighted average price). In this setting, we introduce a new model for the relative volume curve which allows simultaneously for accurate data fit, economic justification and mathematical tractability. Under the assumption of complete information (observability of relative trading volume), we give explicit formulae for the optimal trading rate and liquidation trajectory by tackling the resulting optimization problem using a stochastic control approach. We then study how this strategy can be implemented using dynamic trading volume estimation and analyze its performance for the stocks in the DJIA. The talk is based on a recent article (accepted in Mathematical Finance) and ongoing work both joint with Nicholas Westray (Deutsche Bank AG). (Received January 17, 2014)

1098-60-120 **Clement Boateng Ampadu*** (drampadu@hotmail.com), 31 Carrolton Road, Boston, MA 02132. *Excursion in Quantum Wonder Land: Open Questions and Hints.*

Since 2010-2013, I worked intensively on the quantum random walk, which is regarded as quantum analogue of the classical random walk. Recently, I contributed to the Special Issue of Applied Mathematics (AM) on Stochastic Processes detailing some questions resulting from my "excursion" in this area.

In this talk we examine the questions, and give hints (partial solutions) on how they can be tackled (solved) (Received January 19, 2014)

1098-60-124 **Amarjit Budhiraja*** (budhiraj@email.unc.edu), 357 Hanes Hall, Chapel Hill, NC 27599, and **Rami Atar**. *On Some Free Boundary Problems for Stochastic Systems.*

We consider a family of degenerate elliptic nonlinear PDE with gradient constraints in polyhedral domains. Some results on the well-posedness of the equation will be given and applications to some problems in stochastic networks will be described. Finally some open questions related to the associated free boundary problems and regularity theory of the PDE will be presented. This is joint work with R. Atar. (Received January 20, 2014)

1098-60-141 **Ira B. Schwartz*** (ira.schwartz@nrl.navy.mil), US Naval Research Laboratory, Code 6792, 4555 Overlook Ave, SE, Washington, DC 20375, and **Lora Billings** (billingsl@mail.montclair.edu), **Luis Mier-y-Teran-Romero** (lmier-y@jhsph.edu) and **Brandon Lindley** (brandon.lindley.ctr@nrl.navy.mil). *Intervention-Based Stochastic Disease Eradication-A Stochastic control approach.*

Disease control is of paramount importance in public health, with infectious disease extinction as the ultimate goal. Although diseases may go extinct due to random loss of effective contacts where the infection is transmitted to susceptible individuals, the time to extinction in the absence of control may be prohibitively long. Intervention controls are typically defined on a deterministic schedule. In reality, however, such policies are administered as a Poisson process. We consider the effect of randomly distributed intervention as disease control on large finite populations in the presence of limited resources. Using a variational approach to locate the most likely path to extinction as a rare event, we characterize the optimal noise for extinction. Then we show how control, based on mean period and treatment fraction, modulates the average extinction times as a function of population size and infection spread rate. The results show an exponential improvement in extinction times even though the controls are implemented using a Poisson distribution. In addition, we show the optimal extinction path may be identified using finite time Lyapunov exponents. (Received January 21, 2014)

1098-60-158 **Elena Kosygina*** (elena.kosygina@baruch.cuny.edu). *Excited random walks, or the "cookie" phenomenon.* Preliminary report.

Excited random walks (ERWs), a.k.a. cookie random walks, are a large class of non-markovian random walks, for which the transition probabilities at a given time and location of the walker may depend on the prior history as well as on a random environment. The first ERW model was introduced in 2003 by Itai Benjamini and David B. Wilson, and since then ERWs were studied by many authors.

The talk will describe some of the ERW models and concentrate on open problems concerning ERWs and closely related processes. It is partially based on the joint work with Martin P.W. Zerner (University of Tuebingen, Germany). (Received January 23, 2014)

1098-60-178 **Bruce K. Driver** (bdriver@math.ucsd.edu), **Nathaniel Eldredge*** (neldredge@unco.edu) and **Tai Melcher** (melcher@virginia.edu). *Hypoellipticity and heat kernels in infinite dimensions.*

A hypoelliptic diffusion process is, roughly, a process X_t which locally can only diffuse in certain directions, yet globally is still able to roam freely throughout its state space. For example, for each t, the random variable X_t may have a smooth positive density, which could be called a hypoelliptic heat kernel. Such processes have been extensively studied in $\mathbb{R}^n$ and finite dimensional manifolds and Lie groups.

In this talk, I'll describe a extension of this concept to infinite dimensions. Specifically, we construct a class of such processes on infinite-dimensional Lie groups modeled on abstract Wiener space, and are able to show that they have, in an appropriate sense, a smooth positive density. There is a vast body of knowledge about the analysis of Gaussian measures and abstract Wiener space, including the Malliavin calculus, and it appears that much of it may extend to these infinite-dimensional hypoelliptic heat kernels. I'll discuss some of the open questions that have arisen. (Received January 24, 2014)

1098-60-180 **Lijun Bo*** (bolijunnk@gmail.com) and **Agostino Capponi**. *Optimal Investment in Defaultable Securities under Information Driven Default Contagion.*

We introduce a novel portfolio optimization framework where a power investor decides on optimal portfolio allocations within an information driven default contagion model. The investor can allocate his wealth across several defaultable stocks whose growth rates and default intensities are driven by a hidden Markov chain. The latter acts as a frailty factor introducing dependency across defaults and affecting future comovements of security prices. By a suitable measure change, we reduce the partially observed stochastic control problem to an equivalent fully observed risk-sensitive control problem, where the state is given by the regime filtered probabilities. Using the dynamic programming principle, we then provide a rigorous analysis of default contagion manifested through dependence of the optimal strategies on the gradient of value functions in one-to-one correspondence with the default states of the economy. We prove a verification theorem showing that each value function is recovered as the generalized solution of the corresponding HJB PDE. (Received January 24, 2014)

1098-60-196 **Leonid Koralov*** (koralov@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Stochastic transport in periodic channels.*

We'll discuss stochastic transport in periodic channels. The problems to be considered are motivated by the study of Brownian motors (mechanisms that create directed motion out of fluctuations of an external field), which are of interest in biological and industrial applications. We'll be interested in the effective properties of the flow with respect to parameters that describe the geometry of the channel. Depending on the geometry of the channel, the mathematical analysis may rely on the theories of averaging, homogenization, or large deviations. (Received January 25, 2014)

1098-60-210 **Tim Leung**, **Kazutoshi Yamazaki** and **Hongzhong Zhang*** (hzhang@stat.coumbia.edu), 1255 Amsterdam Ave, New York, NY 10027. *Optimal Stopping with Negative Discount Rate and Random Refraction Times under Levy Models.*

This paper studies a class of optimal single and multiple stopping problems driven by a Levy process. With the reward function resembling the call option payoff, our analysis is applicable to a number of financial applications, including stock loans and real options. A key feature of our model is allowing the effective discount rate to be negative, which arises when the strike price grows at a higher rate than the original discount factor. When multiple stopping opportunities are allowed, the admissible exercise times are separated by i.i.d. random refraction times. For Levy processes with both positive and negative jumps, we show that the optimal timing strategy for the optimal multiple stopping problem is characterized by a decreasing sequence of exercise thresholds. For spectrally negative Levy processes with phase-type jumps with Erlang distributed refraction periods, we further derive analytic expressions for the optimal multiple stopping value functions. Our solution naturally gives rise to a numerical algorithm for computing successively the value functions and optimal exercise thresholds. (Received January 26, 2014)

1098-60-220 **Stanislav A Molchanov*** (smolchan@uncc.edu), Department of Mathematics and Statistics, UNCC, Charlotte, NC 28223. *Intermittency in the random media.*

The concept of the intermittency of the physical fields and first of all, the magnetic fields of the sun and stars was suggested by the famous physicist Ya. Zeldovich in 1970th . The mathematical theory of intermittency (at the semi-physical levle) has been developed in a large paper "Intermittency, diffusion and generation in a non-stationary random medium" by S. Molchanov, A. Ruzmaikin, D. Sokoloff and Ya. Zeldovich (Sov.Sci.Rev.C: Math.Phys., 1988, pp 1- 10). This topic immediately became popular and the number of mathematical publications in this area is counted in hundreds. The talk will contain the review of some recent applications of the idea of intermittency to the parabolic Anderson model and population dynamics. (Received January 26, 2014)

1098-60-236 **Tomoyuki Ichiba*** (ichiba@pstat.ucsb.edu), South Hall 5508 Department of Statistics and, Applied Probability, University of California, Santa Barbara, CA 93106. *Behaviors of interbank lending system near multiple defaults.*

We shall model empirical distributions of large interbank-lending system by interacting diffusion processes. When the interactions are of mean-field type and the average of the system is close to the level of default, multiple defaults can occur with positive probability in a finite time. We are concerned with the behaviors of the large system near the time of multiple defaults, and propose financial health indicators for the system. (Received January 27, 2014)

1098-60-255 **Maxim Bichuch*** (mbichuch@wpi.edu) and **Ronnie Sircar**. *Optimal Investment with Transaction Costs and Stochastic Volatility.*

Two major financial market frictions are transaction costs and uncertain volatility, and we analyze their joint impact on the problem of portfolio optimization. When volatility is constant, the transaction costs optimal investment problem has a long history, especially in the use of asymptotic approximations when the cost is small. Under stochastic volatility, but with no transaction costs, the Merton problem under general utility functions can also be analyzed with asymptotic methods. Here, we look at the long-run growth rate problem when both frictions are present, using separation of time scales approximations. This leads to perturbation analysis of an eigenvalue problem. We find the first term in the asymptotic expansion in the time scale parameter, of the optimal long-term growth rate, and of the optimal strategy, for fixed small transaction costs. (Received January 27, 2014)

1098-60-256 **Thomas A Laetsch*** (thomas.laetsch@uconn.edu), Department of Mathematics, University of Connecticut, Unit 3009, Storrs, CT 06269. *Questions in stochastic sub-Riemannian geometry.*

A sub-Riemannian manifold M is a connected smooth manifold such that the only smooth curves in M which are admissible are those whose tangent vectors at any point are restricted to a subset $\mathcal{H} \subset TM$, called the *horizontal distribution*. Such spaces have several applications in physics and engineering, as well as in the study of sub-elliptic and hypo-elliptic operators. We will be interested in the *hypo-elliptic Laplacian* and the trouble with defining one which is canonical. (Received January 27, 2014)

1098-60-263 **Colin Bogdan***, USNA, 1 Wilson Rd #11305, Annapolis, MD 21412, and **David Ruth**. *Applications of Graph-Theoretic Tests to Online Change Detection.*

Given a sequence of observations, has a change occurred in the underlying probability distribution with respect to observation order? How well can such a change be detected if the sequence is being monitored in real-time? The problem of detecting change, and doing so with minimal delay, is an important one in a wide array of real-world situations. Change-point problems may be classified as online or offline. In online problems, data are collected in real-time, with the goal of identifying a change as soon as possible after it occurs. In offline problems, data collection is halted for analysis to occur and the goal is to determine if, and maybe when, a change occurred in the data sequence. This project explores nonparametric graph-theoretic approaches to solving such problems in an online setting. We use the Ensemble Sum of Pair-Maxima (ESPM) Test, an offline test developed by Ruth and Koyak (2011), as the start for our new methodology and extend it for use in online situations. Our work investigates the capacity of the ESPM Test in a variety of distributional and dimensional settings, and ultimately modifies the ESPM Test for online settings through a novel modification of recently developed multiple testing procedures designed to control false discovery rate. (Received January 27, 2014)

1098-60-284 **Weining Kang*** (wkang@umbc.edu), Department of Mathematics and Statistics, University of Maryland, 1000 Hilltop Circle, Baltimore, MD 21250, and **Kavita Ramanan** (kavita_ramanan@brown.edu), Department of Applied Mathematics, Brown University, Providence, RI 02912. *Characterization of stationary distributions of reflected diffusions.*

We consider a reflected diffusion associated with a domain G, a reflection vector field $d(\cdot)$ on ∂G, and drift and dispersion coefficients $b(\cdot)$ and $\sigma(\cdot)$. Let $\mathcal{L}$ be the usual second-order elliptic operator. Under mild assumptions on the coefficients and reflection vector field, we show that when the associated submartingale problem is well posed, a probability measure π on $\bar{G}$ with $\pi(\partial G) = 0$ is a stationary distribution for the reflected diffusion if and only if $\int_{\bar{G}} \mathcal{L}f(x)\pi(dx) \leq 0$ for every f in a certain class of test functions. The assumptions are verified for a large class of obliquely reflected diffusions in piecewise smooth domains, including those that are not semimartingales. In the cases of bounded smooth domains and polyhedral domains that satisfy a skew-symmetry condition, we show that the reflected diffusion has invariant density of Gibbs form if a certain skew-transform of the drift is conservative and of class $\mathcal{C}^1$ and the covariance matrix is non-degenerate. Finally, under non-degeneracy condition on the covariance matrix, a boundary property is shown that implies that the condition $\pi(\partial G) = 0$ is necessary for π to be a stationary distribution. (Received January 28, 2014)

1098-60-287 **Nayantara Bhatnagar*** (nayantara.bhatnagar@gmail.com). *Mixing of Exclusion Chains.*

I will present some open problems on mixing times of Markov chains on spaces of multiple particles with exclusion. (Received January 28, 2014)

1098-60-307 **Alexander Drewitz*** (drewitz@math.columbia.edu), Department of Mathematics Columbia University, RM 614, MC 4419, 2990 Broadway, New York, NY 10027. *Ballisticity conditions and trapping for higher-dimensional random walk in random environment.*

Random walk in random environment (RWRE) is a fundamental model of statistical mechanics, describing the movement of a particle in a highly disordered and inhomogeneous medium as a random walk with random jump probabilities. It has been introduced around the 70s of the last century in a series of papers as a model of DNA chain replication and crystal growth, and also as a model of turbulent behavior in fluids through a Lorentz gas description. It is a simple but powerful model for a variety of complex large-scale disordered phenomena arising from fields such as physics, biology and engineering. While the one-dimensional model is well-understood, in the multidimensional setting fundamental questions about the RWRE model have resisted repeated and persistent attempts to answer them.

We introduce the model and give an overview over some basic open problems. We proceed to explain the phenomena of ballisticity and trapping in higher dimensions, thereby pointing out some of the progress that has recently been obtained as well as some fundamental questions that still remain open. (Received January 28, 2014)

1098-60-327 **Mokshay Madiman***, Mathematical Sciences–Ewing 404, University of Delaware, Newark, DE 19716. *Some open problems at the intersection of probability and information theory.*

Recent developments as well as open problems at the intersection of probability and information theory will be discussed, including entropic limit theorems. (Received January 29, 2014)

1098-60-329 **Pierre F.J. Lermusiaux***, MIT, 77 Mave Ave, Cambridge, MA 02138. *Towards Bayesian Nonlinear Smoothing and Adaptive Sampling with Swarms of Ocean Vehicles.* Preliminary report.

The focus is on methodologies for optimal marine sensing using collaborative swarms of autonomous platforms that are smart, i.e. knowledgeable about the predicted environment and about the predicted effects of future sampling. First, a methodology for the time-optimal path planning of swarms of autonomous vehicles that optimally utilize ocean currents is presented. Schemes allow optimal planning for coordinated groups of vehicles, maintaining formations and avoiding time-dependent obstacles in complex multiscale flows. Methodologies are then presented for optimal Bayesian nonlinear state estimation and adaptive sampling of large systems, both forward and backward in time. The Bayesian nonlinear smoothing is obtained by combining reduced-order Dynamically-Orthogonal equations with Gaussian Mixture Models. With this result, Bayesian nonlinear adaptive sampling schemes are derived to predict the observations to be collected that maximize information about variables of interest, in the future and in the past, while accounting for the constraints of the available sensing systems. When combined with our rigorous time-optimal path planning schemes, a unified result is efficient coordinated swarms of autonomous ocean sampling systems. This is joint work with Tapovan Lolla. (Received January 29, 2014)

62 ► Statistics

1098-62-96 **Megan M. Marron*** (mmm133@pitt.edu) and **Abdus S. Wahed** (wahed@pitt.edu). *Using Medical Research Data to Motivate Methodology Development among Undergraduates in SIBS Pittsburgh.*

Missing data mechanisms, methods of handling missing data, and the potential impact of missing data on study results are usually not taught to undergraduates because these topics are viewed as too advanced. However, the appropriate handling of missing data is fundamental to biomedical research. The Summer Institute for Training in Biostatistics (SIBS) provides practical experience to motivate students to pursue graduate training and biomedical research. For the past four years, SIBS Pittsburgh has demonstrated the feasibility of introducing missing data concepts to undergraduates in a small-group project-based setting that involves both simulation and data analysis. After learning about missing data mechanisms and statistical techniques, undergraduates apply what they have learned to an NIH/NIDDK-funded Hepatitis C treatment study, to examine how various hypothesized missing data patterns can affect results. Simulation is used to examine the bias and precision of these methods under each missing data pattern. Our experience shows that under such project-based training, advanced topics, such as missing data, can be presented to students with limited statistical preparation. Undergraduates also gain an appreciation for how new statistical methods are developed and evaluated. (Received January 26, 2014)

1098-62-98 **Roslyn A Stone*** (roslyn@pitt.edu), 304 Parran Hall, Graduate School of Public Health, 130 DeSoto Street, Pittsburgh, PA 15261. *Utilizing Research Data in the Summer Institute for Training in Biostatistics (SIBS) Pittsburgh Program: "Collaborative Research, Cardiovascular Health, and Minority Populations".*

To address concerns regarding a national shortage of biostatisticians, since 2003 the NIH National Heart, Lung, and Blood Institute (NHBLI) has supported the development, conduct, and evaluation of summer programs in the basic principles and methods of biostatistics. The purpose of these Summer Institutes for Training in Biostatistics (SIBS) programs is to attract new students into the field, specifically undergraduates majoring in mathematics or other quantitative areas. A total of 8 SIBS programs have been funded for 2013-2015, at Boston U, Columbia, Emory, NCSU-DCRI, and the Universities of Iowa, Minnesota, Pittsburgh, and Wisconsin (Madison). Although each SIBS program exploits unique opportunities and resources available at its institution, all share common elements, such as interactive training activities, innovative approaches to teaching, and high-profile, relevant examples, including NHLBI-sponsored studies of heart, lung, blood, and sleep disorders. We describe how some of the data resources from biomedical and epidemiologic research studies conducted at the U of Pittsburgh have been integrated into the SIBS Pittsburgh program through classroom activities, journal clubs, and individual or small group projects. (Received January 15, 2014)

1098-62-162 **Ali A Al-sharadqah*** (alsharadqaha@ecu.edu), Department of Mathematics, Austin 323D, East Carolina University, Greenville, NC 27858. *A New 'non-minimization' approach and its applications in Computer Vision.*

The technique of "renormalization" for geometric estimation attracted much attention when it appeared in early 1990s for having higher accuracy than any other then known methods. The key fact is that it directly specifies equations to solve, rather than minimizing some cost function. "non- minimization approach" will be exploited to modify renormalization so that it outperforms the standard reprojection error minimization. Doing a precise error analysis in the most general situation, we derive a formula that maximizes the accuracy of the solution; we call the resulting scheme hyper-renormalization. Applying it to ellipse fitting, fundamental matrix computation, and homography computation, we conclude that it is the best strategy that we can take. Our emphasis is on the general principle, rather than on individual methods for particular problems. (Received January 23, 2014)

1098-62-288 **Eric David Buras*** (eburas77@gmail.com), 4511 Klingle St. NW, Washington, DC 20016, and **Hans Engler**. *Capital Bikeshare Station and Ride Analysis.*

As bikesharing systems have grown increasingly popular all over the world, Washington DC opened a bikeshare system called Capital Bikeshare in 2010. Before Citi Bike opened in New York City last summer, Capital Bikeshare was the largest system in the United States. Capital Bikeshare freely publishes all its ride data on its website thus inviting analysis from outside parties. This talk will discuss how the authors mine ride data which includes start and end stations, start and end times, and type of rider. Specifically we will talk about using the Expectation-Maximization algorithm with Poisson count data to introduce a latent variable which clusters the ride data according to different variables. The purpose of the clustering is to identify travel patterns of DC bike commuters and potential station communities. We are also exploring multiple model variations to identify useful new ways of looking at the data. (Received January 28, 2014)

65 ► Numerical analysis

1098-65-16 **K Ren*** (ren@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 2515 Speedway, C1200, Austin, TX 78712. *Efficient Reconstruction Algorithms for Inverse Problems in Quantitative Photoacoustic Imaging.*

Inverse problems in quantitative photoacoustic tomography (QPAT) aim at reconstructing physical parameters in the radiative transport equation or the diffusion equation from absorbed energy map inside the domain. We review here several efficient non-iterative reconstruction algorithms for QPAT in non-scattering media and highly scattering media that we have developed recently. (Received October 26, 2013)

1098-65-51 **Matthias K. Gobbert*** (gobbert@umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, and **Nagaraj K. Neerchal** (nagaraj@umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250. *Undergraduate Research on the Fast Track: From Nothing to Publication in Eight Weeks.*

Since Summer 2010, we have been hosting the REU Site: Interdisciplinary Program in High Performance Computing. It introduces undergraduate students to scientific, statistical, and parallel computing with MPI and conducts research with application scientists from industry, academia, and government agencies in only eight weeks. We will share our experiences of how to make this program work through team work and by involving several layers of support from graduate students to faculty, with lessons that are useful for anyone interested in running an REU Site. (Received December 29, 2013)

1098-65-88 **Sergei Fomin**, MD 20740, and **Ravi Shankar**, **Peter Haine** and **Abigail Gartrell*** (agartrel@terpmail.umd.edu), 6801 Preinkert Dr, 7713c, College Park, MD 20740, and **Alberto Mojica** and **Nate Loker**. *Linear Stability of Non-Newtonian Rimming Flow.* Preliminary report.

The linear stability of a thin film flowing inside a rotating horizontal cylinder is considered. The effects of non-Newtonian shear-thinning and viscoelasticity on stability are considered with two simple constitutive equations:

the Generalized Newtonian fluid model and the Second Order Viscoelastic Fluid model. Using a lubrication approximation, it is found that non-Newtonian shear-thinning properties of the fluid have no effect on the neutral stability of rimming flow. Weak viscoelasticity, however, is found to stabilize the flow regime. (Received January 13, 2014)

1098-65-211 **Xuemei Chen*** (xuemeic@math.umd.edu) and **Alexander M. Powell**. *Fusion frames and randomized subspace actions.*

A randomized subspace action algorithm is investigated for fusion frame signal recovery problems. It is shown that Kaczmarz bounds provide upper bounds on the algorithm's error moments. Moreover, the question of which probability distributions on a random fusion frame lead to provably fast convergence is addressed. In particular, it is proven which distributions give minimal Kaczmarz bounds, and hence give best control on error moment upper bounds arising from Kaczmarz bounds. Uniqueness of the optimal distributions is also addressed. This is a work with Alex Powell. (Received January 26, 2014)

1098-65-271 **Padmanabhan Seshaiyer*** (pseshaiy@gmu.edu), 4400 University Drive, MS 3F2, Mathematical Sciences, Exploratory Hall, George Mason University, Fairfax, VA 22030. *Transforming Practice through Undergraduate Research Experiences.* Preliminary report.

In this talk, we describe the role of a multidisciplinary undergraduate research experience that has helped students become change agents to serve as catalysts to help reinforce and drive reform across an institution. Undergraduate research in computational mathematics is used as an example to transform teaching and research practices for students and faculty from the high school to the graduate levels. The role of institution and faculty in helping transform students into change agents will also be described and specific examples of computational mathematics projects with applications to biological, bio-inspired and engineering systems will be discussed that has had cascading effects on student learning both locally and internationally. (Received January 27, 2014)

1098-65-291 **Fan Zhao**, Philadelphia, PA 19104, **John C Schotland**, Ann Arbor, MI 48109, and **Vadim A Markel*** (vmarkel@mail.med.upenn.edu), Philadelphia, PA 19104. *Inversion of the Star Transform.*

I will discuss inversion of a generalization of the broken-ray transform, which we refer to as the star transform. The star transform is of the form

$$\Phi_K(\mathbf{R}) = \sum_{k=1}^{K} s_k I_k(\mathbf{R}) \ , \quad \mathbf{R} \equiv (Y, Z) \in \bar{\mathbb{S}} = \{0 \leq z \leq L\} \tag{1}$$

$$I_k(\mathbf{R}) = \int_0^{\ell_k(Z)} \mu\left(\mathbf{R} + \hat{\mathbf{u}}_k \ell\right) d\ell \ . \tag{2}$$

Here $\mathbf{R}$ is the vertex of the star and $\Phi_K(\mathbf{R})$ is the data function for a K-ray imaging geometry, $\hat{\mathbf{u}}_k = (u_{ky}, u_{kz})$ is a set of K unit vectors with nonzero projections onto the Z-axis (that is, $u_{ky}^2 + u_{kz}^2 = 1$ and $u_{kz} \neq 0$), $\ell_k(Z)$ is the distance (defined for each ray) from the vertex to the boundary, finally, $s_k \neq 0$ is a set of known coefficients.

I will explain how the star transform can be obtained from physical measurements, discuss computationally-efficient methods for its inversion and analyze stability. (Received January 28, 2014)

1098-65-323 **Wonjun Lee*** (wlee10@gmu.edu), 6826 Georgetown Pike, Mclean, VA 22101. *Reconstruction of Video Using SVD with Delays.*

Singular value decomposition (SVD) is a matrix factorization that can be used to compress or filter data. We apply this idea to reconstruct video acquired with noise. Our goal is to interpret the correlation of the time frames of the data and cancel the noise using delays of time frames. (Received January 28, 2014)

68 ► Computer science

1098-68-145 **Annie S Ross*** (anniesross@gmail.com), 252 West Prospect Road, Apt 34, Fort Collins, CO 80526, and **Elizabeth Clark**, **Christine Klotz** and **Craig Martell**. *Using Bayesian Statistics on Twitter Feeds to Classify Twitter Users.* Preliminary report.

Social media is a hot spot for spreading and gathering information. On networks, including Twitter, components such as the number of followers a user has, number of other users a user follows, tweets per day, number of lists and number of friends may all be indicative of their social media presence and their ability to spread and gather information. This project attempted to classify the level of each above listed component (e.g. many followers versus few followers) a Twitter user is at based only on the text of their tweets. We also discovered a relationship between the usage of Twitter communication techniques (e.g. hashtags, at-replies and URLs) and number of followers. The findings of this project will give a better understanding of the relationship between social media behavior and language utilized on those social media sites. (Received January 21, 2014)

1098-68-150 **Matthew J Patitz*** (patitz@uark.edu), 517 JBHT, 1 University of Arkansas, Fayetteville, AR 72701. *An Introduction to Algorithmic Self-Assembly Within the Abstract Tile Assembly Model.*

Self-assembly is the process by which large collections of small, relatively simple components spontaneously and autonomously combine to form complex structures. The process of self-assembly is ubiquitous in nature, occurring across scales and domains, and drives the formation of everything from cellular components in living systems, to snowflakes and star systems. The abstract Tile Assembly Model (aTAM) introduced by Erik Winfree in 1998 has proven to be an elegant and powerful model of self-assembling systems, and has inspired laboratory implementations based on DNA molecules as well as many lines of mathematical research. In the aTAM, the fundamental components are square "tiles" with labeled "glues" on their edges which allow tiles to bind to each other along edges with matching glues. We will present the aTAM and survey a wide series of results within it, including: upper and lower bounds for the efficient algorithmic self-assembly of shapes, Turing universal computation by self-assembling systems, the self-assembly of self-similar fractal patterns, and the notion of intrinsic universality of the aTAM. We will also briefly discuss some new research directions and outstanding open problems in the field. (Received January 22, 2014)

70 ► Mechanics of particles and systems

1098-70-61 **Mark Levi*** (levi@math.psu.edu), Mathematics Department, Penn State University, University Park, PA 16802. *An explanation of the rising chain paradox.*

Abstract: In this talk I will give an explanation of a counterintuitive effect involving a falling chain, and will mention some related results. (Received January 05, 2014)

1098-70-123 **Kenneth R Ball*** (ballkenneth@gmail.com). *Variational Integrators and Non-coordinate Frames in Velocity Space.*

The analysis of certain mechanical systems may be simplified by the introduction of a moving frame to velocity space that is not tied directly to configuration coordinates. Measuring velocity vectors against such a frame may simplify the equations of motion and provide insight into systems with symmetries and/or velocity constraints (Ball, Zenkov, and Bloch [2012] and Bloch, Marsden, and Zenkov [2009]). The development of numerical integrators for the simulation of such systems is of interest (Kobilarov, Marsden, and Sukhatme [2009]). In this presentation, recent developments will be presented that demonstrate a novel class of numerical integrators motivated by the form of the equations of motion with respect to a non-coordinate frame in velocity space. These discrete approximations of the continuous equations of motion are further demonstrated to be variational integrators, and thus result in update maps that preserve discrete analogues of physically meaningful quantities (Marsden and West [2001]). (Received January 20, 2014)

1098-70-281 **Dmitry V Zenkov*** (dvzenkov@ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695, and **Melvin Leok** and **Anthony M Bloch**. *Hamel's Formalism and a Structure-Preserving Integrator for a Spherical Pendulum.*

Hamel's formalism is a representation of Lagrangian mechanics in which the velocity components are unrelated to configuration coordinates. This formalism is utilized for constructing a global energy and momentum preserving variational integrator for spherical pendulum. (Received January 28, 2014)

1098-70-293 **Scott David Kelly*** (scott@kellyfish.net). *Constrained mechanics in idealized models for propulsive vortex shedding.*

A well-developed formalism exists for the analysis of finite-dimensional mechanical systems subject to integrable and nonintegrable velocity constraints that break symmetries. Symmetry-breaking constraints arise naturally in idealized models for vortex shedding from solid bodies in fluids, exemplified by the Kutta condition from classical hydrodynamics. This talk will detail parallels between problems in the self-propulsion of terrestrial robotic vehicles subject to nonintegrable constraints like rolling constraints and problems in the self-propulsion of aquatic vehicles exploiting localized vortex shedding, highlighting the relevance of notions like nonholonomic momentum to both cases. (Received January 28, 2014)

74 ► Mechanics of deformable solids

1098-74-159 **Robert S Manning*** (rmanning@haverford.edu), Department of Mathematics and Statistics, Haverford College, 370 Lancaster Ave., Haverford, PA 19041. *Monte Carlo simulations within a rigid base model of DNA with comparison to experimental measurements of persistence length and cyclization.* Preliminary report.

We present Monte Carlo simulations within a DNA model (developed by the laboratory of John Maddocks) that assumes the DNA bases are rigid with the two bases in a basepair allowed to move relative to each other. The parameters for shape and flexibility of a given DNA molecule depend on its sequence via parameters extracted by Maddocks and collaborators from a large ensemble of molecular dynamics simulations.

The Monte Carlo simulations allow us to extract estimates of the *persistence length*, a characteristic length-scale for bending often measured experimentally. Averaging over many random sequences, our model predicts a persistence length in good agreement with the generally accepted value for DNA. In addition, we compare our model's predictions for sequence-dependent persistence lengths to experiments designed to explore this same effect.

The Monte Carlo simulations also allow comparison to the *cyclization J-factor*, an experimental measurement related to the likelihood that a DNA molecule forms a loop. We show results for how our model's predicted J-factors depend on DNA length and on the specific basepair sequence for some sequences studied experimentally. (Received January 23, 2014)

76 ► Fluid mechanics

1098-76-62 **Jie Yu*** (jie_yu@ncsu.edu), Civil, Construction and Environmental Engr, North Carolina State University, Raleigh, NC 27695. *Fluid ratcheting by oscillating channel walls with sawteeth.*

Inspired by an experiment (Thiria & Zhang, BAPS.2010.DFD.HC.3) that demonstrates the effects of ratcheting fluid using vibrational motions of the sawtooth channel walls, we put forward here a theory describing the rectified flow field, and the net directional pumping rate which is related to the spatial average of the steady flow. In a conformally transformed plane, the Stokes boundary layer flow is analysed, revealing the nonlinear effects driving the rectified flow and its complex spatial structure. Whereas the wall sawtooth shape is a source of asymmetry, the difference in entrance and exit flow conditions due to the geometries at the channel ends is found to be a second source to break the left-right symmetry of the system, and affect the net directional transport of fluid. Various influences on the net pumping rate are analysed. (Received January 06, 2014)

1098-76-309 **Jonathan C. Horton*** (jhorton3@masonlive.gmu.edu), George Mason University, 4450 Rivanna River Way, Fairfax, VA 22030. *Effects of a Contact Lens and the Blinking Cycle on Tear Film Deposition and Drainage.*

This study analyzes the dynamics of the eye's pre-lens tear film when a contact lens is in place. The blinking cycle replenishes the tear film and causes motion of the contact lens. With assumptions based on lubrication theory, equations governing the fluid dynamics of the tear film are simplified to provide an evolution PDE describing the rate of change in the tear film's thickness. Further research will explore numerical solutions, which may provide necessary insight for treating dry eye in contact lens wearers. (Received January 28, 2014)

78 ► Optics, electromagnetic theory

1098-78-91 **Ge Wang*** (wangg6@rpi.edu), Biomedical Imaging Center, BT 3209, RPI, 110 8th Street, Troy, NY 12180. *Micro-modulated Luminescence Tomography.* Preliminary report.

Imaging depth of optical microscopy has been fundamentally limited to millimeter or sub-millimeter due to multiple scattering of light in a biological sample. X-ray microscopy can resolve spatial details of few microns deeply inside a sample but contrast resolution is inadequate to depict heterogeneous features at cellular or sub-cellular levels. To enhance and enrich biological contrast at large imaging depth, various nanoparticles become essential to basic research and molecular medicine. Nanoparticles can be functionalized as imaging probes, similar to fluorescent and bioluminescent proteins. Recently, $LiGa5O8:Cr3+$ nanoparticles were synthesized to facilitate luminescence energy storage with x-ray pre-excitation and subsequently stimulated luminescence emission by visible/near-infrared (NIR) light. In this talk, we propose a micro-modulated luminescence tomography (MLT) approach to quantify a nanophosphor distribution with or without energy storing characteristics in a thick biological sample with high resolution. Our numerical simulation studies demonstrate the feasibility of the proposed approach. (Received January 14, 2014)

82 ► Statistical mechanics, structure of matter

1098-82-82 **Jean E Taylor*** (jtaylor@cims.nyu.edu). *Archimedian solids and quasigeometric descriptions of atomic positions in quasicrystals.*

Quasicrystals are physically-occurring materials which are nonperiodic and yet have strong signals of order as revealed by diffraction. Mathematical descriptions of them can be downright beautiful. The role of icosahedral symmetry in the diffraction pattern, and of icosahedral clusters in materials, are active areas of speculation and research. (Received January 12, 2014)

83 ► Relativity and gravitational theory

1098-83-94 **Jon A Williams*** (m147242@usna.edu), P.O. Box 15623, Annapolis, MD 21412. *Geodesics and Waves on a Class of Self-Similar spacetimes.* Preliminary report.

In this project we investigate a class of self-similar spacetime metrics given by

$$ds^2 = e^{2t}\left(g_1(x)\,dt^2 + g_2(x)\,dx^2 + e^{2x}d\Omega^2\right),$$

where $d\Omega^2 = d\theta^2 + \sin^2\theta d\phi^2$. We investigate special cases where $g_1(x)$ and $g_2(x)$ are specified. Using the Euler-Lagrange equations we find geodesic paths in our spacetime. Classical singularities are studied by analyzing the Riemann and Ricci tensors as well as the Ricci scalar for our metric. Quantum mechanical singularities are studied using the Klein-Gordon scalar wave equation and Maxwell's field equations. (Received January 15, 2014)

86 ► Geophysics

1098-86-57 **Christopher V Rackauckas*** (crackauc@uci.edu), 6368 Adobe Circle Road S., Irvine, CA 92617, and **Jim A Walsh** (jim.a.walsh@oberlin.edu), 10 N. Professor St, King 220C, Oberlin, OH 44074. *Ice-Albedo Feedback and the Jormungand Climate State.*

The geological and paleomagnetic record indicate that around 750 million and 580 millions years ago glaciers grew near the equator, though as of yet we do not fully understand the nature of these glaciations. The well-known Snowball Earth Hypothesis states that the Earth was covered entirely by glaciers. However, it is hard for this hypothesis to account for certain aspects of the biological evidence such as the survival of photosynthetic eukaryotes. Thus the Jormungand Hypothesis was developed as an alternative to the Snowball Earth Hypothesis. In this talk we investigate previous models of the Jormungand state and look at the dynamics of the Hadley cells to develop a new model to represent the Jormungand Hypothesis. We develop an analytical approximation to the model using a finite Legendre expansion and prove the existence of an attracting one-dimensional invariant manifold using geometric singular perturbation theory. The resultant model gives a stable equilibrium point near the equator with strong hysteresis that satisfies the Jormungand Hypothesis. (Received January 03, 2014)

90 ► Operations research, mathematical programming

1098-90-26 **Robert J. Vanderbei*** (rvdb@princeton.edu), 209 Sherrerd Hall, Princeton University, Princeton, NJ 08544. *Two New Efficient Algorithms for Compressed Sensing Problems.*

We present two new approaches for efficiently solving large-scale compressed sensing problems. These two ideas are independent of each other and can therefore be used either separately or together. We consider all possibilities.

For the first approach, if the underlying signal is very sparse, some variants of the simplex method can be expected to take only a small number of pivots to arrive at a solution. We implemented one such variant and demonstrate a dramatic improvement in computation time on very sparse signals.

The second approach requires a redesigned sensing mechanism in which the vector signal is stacked into a matrix. The matrix variant, modeled correctly, is a much sparser linear optimization problem. Hence, algorithms that benefit from sparse problem representation, such as interior-point methods, can solve matrix sensing problems much faster than the corresponding vector problem. In our numerical studies, we demonstrate a ten-fold improvement in the computation time. (Received November 30, 2013)

1098-90-30 **Yunlong He** and **Renato D C Monteiro*** (monteiro@isye.gatech.edu), School of ISyE, Georgia Tech, Atlanta, GA 30332. *Accelerating block-decomposition first-order methods for solving generalized saddle-point and Nash equilibrium problems.*

This talk considers the generalized (two-player) Nash equilibrium (GNE) problem with a separable non-smooth part, which is known to include the generalized saddle-point (GSP) problem as a special case. We consider solving these problems by an accelerated version of the block-decomposition HPE method where the block-subproblems are approximately solved by a Nesterov-type accelerated method. Since this block-decomposition variant is able to take large stepsizes, it can substantially outperform both theoretically and computationally other existing zero-th order methods on many relevant GSP and GNE instances. (Received December 06, 2013)

1098-90-36 **Stephen G Nash*** (snash@gmu.edu), Volgenau School of Engineering, MS 5C8, George Mason University, Fairfax, VA 22030. *Using Inexact Gradients in a Multilevel Optimization Algorithm.*

Many optimization algorithms require gradients of the model functions, but computing accurate gradients can be computationally expensive. We study the implications of using inexact gradients in the context of the multilevel optimization algorithm MG/Opt. MG/Opt recursively uses (typically cheaper) coarse models to obtain search directions for finer-level models. However, MG/Opt requires the gradient on the fine level to define the recursion. Our primary focus here is the impact of the gradient errors on the multilevel recursion. We analyze, partly through model problems, how MG/Opt is affected under various assumptions about the source of the error in the gradients, and demonstrate that in many cases the effect of the errors is benign. Thus, the excellent performance of multilevel methods can be achieved even with inexact gradients. Computational experiments are included. (Received December 20, 2013)

1098-90-70 **Alexander B. Németh** (nemab@math.ubbcluj.ro) and **Sándor Zoltán Németh*** (s.nemeth@bham.ac.uk). *Lattice-like subsets of Euclidean Jordan algebras.*

While studying some properties of linear operators in a Euclidean Jordan algebra, Gowda, Sznajder and Tao have introduced generalized lattice operations based on the projection onto the cone of squares. We have shown that these lattice-like operators and their generalizations are important tools in establishing the isotonicity of the metric projection onto some closed convex sets. The results of this kind are motivated by methods for proving the existence of solutions of variational inequalities and methods for finding these solutions in a recursive way. It turns out, that the closed convex sets admitting isotone projections are exactly the sets which are invariant with respect to these lattice-like operations, called lattice-like sets. We have shown that the Jordan subalgebras are lattice-like sets, but the converse in general is not true. In the case of simple Euclidean Jordan algebras of rank at least three the lattice-like property is rather restrictive, e.g., there are no lattice-like proper closed convex sets with interior points. (Received January 09, 2014)

1098-90-90 **Jiyuan Tao**, **M. Seetharama Gowda** and **Roman Sznajder*** (rsznajder@bowiestate.edu), Department of Mathematics, Bowie State University, 14000 Jericho Park Road, Bowie, MD 20715. *On the block norm-***P** *property.*

A real $n \times n$ matrix M is said to be a $\mathbf{P}$-matrix if all its principal minors are positive. In a recent paper Chua and Yi describe this property in terms of norm: There exists a $\gamma > 0$ such that for all nonnegative diagonal matrices D and vectors x, $||Mx + Dx|| \geq \gamma ||x||$. We introduce here a block version of this property for a linear transformation defined on a product of normed or inner product spaces. In addition to relating this to (real) positive stability and positive principal minor properties, we study the invariance of this property by principal subtransformations and Schur complements. We also specialize this property to $\mathbf{Z}$-transformations and to Euclidean Jordan algebras. (Received January 14, 2014)

1098-90-93 **David E Stewart*** (david-e-stewart@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Uniqueness of solutions to dynamic complementarity problems.*

Dynamic complementarity problems have the form $K^* \ni w(t) \perp z(t) \in K$ where K is a closed convex cone and K^* is its dual cone (typically $K = K^* = \mathbb{R}^n_+$), and there is some dynamic relationship between $w(t)$ and $z(t)$ such as a differential equation. There is theory which shows when existence and uniqueness of solutions can be expected based on the *index* of the relationship between $z(\cdot)$ and $w(\cdot)$ similar to the index of differential algebraic equations. Sometimes the dynamics are best expressed through a convolution: $w(t) = (m * z)(t) + q(t)$.

In these cases the index does not need to be an integer. While a satisfactory existence theory has been developed for these problems, up until recently the uniqueness theory has not been satisfactory for index between one and two. (Received January 14, 2014)

1098-90-97 **Arkadi Nemirovski*** (nemirovs@isye.gatech.edu), 755 Ferst Drive, NW, Atlanta, GA 30332-0205. *Convex optimization on large-scale domains given by Linear Minimization Oracles.* Preliminary report.

We present algorithms for convex-concave saddle point and nonsmooth convex minimization problems on large-scale domains given by "computationally cheap" Linear Minimization Oracles capable to minimize linear forms over the domain. Domains of our primary interest are large-scale nuclear/total variation norm balls, where the common tools of large-scale convex optimization, proximal algorithms which at every step minimize over problem's domain perhaps simple, but nonlinear convex functions, become too time consuming, while minimizing a linear form over the domain still is relatively easy. The first component of our approach is "Fenchel-type representations" of monotone operators allowing to associate with the original problem its dual – a monotone variational inequality on some other domain. The latter in many important cases is "proximal-friendly," so that the dual problem can be solved by a proximal algorithm. The second component of our approach is "accuracy certificates" allowing to recover a good solution to the original problem from the information collected when solving the dual. We illustrate our approach by applying it to large-scale Matrix Completion with uniform and spectral norm fits. The talk is based on joint research with Dr. Anatoli Iouditski, France. (Received January 15, 2014)

1098-90-104 **Amitabh Basu*** (basu.amitabh@jhu.edu), 100 Whitehead Hall, 3400 N. Charles St., Baltimore, MD 21218. *Recent Progress in Gomory and Johnson's Infinite Group Problem.*

Ralph Gomory and Ellis Johnson introduced the so-called infinite group problem in the 70s as an elegant infinite dimensional abstraction of general mixed-integer optimization problems. Since then it has played a very important role in polyhedral combinatorics - a key tool for solving general mixed-integer optimization problems. In recent years powerful tools from analysis, convex geometry, and combinatorics have come together to make significant breakthroughs in this problem. We review recent results for the infinite group problem, and discuss the many challenging open problems that still remain. (Received January 16, 2014)

1098-90-181 **Gabor Pataki***, 522 aberdeen drive, apt 207. *Bad semidefinite programs: they all look the same, part 2.*

We call a semidefinite system (P) badly behaved if for some objective function "c" the values of

$$sup\{\langle c,x\rangle : x \text{ is feasible in } (P)\}$$

and its dual differ, or the dual value is unattained.

In previous work we characterized such systems by the presence of a certain certificate matrix; these certificate matrices are easy to spot in all such systems that appear in the literature.

Here we prove that we can verify the bad behavior of such a system only by elementary linear algebra; without referring to any theorem. Thus our certificates are analogous (though somewhat more complex) to the Farkas' lemma certificate of the infeasibility of a linear inequality system.

We prove an analogous result for systems that are well-behaved (i.e. not badly behaved). (Received January 24, 2014)

1098-90-227 **Hande Y. Benson*** (benson@drexel.edu), Department of Decision Sciences, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104, and **David F. Shanno**. *Cubic Regularization in Interior-Point Methods.*

We present several algorithms for nonlinear optimization, all employing cubic regularization. The favorable theoretical results of Griewank (1981), Nesterov and Polyak (2006), and Cartis et.al. (2011) motivate the use of cubic regularization, but its application at every iteration of the algorithm, as proposed by these papers, may be computationally expensive. We propose some modifications, and numerical results are provided to illustrate the robustness and efficiency of the proposed approaches on both unconstrained and constrained problems. (Received January 26, 2014)

1098-90-233 **Farid Alizadeh*** (farid.alizadeh@rutgers.edu), Management Science and Informaton Systems Dep, 100 Rockefellar Rd, Piscatawy, NJ 08, and **Marta Cavaleiro**, **Deniz Seyed eskandani** and **Mohammad Mehdi Ranjbar**. *Time Varying Maximum Flow Problem With Polynomial Capacities and Flows.*

We consider the maximum flow problem in a network where each arc has a time varying capacity: a univariate polynomial of fixed degree. We seek time varying polynomials representing instantaneous flow on each arc such that the total flow into the sink between times 0 and 1 is maximal. Nonnegative flow should not exceed capacity at any instance between 0 and 1. This problem can be solved by semidefinite programming. We also consider the case where there are time delays on each arc. We consider the possibility extending classical results based on augmenting paths to this case (Received January 26, 2014)

1098-90-283 **Uday V. Shanbhag*** (udaybag@psu.edu), 310 Leonhard Building, University Park, PA 16803, and **Hao Jiang**. *Stochastic approximation schemes for stochastic optimization problems with imperfect information.*

We consider the solution of a stochastic convex optimization problem $\mathbb{E}[f(x;\theta^*,\xi)]$ over a closed and convex set X in a regime where θ^* is unavailable. Instead, θ^* may be obtained through the solution of a learning problem that requires minimizing $\mathbb{E}[g(\theta;\eta)]$ in θ over a closed and convex set Θ. Traditional approaches have been inherently sequential and practical implementations may often be corrupted by error. To resolve this challenge, we present a coupled stochastic approximation scheme which simultaneously solves *both* the computational and the learning problems. The schemes are shown to be equipped with almost sure convergence properties in regimes when the function f is either strongly convex as well as merely convex. Importantly, the scheme displays the optimal rate for strongly convex problems while in merely convex regimes, through an averaging approach, we quantify the degradation associated with learning by noting that the error in function value is $\mathcal{O}\left(\sqrt{\frac{\ln(K)}{K}}\right)$, rather than $\mathcal{O}\left(\sqrt{\frac{1}{K}}\right)$ when θ^* is available. Preliminary numerics demonstrate the performance of the prescribed schemes. (Received January 28, 2014)

1098-90-295 **M. Seetharama Gowda*** (gowda@math.umbc.edu), Department of Mathematics and Statistics, UMBC, Baltimore, MD 21250. *The Lyapunov rank of a proper cone.*

In various strategies for solving primal-dual cone-LP problems or cone complementarity problems, one tries to write the optimality/complementarity conditions in the form of a square system by replacing the complementarity constraints by linearly independent bilinear relations. In order to identify proper cones where this can be achieved, we define the Lyapunov rank (also called the bilinearity rank) of a proper cone in R^n as the maximal number of linearly independent Lyapunov-like transformations (bilinearity relations) on the cone, or equivalently, as the dimension of the Lie algebra of the automorphism group of that cone. In this talk, we present some rank results for polyhedral cones, symmetric cones, completely positive cones, and Bishop-Phelps cones. We show, for example, that proper irreducible polyhedral cones (such as the l_1-cone, for $n \geq 3$) have rank one and symmetric cones admit square complementarity systems. (Received January 28, 2014)

1098-90-319 **James C Spall***, james.spall@jhuapl.edu, and **Karla Hernández**. *Extending Cyclic Seesaw Optimization from Deterministic Setting to Noisy Setting.*

Consider the problem of optimizing a function with respect to multiple parameters. A known approach to such optimization in the deterministic setting is the cyclic (or alternating or block coordinate) method, where the full parameter vector is divided into two or more subvectors and the process proceeds by sequentially optimizing each of the subvectors, while holding the remaining parameters at their most recent values. Because our focus is on the division of the full parameter vector into two subvectors, we sometimes refer to the resulting back-and-forth cyclic process as a "seesaw" process. Reasonable conditions exist in the deterministic setting under which it is known that the cyclic seesaw scheme leads to parameter estimates that converge to the optimal joint value for the full vector of unknown parameters. In this paper we consider a non-trivial extension of the known results to the setting of cyclic stochastic optimization where loss function measurements contain noise. We give a set of convergence conditions for a cyclic version of stochastic gradient and SPSA. Further, numerical results are presented comparing cyclic methods and non-cyclic (standard) methods and some conjectures are offered relative to the formal rate of convergence. (Received January 28, 2014)

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

1098-91-272 **Maxim Bichuch** and **Stephan Sturm*** (ssturm@wpi.edu), Department of Mathematical Sciences, 100 Institute Road, Worcester, MA 01609. *Optimal incentives for delegated portfolio optimization.* Preliminary report.

We study the problem of an investor who hires a fund manager to manage his wealth. The latter is paid by an incentive scheme based on the performance of the fund. Manager and investor have different risk aversions;

the manager may invest in a financial market to form a portfolio optimal for his expected utility whereas the investor is free to choose the incentives – taking only into account that the manager is paid enough to accept the managing contract. We discuss the problem of existence of optimal incentives in general semimartingale models and give an assertive answer for some classes of incentive schemes. This is joint work with Maxim Bichuch (Worcester Polytechnic Institute). (Received January 27, 2014)

92 ► Biology and other natural sciences

1098-92-50 **Antonio Mastroberardino*** (axm62@psu.edu), **Yuanji Cheng**, **Ahmed Abdelrazec** and **Hao Liu**. *Mathematical modeling of the HIV/Aids epidemic in Cuba.* Preliminary report.

In this talk, we present a nonlinear mathematical model for the transmission dynamics of HIV/Aids in Cuba. Due to Cuba's highly successful national prevention program, we assume that the only mode of transmission is through contact with people who do not know that they are HIV positive. We find the equilibria of the governing nonlinear system, perform a linear stability analysis, and then determine the threshold for global stability. We conclude with an application of optimal control as a demonstration of the effectiveness of the Cuban prevention program. (Received December 28, 2013)

1098-92-53 **Rosemary K Le*** (rosemary.le@stanford.edu), 126 Blackwelder Court, Apt 515, Stanford, CA 94305, and **David A Mely** and **Thomas Serre**. *Computational Mechanisms Responsible for the Hermann Grid Illusion.*

The Hermann grid is a well-known illusion. In its classical form, one perceives gray spots at the intersections of a black-and-white grid. Textbooks typically attribute the phenomenon to retinal ganglion cells. But in recent years, variations of the illusion have demonstrated that ganglion cells cannot be the sole mechanism. While many qualitative theories have been proposed, no computational model has been shown to account for all variations.

Here we consider several computational models of early vision, including a model of ganglion cells and increasingly sophisticated models of visual cortex. We conducted an experiment where participants ranked illusion variations according to their relative strength. The average of the participants' rankings produced a ground truth against which model output rankings were compared. Spearman's correlation measured the consistency of the model's ranking to the ground truth. Model parameters were constrained by physiological data and optimized to best fit human data.

We find that the most complete model of V1 is the best predictor of human perception. Our results confirm that the origin of the Hermann grid illusion is cortical in nature and that the strength of its variations stem from the interaction of several cortical processes. (Received December 30, 2013)

1098-92-78 **Jesus Alberto Leyva*** (jesus_leyva@brown.edu), 69 Brown Street Box 3852, Providence, RI 02912. *Monte Carlo Methods for Phylogenetic Analysis.* Preliminary report.

The research conducted in our lab is concerned primarily with the study and application of mathematical models for the purposes of analyzing phylogenetic data. Phylogenetics is defined as the branch of genetics concerned with the study of the evolutionary relationships between organisms and the overall tree models that allow us to better understand just how organisms interact.This is achieved by generating phylogenetic trees with predetermined structures so that if any errors are to arise in the algorithm they will be easier to detect that if the algorithms were tested with real data. Naturally, there are complexities that need to be taken into consideration when looking into developing test data such as the intended nuclear-mutation-rate matrices involved as well as the ideal node lengths involved in the test tree that is to be used. (Received January 10, 2014)

1098-92-111 **Isaac Klapper*** (klapper@temple.edu), Department of Mathematics, Wachman Hall, Temple University, 1805 North Broad Street, Philadelphia, PA 19122, and **Jack Dockery** and **Hal Smith**. *Niche Partitioning Along an Environmental Gradient.*

Biological systematics studies suggest that species are discretized in niche space. That is, rather than seeing a smoothly varying continuum of organism types with respect to continuous environmental variations, instead observers find discrete species or clumps of species, with one clump separated from another in niche space by a gap. Here, using a simple one dimensional model with a smoothly varying environmental condition, we investigate conditions for a discrete niche partitioning instability of a continuously varying species structure in the context of asexually reproducing microbes. We find that significant perturbation of translational invariance is required for instability, but that conditions for such perturbations might reasonably occur, for example through influence of boundary conditions. (Received January 17, 2014)

1098-92-125 **Nicolette Meshkat*** (ncmeshka@ncsu.edu) and **Seth Sullivant**. *Identifiable Reparametrizations of Linear Compartment 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. We study a particular class of unidentifiable models and find conditions to obtain identifiable reparametrizations of these models. In particular, we use a graph-theoretic approach to analyze the models and show that graphs with certain properties allow a monomial scaling reparametrization over identifiable functions of the parameters. (Received January 20, 2014)

1098-92-154 **Zhilan Feng**, **Katharine Gurski*** (kgurski@howard.edu), **Carrie Manore**, **Angela Peace**, **Olivia Prosper** and **Miranda Teboh-Ewungkem**. *The Role of Intermittent Preventive Treatment (IPT) and the Spread of Drug Resistance to Malaria.* Preliminary report.

Intermittent Preventive Treatment (IPT) is a malaria control strategy in which vulnerable asymptomatic individuals are given a full curative dose of an antimalarial medication at specified intervals. Though the use of IPT in vulnerable humans has been shown to positively impact certain aspects of malaria transmission in these groups, this control strategy also faces the problem of drug resistance. Developing studies to understand how IPT impacts the spread of drug resistance is essential. However, because the same drug is used for both IPT and the treatment of symptomatic cases, determining which treatment protocol drives the spread of drug resistance is challenging to investigate experimentally, thus a mathematical model is beneficial. We develop a structured model to investigate the relationship between IPT and the spread of drug resistance to malaria to determine both the critical level of IPT treatment that would minimize the spread of drug resistance in addition to the IPT dose that will lead to invasion of a resistant parasite strain. Our model differs from that of O'Meara et al. (2006) in that the transmission dynamics of the vector population is explicitly modeled, as well as the dynamics of the resistant malaria strain. (Received January 22, 2014)

1098-92-155 **Matthew W. Brewster*** (bmatt3@umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, **Xuan Huang** (hu6@umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, **Matthias K. Gobbert** (gobbert@umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, **Bradford E. Peercy** (bpeercy@umbc.edu), Department of Mathematics and Statistics, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, and **Padmanabhan Seshaiyer** (pseshaiy@gmu.edu), Department of Mathematical Sciences, George Mason University, 4400 University Drive, Fairfax, VA 22030. *The Influence of Stochastic Parameters on Calcium Waves in a Heart Cell.* Preliminary report.

Calcium is a critical component in many cellular functions. It serves many important functions such as signal transduction, contraction of muscles, enzyme function, and maintaining potential difference across excitable membranes. In this study, we examine spontaneous calcium waves in heart cells and how they initiate, propagate, and effect a transient measure of total cytosolic calcium. Calcium sparks are intracellular release events which are important in converting electrical stimuli into mechanical responses. We investigate the effects of stochastic release from calcium release units (CRUs) on generating calcium waves considering a distribution for the flux density term sampled (i) once for all CRUs and (ii) for each CRU independently. We include a stochastic flux density term as more physiologically appropriate than a fixed release rate. We use an array of statistical techniques as well as parallel computing to facilitate the large number of simulation runs. (Received January 22, 2014)

1098-92-161 **David A Edwards*** (edwards@math.udel.edu), Department of Mathematical Sciences, Ewing Hall, University of Delaware, Newark, DE 19716. *Increasing the Utility of Optical Biosensors.*

The ubiquity of surface-volume reactions makes knowledge of their kinetics critical. To that end, several optical biosensors have appeared on the market to measure rate constants. In this talk, we focus on an extended application of such biosensors. Traditionally, the biosensors have been considered limited to two-component reactions because they measure mass changes at the sensor surface. However, many biological reactions of interest involve multiple steps and multiple components. A model is presented which shows how certain multistep reactions can be analyzed easily with these devices. (Received January 23, 2014)

1098-92-168 **Margaret Watts*** (margaret.watts@nih.gov), **Ofer Kimchi** and **Arthur Sherman**.
Modeling the Pancreatic-α-cell: Paracrine versus Intrinsic Regulation of Glucagon Secretion.

It has been proposed that glucagon secretion is under paracrine control; however, there is evidence that α-cells also possess an intrinsic glucose-sensing mechanism. We consider two intrinsic mechanisms of glucagon secretion: ATP-sensitive potassium channels and a store operated current. Using a mathematical model of glucagon secretion in α-cells, we show that both mechanisms can suppress glucagon secretion, but both have to work together to reproduce the glucose dose response curve seen experimentally. We also investigate how paracrine effects in the form of insulin regulate glucagon secretion. By adding the inhibitory effect of insulin on glucagon secretion, we can model the anti-synchronous pulses of insulin and glucagon observed in elevated glucose. It is also known that α-cells are extremely heterogeneous and not coupled by gap junctions like β-cells. Therefore, we conclude that the paracrine effects modulate the intrinsic mechanisms and overcome the heterogeneity of the α-cells. (Received January 24, 2014)

1098-92-172 **Michael J Crone***, mcrone@masonlive.gmu.edu, and **Evelyn Sander**. *Investigating the Limit Cycles of the Ratio-Dependent Predator-Prey System with Constant Harvests.*

The Ratio-Dependent Predator-Prey System (RDPPS) is an ODE population model that has empirical support for its ecological accuracy. We investigate a modification of the RDPPS with constant rate harvesting subtracted from both the predator and the prey populations, to represent the populations being harvested by humans, as in a commercial fishery. Previous results have shown that the standard RDPPS model has no limit cycle solutions throughout its parameter space, but that subtracting a constant harvest from the predator or the prey in the model can lead to limit cycle solutions for certain parameter values. We present the preliminary results from a numerical investigation of the entire parameter space for the model investigating the robustness of the limit cycles. Our informal investigations have shown that these limit cycles exist for a very small region of parameter space: a 1% change in the predator harvest is observed to be more than enough to pass entirely through the region of parameter space that allows limit cycles. (Received January 24, 2014)

1098-92-174 **Mustafa Mert Ankarali*** (mertankarali@jhu.edu), 3400 N Charles Street, 136 Hackerman Hall, Baltimore, MD 21218, **Manu S Madhav** (manusmad@jhu.edu), 3400 N Charles Street, 136 Hackerman Hall, Baltimore, MD 21218, **Shahin Sefati** (shahin@jhu.edu), 3400 N Charles Street, 136 Hackerman Hall, Baltimore, MD 21218, and **Noah J Cowan** (ncowan@jhu.edu), 3400 N Charles Street, 126 Hackerman Hall, Baltimore, MD 21218. *Fitting low-order transfer function models to messy biological data.*

Biological systems are not low order, linear, nor time invariant. But it is often useful to model them as such. Given the significant variability in biological systems, we want to fit models that are robust to biological "noise"—such as trial-to-trial variability, differences between individuals, sex differences, and parameter drift that may occur over time—but that nevertheless capture the system behavior in a parsimonious manner. Here, we present a straightforward approach for fitting low-order parametric transfer functions to frequency-domain data. Our goal is to produce a user-friendly set of tools based on model selection (e.g. AIC, BIC, cross validation) that will enable biologists to generate simple analytical expressions from necessarily nonlinear, time-varying, and infinite dimensional biological phenomena. Application to problems in sensorimotor control systems illustrate the approach. (Received January 24, 2014)

1098-92-182 **Sergey V. Krivovichev*** (s.krivovichev@spbu.ru), Department of Crystallography, St.Petersburg State University, University Emb. 7/9, St. Petersburg, 199034, Russia.
Quantitative Measures of Complexity of Crystal Structures.

Discovery of diffraction of X-rays on crystals opened up a new era in our understanding of nature, leading to a multitude of striking discoveries of structures and functions of matter on the atomic and molecular scales. Over the last hundred years, about 150 000 of inorganic crystal structures have been elucidated and visualized. The advent of new technologies such as area detectors and synchrotron radiation led to solution of structures of unprecedented complexity. However, the very notion of structural complexity of crystals lacked its unambigous quantitative definition until recently. It was demonstrated in [Acta Cryst. 2012, A68: 393-398; Min. Mag. 2013, 77: 275-326; Angew. Chem. Int. Ed. 2014, 53: 654-661] that representation of a crystal structure in terms of its quotient graph allows to use information entropies of graphs as a measure of static structural complexity of crystals. To describe structural complexity in algorithmic (dynamic) terms one has to develop more sophisticated techniques and there is still no accessible and straightforward approach to construct universal measures of algorithmic complexity that are applicable to any crystal structure. Some of the possible solutions of the problem will be outlined. (Received January 25, 2014)

1098-92-189 **Kathryn R, Hedrick*** (khedrick@jhu.edu) and **Kechen Zhang**. *Megamap: Continuous Attractor in a Network of Place Cells Representing a Large Region.*

The brain stores a cognitive map of a spatial region through the activity of specialized cells called place cells. According to the traditional theory, each place cell fires within a single subregion, known as the cell's place field, and the network of place cells forms a continuous attractor by modifying the strength of connections among cells. We extend this theory by proposing that the hippocampus stores a megamap, or a continuous attractor representing a large region, in which each cell may have multiple, irregularly spaced place fields. We first show that the system can stably represent a large region by setting the connections optimally such that the expected attractor states are fixed points of the dynamical system governing cellular activity. Through numerical simulations and perturbation analysis, we then examine the computational properties that emerge as the represented region becomes sufficiently large. We demonstrate that the system transitions to a combinatorial mode in which spurious attractor states reflect environmental changes by combining previously stored memories. Consequently, the megamap extends the size of the region a place cell network can represent while uniting stability and flexibility as two fundamental properties of hippocampal networks. (Received January 25, 2014)

1098-92-197 **Bradford E Peercy*** (bpeercy@umbc.edu), **Ann Marie Weideman**, **Lathiena Manning**, **Bilal Moiz** and **Michelle Starz-Gaiano**. *Extracellular Geometry Impacts Intracellular Signaling.* Preliminary report.

The cellular decision to migrate depends on cascades of intracellular signals initiated in part by extracellular stimuli. In the fly *Drosophila melanogaster*, border cells in the epithelium of the developing egg chamber are triggered to migrate or not depending on a secreted morphogen Unpaired. While secretion into a uniform extracellular space should yield symmetry in activation, a majority of the time asymmetry in activation is observed experimentally. We propose that heterogeneity in extracellular space due to neighboring cells can divert Unpaired and affect the distribution of activation. We show this effect in modeling the diffusion and reaction of Unpaired in a relevant geometry. (Received January 25, 2014)

1098-92-201 **Timothy Reluga*** (timothy@reluga.org) and **Eunha Shim**. *Population viscosity reduces the risk of disease emergence.*

Infectious disease reservoirs in wild animals pose on-going risks to human populations. In the existing theory of zoonotic emergence, introduction events leading to epidemics are assumed to be independent of all preceding events. However, introductions are often correlated through ecological interfaces, leading to repeated exposures in bridge communities. Repeated exposures within bridge communities can induce immunity, which may in turn form a barrier preventing the emergence of zoonoses into the larger population.

We'll use simulations and math to illustrate how strong population viscosity that maintains correlation between contacts and introductions in bridge communities, in combination with immunity acquired through exposures, creates a localized herd-immunity barrier and reduces the number of opportunities for disease emergence. In some cases, reducing exposure rates has the counter-intuitive affect of increasing the risk of disease emergence because of off-setting reductions in immunity within a bridge community. (Received January 25, 2014)

1098-92-202 **Angelica Caicedo Casso** and **Hye-Won Kang***, hwkang@umbc.edu, and **Christian Hong** and **Sookkyung Lim**. *Stochastic effects on biochemical oscillators.*

Oscillatory behaviors are observed in the biological systems with circadian rhythms. In this talk, I will suggest five minimal models of nonlinear ordinary differential equations with feedback. Bifurcation analyses of the models demonstrate that positive feedback may increase oscillatory domains. Using period sensitive analysis and stochastic simulation, the robustness of the models in the context of maintaining the period is investigated. This is joint work with Angelica Caidedo Casso, Christian Hong, and Sookkyung Lim at University of Cincinnati. (Received January 26, 2014)

1098-92-204 **Doron Levy*** (dlevy@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *The Dynamics of Drug Resistance in Cancer.*

The development of drug resistance is a major challenge in the treatment of cancer. In this talk we will overview some of the aspects of drug resistance that have been studied by the mathematical community. We will focus on two examples: 1) Modeling the dynamics of cancer stem cells and their role in developing drug resistance. 2) Studying the role of cell density and mutations on the dynamics of drug resistance in solid tumors. This is a joint work with J. Greene, C. Tomasetti, O. Lavi, and M. Gottesman. (Received January 26, 2014)

1098-92-216 **Jonathan Bell*** (jbell@umbc.edu), Department of Mathematics & Statistics, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250. *Neuronal Cable Theory on Dendritic Trees.*

We are interested in the qualitative behavior of diffusion problems on metric tree graphs. In this talk we extend neuronal cable theory to tree graphs that represent (idealized) dendritic trees, and discuss analytical results concerning threshold conditions, traveling wave solutions, bounds on conduction speed, and conduction block. As time permits we will mention work on an (inverse) problem in linear cable theory on tree graphs of recovering a parameter, namely the conductance on each branch. (Received January 26, 2014)

1098-92-218 **Jonathan Bell*** (jbell@umbc.edu), Department of Mathematics & Statistics, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250. *Persistence and Competition in River Networks.* Preliminary report.

Starting with work of Speirs, Gurney, Carlson, and others, we review some work done on persistence in population models in advection-driven environments, which includes river networks as metric tree graphs. Then we discuss the competition model work of Vasilyeva-Lutscher and extensions to a tree graph. Of particular interest here is the nature of the competitive exclusion principle in these environments. We'll also mention further questions to be explored. (Received January 26, 2014)

1098-92-279 **Evelyn Thomas*** (ekthomas@umbc.edu), 1000 Hilltop Circle, M/P Building 410, Baltimore, MD 21250. *Epidemiological Models with Multiple Couplings between many Subpopulations.*

Dynamical systems techniques are used to study epidemic models with multiple interacting populations. Our approach is to study decoupled subpopulations of the populations and determine the influence of other populations on the basic reproductive number and endemic equilibria of these subpopulations. We present a system of ordinary differential equations to describe the dynamics within the spread of communicable and sexually transmitted diseases; namely, HIV and cholera outbreaks. Data is used to determine the parameter ranges for the model and such information will assist in analyzing the size and stability of the endemic equilibria and making predictions, through numerical simulations, as to whether the disease will stabilize, increase, or decrease. (Received January 28, 2014)

1098-92-285 **Louis F Rossi*** (rossi@math.udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Dynamics and information transfer in swarms with covert leaders.*

We report on modeling and analysis of large three-zone swarms with *covert leaders.* In three-zone swarming behavior, individual behavior is driven by the position and orientation of neighboring individuals in each of three concentric zones: repulsion, orientation and attraction. The fundamental purpose of this research is to understand how interactions between individuals are mapped to the dynamics of the entire swarm.

A *covert leader* is treated no differently from a follower but has information that followers do not possess. In the continuum limit, swarms are represented as densities and velocities which are functions of space and time. The dynamics of the swarm is described by a system of partial differential equations capturing conservation principles and the local interactions (i.e. behavior) within the swarm.

Using this approach, we report on the fundamental dynamics (coherence and stability) of the swarm. We also report on the theoretical information transfer in the swarm and on the potential for using transfer entropy to distinguish between leaders and followers in swarms. (Received January 28, 2014)

93 ► Systems theory; control

1098-93-56 **Tim Leung** (tl2497@columbia.edu) and **Peng Liu*** (pliu19@jhu.edu). *static-dynamic quantile hedging.*

We study the portfolio optimization problem of maximizing the probability to outperform a given random benchmark. In addition to dynamically trading the underlying asset, the investor also holds a portfolio of options. This leads us to introduce and analyze the static-dynamic approach to quantile hedging. Among our results, we find that, for the same success probability, the cost to outperform the aggregate of multiple positive benchmarks exceeds the sum of the costs to outperform the individual benchmarks. Through closed-form formulas and numerical examples, we illustrate the effect of an existing static options portfolio on the probability of outperformance. (Received January 03, 2014)

1098-93-65 **Donghua Shi*** (dshi@ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC. *Virtual Constraints in the formation Control of Automatic Vehicles.* Preliminary report.

This talk presents applications of virtual constraints which are nonphysical constraints making an attractor for the dynamics of close loop system in the formation control of Automatic Vehicles. The Matching and Homotopic methods are proposed for its control implementation in the framework of nonholonomic systems. We also discuss its relation with Controlled Lagrangian Method and Optimal Control. Flexible virtual constraints will also be introduced. (Received January 07, 2014)

1098-93-101 **Teresa Lebair*** (ei44375@umbc.edu), 1000 Hilltop Circle, Baltimore, MD 21250, and **Jinglai Shen** (shenj@umbc.edu), 1000 Hilltop Circle, Baltimore, MD 21250. *Optimal Control Approach and Numerical Methods for Constrained Smoothing Splines.*

With a plethora of applications in science and engineering, shape constrained estimation garners increasing attention in the areas of applied mathematics and statistics. Smoothing spline estimators subject to inequality shape constraints are an efficient array of shape constrained estimators, whose performance often surpasses that of their unconstrained counterparts. These estimators can be formulated as the solutions of optimal control problems, and thus, optimal control techniques play a critical role in the numerical resolution and statistical performance analysis of these estimators. We consider the computation and numerical analysis of smoothing splines subject to general dynamics and control constraints, as well as (initial) state constraints. The optimal control formulation of shape constrained smoothing splines is developed. Additionally, two algorithms, namely a directional derivative based nonsmooth Newton method and a projection based algorithm, to compute these constrained splines are introduced. The convergence analysis of these algorithms is presented along with several numerical examples. (Received January 16, 2014)

1098-93-200 **P. S. Krishnaprasad*** (krishna@umd.edu), P. S. Krishnaprasad, Professor, Institute for Systems Research, University of Maryland, College Park, MD 20742. *Optimality in Networks.*

Problems of optimal control on Lie groups are of broad interest and application dating back to the early days of geometric control theory. Special classes of integrable problems arise in the setting of rigid motion groups. In this talk we present recent developments along these lines pertaining to networks of many copies of systems on Lie groups, using reduction techniques. We consider low-dimensional examples of interest in engineering and biology. This is joint work with Eric W. Justh of the Naval Research Laboratory. (Received January 25, 2014)

1098-93-225 **Thomas I Seidman*** (seidman@umbc.edu). *Optimal boundary control of a reaction/diffusion/switching system.* Preliminary report.

We consider a bioreactor with diffusing bacteria, individually subject to hysteretic switching between dormant and active modes when encountering thresholds in the local level of a critical nutrient. This nutrient is provided at the boundary and then diffuses in the region so one has PDEs for the bacteria and nutrient concentrations coupled with pointwise ODEs for the pollutant to be cometabolized. Note that this is not a standard hybrid control problem since the modal index must be obtained for the continuum of individual bacteria. (Received January 26, 2014)

1098-93-251 **Jinglai Shen*** (shenj@umbc.edu), Dept. of Mathematics and Statistics, University of Maryland Baltimore County, Baltimore, MD 21250, and **Jianghai Hu**. *Domain of Convergence of Generalized Input-to-State ℓ_2-Gains of Discrete-time Switched Linear Control Systems.* Preliminary report.

The concept of $\mathcal{L}_2$ or ℓ_2-gains plays an important role in robust control and stability theory. It can be thought as the maximum output energy excited by a given input or perturbation energy. Computation and characterization of ℓ_2-gains for switched control systems poses a difficult numerical and analytical problem. Recently, a generalized input-to-state ℓ_2-gain is proposed for discrete-time switched linear control systems. Such an ℓ_2-gain is characterized by generating functions and can be efficiently computed. In this talk, we discuss more properties of the generalized ℓ_2-gains. In particular, we introduce the concept of domain of convergence (DOC) of two discount factors in the associated generating function. A variety of analytic properties of the DOC are established, and their implications for analysis and computation of the generalized ℓ_2-gains are discussed. (Received January 27, 2014)

1098-93-262 **Taeyoung Lee*** (tylee@gwu.edu), 801 22nd St NW, Washington, DC 20052. *Stochastic Optimal Motion Planning and Estimation for the Attitude Kinematics on SO(3).*

Stochastic motion planning and estimation for the attitude kinematics of a rigid body are studied. Fokker-Planck equation on the special orthogonal group is numerically solved via noncommutative harmonic analysis to propagate probability density functions through the flow of attitude kinematics. Based on this, a stochastic optimal control problem is formulated for motion planning, and a Bayesian framework is applied for estimation. The proposed intrinsic, geometric formulation does not require the common assumption that uncertainties are Gaussian or localized. It can be also applied to complex rotational maneuvers of a rigid body without singularities in a unified way. The desirable properties are illustrated by numerical examples. (Received January 27, 2014)

1098-93-282 **Levi D. DeVries*** (lddevrie@gmail.com) and **Derek A. Paley**. *Observability-based Optimization of Controlled Sampling Formations for Flowfield Estimation.* Preliminary report.

Unmanned, mobile platforms are effective environmental sampling vehicles that can shed light on spatiotemporal processes in nature. Sampling performance can be increased by coordinating the motion of vehicles to target measurements in information-rich but under-sampled regions of the environment. This presentation describes recent results in multi-vehicle control, observability optimization, and flowfield estimation for data assimilation. Decentralized, multi-vehicle control algorithms provide families of vehicle sampling formations parameterized by a minimal number of scalar quantities. We optimize the formation parameters using measures of empirical flowfield observabiilty as a scoring metric, which improves flowfield estimation performance. (Received January 28, 2014)

1098-93-298 **M. Ani Hsieh*** (mhsieh1@drexel.edu), 3141 Chestnut St, Randell 115, Philadelphia, PA 19104, and **Matthew Michini**, **Dennis Larkin**, **Eric Forgoston** and **Phil A. Yecko**. *Collaborative Tracking of Geophysical Fluid Dynamics: An Experimental Approach.* Preliminary report.

There has been a steady increase in the deployment of autonomous underwater and surface vehicles for applications such as ocean monitoring, tracking of marine processes, and underwater hazardous waste mitigation. The underwater environment poses unique challenges since robots must operate in a communication and localization-limited environment where their dynamics are tightly coupled with the environmental dynamics. This work presents current efforts in understanding the impact of geophysical fluid dynamics on underwater vehicle control and autonomy. This talk focuses on the experimental design and validation of the multi-robot Coherent Structure Testbed (mCoSTe) - an experimental testbed for evaluating the performance of manifold and coherent structure tracking strategies by a team of autonomous vehicles in 2D flows. We show how the mCoSTe is capable of producing repeatable and controllable coherent structures in 2D by analyzing the surface flows using a combination of Finite-Time Lyapunov Exponents (FTLE) and Dynamic Mode Decomposition (DMD). Building upon our existing work, we show how robotic tracking of manifolds and coherent structures in 2D flows can be validated using the mCoSTe. (Received January 28, 2014)

1098-93-322 **Ruzhou Yang*** (yangruzhou@gmail.com), Dept. of Mechanical & Industrial Engineering, 2508 Patrick F. Taylor Hall, Louisiana State University, Baton Rouge, LA 70803-6419. *Predictor-Based Tracking for Neuromuscular Electrical Stimulation.*

We present a new tracking controller for neuromuscular electrical stimulation, which is an emerging technology that artificially stimulates skeletal muscles to help restore functionality to human limbs. The novelty of our work is that we prove that the tracking error globally asymptotically and locally exponentially converges to zero for any positive input delay, coupled with our ability to satisfy a state constraint imposed by the physical system. Also, our controller only requires sampled measurements of the states instead of continuous measurements, and allows perturbed sampling schedules, which can be important for practical purposes. Our work is based on a new method for constructing predictor maps for a large class of time-varying systems, which is of independent interest. This work is joint with Professors Iasson Karafyllis, Michael Malisoff, Marcio de Queiroz, and Miroslav Krstic. (Received January 28, 2014)

97 ► Mathematics education

1098-97-40 **Muhammad Shabeer*** (m.shabeer@qu.edu.qa), Department of Mathematics, Foundation Program, Qatar University, Doha, 2713, Qatar. *Critical thinking skill; how it can be improved by changing teaching methodologies for college mathematics students.*

As it is, generally agreed upon that critical thinking skills are crucial to one's success in the modern world, where making rational decisions is increasingly becoming a part of everyday life. While teaching mathematics, it is undoubtedly easier for a teacher to teach the mathematics concepts in the traditional way of lecturing, but the question arises is; does it improve students thinking skills required to understand mathematical concepts in a clear and better way? The answer is not very optimistic. To cope with this issue, in this paper we have discussed different approach of lecture delivery, which helps students think critically to understand mathematical concepts in a better way. We will present some of the innovative teaching methodologies with illustrated examples from basic mathematics concepts. Examples for each of the "Compare-Contrast", "Whole-Parts", "Decision Making" or "Creating a Model" (aka creating a Metaphor or Making a Connection) are presented in this paper. (Received January 15, 2014)

1098-97-60 **Eka Oche Ogbaji*** (ogbajieka@yahoo.com), Federal University, Wukari, 9600001, Nigeria. *Teachers' perception of factors determining effective teaching of mathematics in secondary schools In ogbadibo local government area of benue state.* Preliminary report.

ABSTRACT The study examined teacher's perception of factors which determine effective teaching of mathematics in secondary schools in Benue State. It has been observed by mathematics educators all over the world that competent teachers, adequate workshops and instructional materials are indispensable in the teaching of mathematics. These are factors adjudged to be capable of causing a decline in the standard of performance of students in mathematics examinations. Therefore, this study is designed to ascertain teachers' perceptions of factors determining effective teaching of mathematics in secondary school in Ogbadibo LGA of Benue State. A random sample of 11 qualified and 3 non-qualified mathematics teachers from 10 secondary schools in Ogbadibo were sampled from 23 teachers that teach the subject and t-test was used for the analysis and it was show that;the instructional materials are grossly inadequate in our schools and even where they are available, teachers hardly make use of them and secondary school management is ineffective in enhancing the effective teaching and learning of mathematics. It is recommended among others that; teachers should be assisted to improve their skills and develop positive attitudes towards these identified factors. (Received January 05, 2014)

1098-97-77 **Leslie Chandrakantha*** (lchandra@jjay.cuny.edu), 524 West 59th Street, New York, NY 10019. *Teaching One-Way ANOVA using Resampling in Introductory Statistics.*

Analysis of Variance (ANOVA) is an important topic in introductory statistics classes. ANOVA has applications in many fields. Research has shown that many students have difficulties in understanding the concepts using traditional way of teaching with books and lecture. In this paper, we show how to use the simulation approach to introduce the ANOVA concepts. Resampling and Excel Data Tables are used to generate many samples and to compute the value of the test statistic. Empirical distribution of the test statistic is tabulated and it agrees with the theoretical F- distribution closely. Our preliminary assessment shows that this approach enhances student's understanding of the concept. (Received January 10, 2014)

1098-97-109 **Zengxiang Tong*** (ztong@otterbein.edu), Dr. Zengxiang Tong, Department of Mathematical Sciences, Otterbein University, Westerville, OH 43081, and **Zhaozhi Zhang** (ztong@otterbein.edu), Prof. Zhaozhi Zhang, Editorial Board of Studies in College Mathema, Northwestern Polytechnical University, Xi'an, Xi'an 710072, Peoples Rep of China. *Promote Research in Educational Mathematics (I) — What Is Educational Mathematics?* Preliminary report.

Educational Mathematics is a new terminology and a new idea. This paper focuses on explaining what educational mathematics is. We think that the whole mathematics consists of three major fields: pure, applied, and educational mathematics. Recognizing the importance of educational mathematics, understanding its relationship with pure and applied mathematics, and its relationship with mathematics education will greatly enhance the quality of our mathematics education. (Received January 17, 2014)

1098-97-110 **Zengxiang Tong** (ztong@otterbein.edu), Dr. Zengxiang Tong, Department of Mathematical Sciences, Otterbein University, Westerville, OH 43081, and **Zhen Huang*** (zhuang@otterbein.edu), Dr. Zhen Huang, Department of Mathematical Sciences, Otterbein University, Westerville, OH 43081. *Promote research in Educational Mathematics (II) — Why It Is Important and Imperative to Promote Research in Educational Mathematics?* Preliminary report.

Many mathematicians and educators and even our presidents have realized that our mathematics education has fallen behind many European and Asian countries. Many people have proposed how to enhance the quality of our mathematics education. This paper will show that the most important way is to promote research in educational mathematics. (Received January 17, 2014)

1098-97-132 **Dr. Atma Sahu*** (asahu@coppin.edu), 7704 Mystic River Terrace, Glenn Dale, MD 20769. *Beyond the CCSS and NGSS Boarders: The CAEP Standards for All US Institutions.*

Newly formed CAEP - "The Council for the Accreditation of Educator Preparation", will ensure that educator preparation providers (EPPs) prepare and graduate future teachers who know the content of the subject(s) they will teach, know how to teach that content effectively to students from diverse groups, and demonstrate their positive impact on P-12 student learning in diverse school settings. Accordingly, keeping in view the pedagogical aspects of knowing how to teach students mathematics, the coherence of CAEP's first standard of educator preparation has been cross examined in this presentation, with the Common Core State Standards Mathematics Practice (CCSSMP) 1 to 8, and discussion is limited to the secondary mathematics content and teacher preparation level. Furthermore, the CCSSMP 1-8 content standards which set an expectation of mathematics instructional and conceptual understanding are potential 'points of intersection' of the Standards for Mathematical Content, Standards for Mathematical Practice, and CAEP's first standard. The presenters will also discuss the necessity to qualitatively improve the instruction and professional development practices that merits the time, resources, and new energies invested in mathematics educator's preparation programs. (Received January 21, 2014)

1098-97-134 **Zengxiang Tong** (ztong@otterbein.edu), Dr. Zengxiang Tong, Department of Mathematical Sciences, Otterbein University, Westerville, OH 43081, and **Zhaozhi Zhang*** (ztong@otterbein.edu), Prof. Zhaozhi Zhang, Editorial Board of Studies in College Mathema, Northwestern Polytechnical University, Xi'an, Xi'an 710072, Peoples Rep of China. *Promote Research in Educational Mathematics (III) — How To Do Research in Educational Mathematics?* Preliminary report.

In this paper, we will talk on what should be researched in educational mathematics, who will do the do the research, and how to do the research. We want to show that promoting research is the best way to enhance the quality of mathematics education in our nation. (Received January 20, 2014)

1098-97-257 **Luis A. Melara*** (lamelara@ship.edu), 1871 Old Main Drive, Shippensburg, PA 17257-2299. *Mentoring Undergraduates through Research in Mathematical Biology.*

In this presentation, the speaker will share his experiences as a faculty participant in the Mathematical and Theoretical Biology Institute (MTBI) at Arizona State University. The MTBI summer program was founded by Carlos Castillo-Chavez in 1996. Over time, the program has encompassed graduate students, post-docs and faculty. The speaker first participated in MTBI in 2010. The presenter will also describe the mentorship process embraced by the program as well as discuss the profile of student participants, the student-driven research projects and the mentorship and advising practices embraced by MTBI faculty, post-docs and graduate students. (Received January 27, 2014)

ALBUQUERQUE, NM, April 4–6, 2014

Abstracts of the 1099th Meeting.

00 ► General

1099-00-223 **Oleksandra V Beznosova** and **Temitope E Ode*** (temitope_ode@baylor.edu), 1825 South 3rd Street, APT 1206, Waco, TX 76706. *Mutual estimates for the dyadic Reverse Hölder and Muckenhoupt constants for the dyadically doubling weights.*

Muckenhoupt and Reverse Hölder classes of weights play an important role in harmonic analysis, PDE's and quasiconformal mappings. In 1974 Coifman and Fefferman showed that a weight belongs to a Muckenhoupt class A_p for some p if and only if it belongs to a Reverse Hölder class RH_q for some q. In 2009 Vasyunin found the exact dependence between p, q and the corresponding characteristic of the weight. The result of Coifman and Fefferman works for the dyadic classes of weights under an additional assumption that the weights are dyadically doubling. We extend the Vasyunin's result to the dyadic Reverse Hölder and Muckenhoupt classes and obtain the dependence between p, q, the doubling constant and the corresponding characteristic of the weight. We obtain our results using the method of Bellman functions. (Received February 09, 2014)

1099-00-400 **Denis A. Silantyev*** (dsilant@math.unm.edu), **Pavel Lushnikov** and **Harvey Rose**. *Langmuir wave filamentation instability.* Preliminary report.

We consider laser-plasma interaction in underdensed collisionless plasma withing the Vlasov-Poisson system. Full 3+3 Vlasov simulation (3 spatial directions and 3 velocity directions) is nearly impossible with the modern computational tools. Instead we consider the reduced model that we call Vlasov Multi-Dimensional model (VMD). VMD model retains full kinetic description along laser direction and utilizes multi-fluid description in transverse direction. Transverse modulational instability of nonlinear Bernstein-Greene-Kruskal (BGK) mode is studied in the framework of VMD model. Numerical results for growth rates of transverse instability are compared to analytically predictions. (Received February 11, 2014)

01 ► History and biography

1099-01-275 **Su Gao*** (sgao@unt.edu), Department of Mathematics, 1155 Union Circle #311430, University of North Texas, Denton, TX 76203. *Countable group actions and Borel homomorphisms.*

I will talk about some recent results on Borel homomorphisms from Borel graphs into finite graphs. The Borel graphs arise from countable group actions and are induced from the Caley graphs of the acting group. The existence of continuous chromatic colorings on the Borel graphs is a special case of the existence problem of Borel homomorphisms. The work reported in my talk comes from joint work withm Steve Jackson, Edward Krohne, and Brandon Seward. (Received February 10, 2014)

03 ► Mathematical logic and foundations

1099-03-22 **Phillip R Wesolek*** (pwesol3@uic.edu), MSCS UIC 322 SEO 851 S. Morgan Street, chicago, IL 60607. *Constructible totally disconnected locally compact Polish groups and an application.*

The class of constructible totally disconnected locally compact (t.d.l.c.) Polish groups is the collection of t.d.l.c. Polish groups built from profinite and discrete groups via group extension and countable increasing union. These groups appear often in the study of t.d.l.c. Polish groups. We show this class satisfies surprisingly robust closure properties. We go on to give an application to the study of p-adic Lie groups. In particular, we show every p-adic Lie group decomposes into constructible and topologically simple groups via group extensions. This result is analogous to the solvable by semi-simple decomposition for connected Lie groups. (Received December 02, 2013)

1099-03-51 **Antonio Montalban*** (antonio@math.berkeley.edu), Evans Hall #3840, Department of Mathematics – U.C. Berkeley, Berkeley, CA 94720. *Equivalence relations satisfying hyperarithmetic-is-recursive.*

We will present our result characterizing the analytic equivalence relations with $\aleph_1$-many equivalence classes as the ones that satisfy hyperarithmetic-is-recursive. This result explains the general behavior behind various other results previously obtained by the author. (Received January 17, 2014)

1099-03-57 **Steve C Jackson*** (jackson@unt.edu), Department of Mathematics, University of North Texas, Denton, TX 76203. *Some Borel Combinatorics of Z^n Actions.*

Using some recently developed techniques involving 2-colorings and a related forcing notion, we settle some problems concerning Z^n actions, in particular the continuous chromatic number. This is joint work with Gao, Krohne, and Seward. (Received January 21, 2014)

1099-03-82 **Simon Thomas*** (sthomas@math.rutgers.edu), Mathematics Department, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. *Invariant random subgroups of locally finite groups.*

I will discuss recent work with Robin Tucker-Drob on the invariant random subgroups of locally finite groups. (Received January 28, 2014)

1099-03-142 **Dana Bartosova*** (dana@ime.usp.br), Rua do Matao 1010, Sao Paulo, SP 05508-090, Brazil. *Ramsey classes of Boolean algebras with ideals.*

We present a classification result about Fraïssé classes of Boolean algebras with ideals satisfying the Ramsey property. We show how this result applies to dynamics of groups of homeomorphisms of Cantor cubes. (Received February 05, 2014)

1099-03-146 **Marcin Sabok***, Institut de Mathématiques de Jussieu, Université Paris Diderot, 75205 Paris, France. *Automatic continuity for isometry groups.*

We present a general framework for automatic continuity results for groups of isometries of metric spaces. In particular, we prove automatic continuity property for the groups of isometries of the Urysohn space and the Urysohn sphere, i.e. that any homomorphism from either of these groups into a separable group is continuous. This answers a question of Melleray. As a consequence, we get that the group of isometries of the Urysohn space has unique Polish group topology and the group of isometries of the Urysohn sphere has unique separable group topology. Moreover, as an application of our framework we obtain new proofs of the automatic continuity property for the group $\mathrm{Aut}([0,1],\lambda)$, due to Ben Yaacov, Berenstein and Melleray and for the unitary group of the infinite-dimensional separable Hilbert space, due to Tsankov. The results and proofs are stated in the language of model theory for metric structures. (Received February 05, 2014)

1099-03-154 **Anush Tserunyan*** (anush@illinois.edu). *Mixing and triple recurrence in probability groups.*

We consider a class of groups equipped with an invariant probability measure that respects the group structure in an appropriate sense; call such groups probability groups. This class contains all compact groups and is closed under taking ultraproducts with the induced Loeb measure. We prove a triple recurrence result for mixing probability groups, which generalizes a recent result of Bergelson-Tao proved for ultra quasirandom groups (the latter being examples of mixing probability groups), nevertheless having a considerably shorter proof. (Received February 06, 2014)

1099-03-161 **Jay Williams*** (jaywill@caltech.edu), Mathematics 253-37, California Institute of Technology, Pasadena, CA 91125. *Isomorphism of finitely generated solvable groups is weakly universal.*

Modifying a construction of Neumann and Neumann, we show that the isomorphism relation for finitely generated solvable groups of class 3 is a weakly universal countable Borel equivalence relation. Cardinality arguments show that isomorphism of finitely generated solvable groups of class 2 can not achieve this Borel complexity, so the result is sharp. (Received February 06, 2014)

1099-03-183 **Samuel Coskey*** (scoskey@nylogic.org). *Generalized Choquet spaces.*

Considerable work has been done to study descriptive set theory in spaces of size larger than the continuum. In order to generalize the notion of Polish space or standard Borel space to this setting, it is necessary to find a replacement for the notion of complete metrizability. In this talk we will study a class of spaces satisfying a variant of the Choquet property, where the Choquet game is replaced by an analogous game of length κ. We will show for example that there is a surjectively universal space in this class. We then give a Kuratowski-like result that under appropriate hypotheses, any two such spaces are isomorphic by a κ-Borel function. This is joint work with Philipp Schlicht. (Received February 07, 2014)

1099-03-210 **Theodore A Slaman*** (slaman@math.berkeley.edu) and **Veronica Becher**. *On Normal Numbers.*

A real number is simply normal in base b if in its base-b expansion each digit appears with asymptotic frequency 1/b. It is normal in base b if it is simply normal in all powers of b, and absolutely normal if it is simply normal in every integer base. By a theorem of E. Borel, almost every real number is absolutely normal. We will present three main results. We will give an efficient algorithm, which runs in nearly quadratic time, to compute the binary expansion of an absolutely normal number. We will demonstrate the full logical independence between normality in one base and another. We will give a necessary and sufficient condition on a set of natural numbers M for there to exist a real number X such that X is simply normal to base b if and only if b is an element of M. (Received February 09, 2014)

1099-03-213 **Brandon Seward***, Department of Mathematics, 2074 East Hall, 530 Church St, Ann Arbor, MI 48109, and **Robin D. Tucker-Drob**, Department of Mathematics, Hill Center for the Mathematical Sciences, 110 Frelinghuysen Rd, Piscataway, NJ 08854. *Borel structurability on the 2-shift of a countable group.*

We show that for any infinite countable group G and for any free Borel action $G \curvearrowright X$ there exists a G-equivariant Borel map from X into the free part $\mathrm{Free}(2^G)$ of $G \curvearrowright 2^G$. In fact, under a suitable notion of genericity, the generic equivariant Borel map into 2^G lands in the free part. This implies that if $G \curvearrowright \mathrm{Free}(2^G)$ is treeable then all free Borel actions of G are treeable. Furthermore, it implies that $G \curvearrowright \mathrm{Free}(2^G)$ has maximal Borel chromatic number among all free Borel actions of G, answering a question of Marks. (Received February 09, 2014)

1099-03-231 **Dana Bartosova** and **Aleksandra Kwiatkowska*** (akwiatk2@math.ucla.edu). *Lelek fan from a projective Fraisse limit.*

We show that a natural quotient of the projective Fraïssé limit of a family of finite rooted trees is the Lelek fan. We then study properties of the Lelek fan and of its homeomorphism group. In particular, we show that the homeomorphism group of the Lelek fan is totally disconnected, generated by every neighbourhood of the identity, has a dense conjugacy class, and is simple. (Received February 09, 2014)

1099-03-236 **Andrew S Marks*** (marks@caltech.edu). *Universality of countable Borel equivalence relations from computational complexity theory.* Preliminary report.

We discuss some universality results for resource bounded Turing equivalence and many-one equivalence in the setting of countable Borel equivalence relations. (Received February 10, 2014)

1099-03-244 **Valentina Harizanov*** (harizanv@gwu.edu), Department of Mathematics, Washington, DC 20052. *Coding information into orders on groups.*

Orders on algebraic structures are ubiquitous in mathematics and have been studied since Dedekind, Hölder and Hilbert. Here, we consider total orderings of the elements of a group, which respect the group structure. In the last decade, the theory of such orders on groups has become an important tool in understanding the geometric properties of 3-dimensional manifolds. It is important to understand constructive properties of these orders. Thus, we ask whether computable orders are admitted. Furthermore, we use computablity-theoretic methods to investigate to what extent it is possible to code information into the orders on certain classes of groups. (Received February 10, 2014)

1099-03-318 **Leah Marshall*** (lbm@gwmail.gwu.edu). *Computable Categoricity of Partial Injection Structures.* Preliminary report.

A computable structure is computably categorical if every isomorphic copy of it is isomorphic via a computable isomorphism. A computable injection structure is a mathematical structure consisting of a computable set and a computable injective (1-1) function. Recent work has been done by Cenzer, Harizanov, and Remmel investigating the effective categoricity of computable injection structures. We generalize this notion to partial injection structures and explore the different types of effective categoricity exhibited. (Received February 10, 2014)

1099-03-319 **Scott Schneider*** (sschnei@umich.edu). *Generalized tail equivalence relations.* Preliminary report.

We examine higher-dimensional analogues of the tail equivalence relations E_t and E_0, and consider the problem of constructing Borel marker sets for actions of the commutative monoids $\mathbb{N}^d$. (Received February 10, 2014)

1099-03-324 **Aaron Hill*** (aaron.hill@unt.edu). *The inverse problem for measure-preserving transformations.*

We will discuss various aspects of the following question: when is a measure-preserving transformation isomorphic to its inverse? Particular (but not exclusive) attention will be paid to rank-1 measure-preserving transformations. (Received February 10, 2014)

1099-03-366 **Clinton T Conley***, clintonc@math.cornell.edu. *Unfriendly colorings and weak equivalence.*

An unfriendly coloring of a graph is one in which each vertex is adjacent to at least as many neighbors of a different color (than its own) as those of the same color. Motivated by the fact that every finite graph admits an unfriendly coloring with two colors, we investigate measure-theoretic analogs of this for graphs arising from probability-measure-preserving actions of groups. (Received February 11, 2014)

1099-03-390 **Konstantinos A. Beros*** (beros@unt.edu), Department of Mathematics, University of North Texas, GAB 435, 1155 Union Circle, Denton, TX 76203-5017. *Co-analytic ideals on ω.*

We say that $f : \omega \to \omega$ is a *weak Rudin-Keisler map* if the domain of f is an infinite (possibly proper) subset of ω. If $\mathcal{I}$ and $\mathcal{J}$ are ideals on ω, we say that $\mathcal{I}$ is *wRK-reducible* to $\mathcal{J}$ if there is a weak Rudin-Keisler map f such that, for each $A \subseteq \omega$, one has $A \in \mathcal{I} \iff f^{-1}(A) \in \mathcal{J}$. We show that there is a wRK-complete co-analytic ideal, i.e., a co-analytic ideal to which every co-analytic ideal is wRK-reducible. The method of our proof also yields a simple proof to a theorem of Hjorth on co-analytic equivalence relations.

We will mention some analogous results for ideals on ω which belong to other projective classes. (Received February 11, 2014)

1099-03-402 **Sankha S Basu***, basu@math.psu.edu. *A model of intuitionism based on Turing degrees.*

Intuitionism is a constructive approach to mathematics introduced in the early part of the twetieth century by L. E. J. Brouwer and formalized by his student A. Heyting. A. N. Kolmogorov, in 1932, gave a natural but non-rigorous interpretation of intuitionism as a calculus of problems. In this document, we present a rigorous implementation of Kolmogorov's ideas to higher-order intuitionistic logic using sheaves over the poset of Turing degrees with the topology of upward closed sets. This model is aptly named as the Muchnik topos, since the lattice of upward closed subsets of Turing degrees is isomorphic to the lattice of Muchnik degrees which were introduced in 1963 by A. A. Muchnik in an attempt to formalize the notion of a problem in Kolmogorov's calculus of problems. (Received February 12, 2014)

05 ► Combinatorics

1099-05-3 **Fan Chung Graham*** (fan@ucsd.edu). *Some problems and results in spectral graph theory.*

We will discuss some recent developments in spectral graph theory and mention a number of results and problems on random walks on vertex and edge ranking, interlacing theorems, partition and clustering, among others. (Received August 20, 2013)

1099-05-15 **Deborah C. Arangno*** (darangno@yahoo.com) and **David E. Brown**, Department of Mathematics and Statistics, 3900 Old Main Hill, Logan, UT 84322-3900. *Edge-Avoiding and F-Avoiding Hamiltonicity in Bipartite Graphs.*

In this paper, we will examine the conditions under which a bipartite graph has a Hamiltonian cycle that avoids a specified set of edges, or a subgraph F. Such a graph is called "edge-avoiding" or "F-avoiding" Hamiltonian, respectively, originally studied by Harris, Ferrara and Jacobson, for non-bipartite graphs. We will introduce a version of Bondy-Chvátal's Theorem, which states that a graph is Hamiltonian if and only if its closure is Hamiltonian, and which we will define for the bipartite case.

Keywords: cycles, Hamiltonicity, Bondy-Chvátal, bipartite graph (Received November 18, 2013)

1099-05-96 **Jakub Jasinski*** (jjasinsk@ucalgary.ca), 2500 University Dr NW, Calgary, Alberta T2N 1N4, Canada, **Claude Laflamme** (laflamme@ucalgary.ca), 2500 University Dr NW, Calgary, Alberta T2N 1N4, Canada, **Lionel Nguyen Van Thé** (lionel@latp.univ-mrs.fr), 39, rue F. Joliot Curie, 13453 Marseille, France, and **Robert Woodrow** (woodrow@ucalgary.ca), 2500 University Dr NW, Calgarey, Alberta T2N 1N4. *Ramsey Precompact Expansions of Homogeneous Directed Graphs.*

In 2005, Kechris, Pestov and Todorcevic provided a powerful tool to compute an invariant of topological groups known as the universal minimal flow, immediately leading to an explicit representation of this invariant in many concrete cases. More recently, the framework was generalized allowing for further applications, and the purpose of this paper is to apply these new methods in the context of homogeneous directed graphs.

In joint work with Claude Laflamme, Lionel Nguyen Van Thé and Robert Woodrow, I have shown that the age of any homogeneous directed graph allows a *Ramsey precompact expansion*. Moreover, we have verified the relative expansion properties and consequently have described the respective universal minimal flows. (Received January 30, 2014)

1099-05-124 **Evans M Harrell*** (harrell@math.gatech.edu), School of Mathermatics, Georgia Institute of Technology, Atlanta, GA 30332-0160, and **Joachim Stubbe**. *Sums of eigenvalues of graphs.*

We consider the spectra of three self-adjoint matrices associated with a combinatorial graph, viz., the adjacency matrix A, the graph Laplacian $H = -\Delta$, and the normalized graph Laplacian L. Using an averaged variational techniques we obtain sharp bounds on sums and the statistical distribution of the lowest k eigenvalues eigenvalues of these operators, and relate them to the structure of the graph. (Received February 04, 2014)

11 ► Number theory

1099-11-42 **Ivan Horozov*** (horozov@math.wustl.edu), Washington University in St. Louis, Department of Mathematics, One Brookings Dr, Campus Box 1146, Saint Louis, MO 63130. *Non-commutative Hilbert modular symbol.*

I am going to present a construction of non-commutative Hilbert modular symbol, which is a generalization of Manin's non-commutative modular symbol to the case of Hilbert modular groups. I use a new method based on generalization of iterated path integrals to higher dimensions, which I call iterated integrals over membranes. (Iterated integrals were used by K.-T. Chen to give de Rham structure on a loop space of a manifold.)

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. I will present 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 over membranes.

Manin's non-commutative modular symbol is a non-commutative 1-cocycle. Similarly, the non-commutative Hilbert modular symbol is a non-commutative 2-cocycle. (Received January 14, 2014)

1099-11-56 **Matthew Ward*** (wardm4@math.washington.edu). *Properties of Ordinary Calabi-Yau Threefolds.*

In positive characteristic, we use the Artin-Mazur formal group to define a notion of ordinary for Calabi-Yau threefolds. These satisfies many similar properties to ordinary elliptic curves including having a Serre-Tate isomorphism for its deformation theory. (Received January 20, 2014)

1099-11-118 **Dinesh S Thakur*** (dinesh.thakur@rochester.edu). *Higher congruences and Higher arithmetic derivatives.*

We will explain how two function field analogs of Fermat and Wilson congruences, get linked with each other as well as with various arithmetic derivatives, when looked at modulo higher powers of primes. There are also links with zeta values carrying over to number fields. We will also mention some open questions. (Received February 03, 2014)

1099-11-150 **Kiran S. Kedlaya*** (kedlaya@ucsd.edu) and **Christopher Davis**. *Almost purity and overconvergent Witt vectors.*

Let R be a ring for which the Frobenius maps on finite p-typical Witt vectors over R are surjective. (This condition is closely related to the condition of a Banach algebra being *perfectoid*.) Using results of Kedlaya-Liu and Scholze (generalizing a theorem of Faltings), we show that the integral closure of R in a finite étale extension of $R[p^{-1}]$ is *almost finite étale* over R. We then lift the finite étale extension of $R[p^{-1}]$ to a finite étale extension of rings of *overconvergent Witt vectors*. The point is that no hypothesis of p-adic completeness is needed; this result thus points towards potential global analogues of p-adic Hodge theory. (Received February 05, 2014)

1099-11-225 **Bryden Cais*** (cais@math.arizona.edu) and **Christopher Davis**. *Canonical lifts of norm fields and applications.*

We will explain how to canonically lift the norm field functor of Fontaine-Wintenberger in many interesting cases, and some resulting applications to p-adic Hodge theory. (Received February 09, 2014)

1099-11-355 **Oscar G Villareal*** (ovillare@iun.edu), IU Northwest, Mathematics and Actuarial Sciences Department, HH room 437, Gary, IN 46408. *On the Degree of a Torsion Point for Certain Abelian Varieties in Characteristic p.*

Let k be a field of positive characteristic p, $\overline{k}$ an algebraic closure, and let A be an abelian variety defined over k. Assume that $\mathrm{End}_{\overline{k}}(A) = \mathbb{Z}$ and let $g = \dim A$. Let ℓ be a prime number, and suppose P is an ℓ torsion point. We show that there exist positive constants ℓ_0, C such that for every $Q \in A(\overline{k})$ with $\ell Q = O$, we have $[k(Q) : k] \geq C\ell^{1/2g}$ for $\ell \geq \ell_0$. We use this lemma to give results in the direction of the Geyer-Jarden Conjecture. (Received February 11, 2014)

1099-11-388 **Frank David*** (frank_w_david@nnmc.edu), Northern New Mexico College, 921 Paseo de Onate, Espanola, NM 87532, and **Ruben Rivers** (ruben_m_rivera@nnmc.edu), **Ajit Hira** (hira@nnmc.edu) and **David Dillon** (pecosdillon@gmail.com). *Infinity of Twin Primes and Generlizations.* Preliminary report.

We present some results of our research work on the problem of the Infinity of Twin Primes and Generalizations. Last year, Yitang Zhang proved that there are infinitely many primes that are apart by less than 70,000,000. Zhang's work has given strong impetus to research efforts aimed at narrowing this gap. Our goal is to remedy the deficiencies of the existing algorithms for prime number generation and to improve their of the O(n**4/log n) performance. Our work examines the distributions of Cousin Primes and Sexy Primes, in addition to distribution of Twin Primes. The generation primes is important in the use of most public-key schemes, for the creation of key pairs and in the computation stage of many cryptographic setups. This research also has potential application in developing fast factoring algorithms. (Received February 11, 2014)

12 ► *Field theory and polynomials*

1099-12-149 **Andy R Magid*** (amagid@ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73072. *Free Prounipotent Differential Galois Groups.* Preliminary report.

Let F be a differential field of characteristic zero with algebraically closed field of constants. Let F_u be the compositum of all differential Galois extensions of F which have unipotent differential Galois group. It is shown that $\mathrm{Aut}_F(F_u)$ is a free prounipotent group. This is established by proving an embedding theorem which asserts that if $E \supset F$ is a differential Galois extension with (pro)unipotent differential Galois group H and $1 \to \mathbb{G}_a \to G \to H \to 1$ is a non-trivial extension then there is a differential Galois extension $K \supset F$ containing E and realizing G. (Received February 05, 2014)

13 ► *Commutative rings and algebras*

1099-13-5 **Karen E Smith*** (kesmith@umich.edu), Math Dept, University of Michigan, Ann Arbor, MI 48109. *Characteristic p Tricks in Algebra, Geometry and Combinatorics.* Preliminary report.

Consider a commutative ring of prime characteristic p, such as a polynomial ring over the field $\mathbb{F}_p$ of p elements. For any two elements x and y, we can easily verify that $(x + y)^p = x^p + y^p$, because the binomial coefficients $\binom{p}{i}$ are all divisible by p for $0 < i < p$. This simple algebraic fact is remarkably powerful, often leading to deep theorems even about algebras over $\mathbb{Q}$ or $\mathbb{C}$ with surprisingly easy proofs. An early example is the Hochster Roberts theorem on the Cohen-Macaulayness of rings of invariants. In algebraic geometry, tricks involving p-th powers have led to strong vanishing theorems for line bundles on certain projective varieties. More recently, the Frobenius (or p-th power) map has been used to clarify the structure of certain cluster algebras, a new class of algebra with combinatorial structure introduced by Fomin and Zelevinsky in order to understand total positivity and canonical bases in a variety of contexts. In this talk, we hope to introduce the magic of the p-th power map to non-experts, with examples drawn from commutative algebra, algebraic geometry, and combinatorics. (Received February 06, 2014)

1099-13-50 **Richard Erwin Hasenauer***, 300 E College Ave., Eureka, IL 61530. *Almost Dedekind finite factorization domains.*

Using Dedekind domains we will construct non-Noetherian almost Dedekind finite factorization domains. We will give a characterization of almost Dedekind FFDs and discuss conditions under which atomic, ACCP, BFD, and FFD are equivalent. (Received January 17, 2014)

1099-13-53 **Yi Zhang***, Department of Mathematics, 1409 W Green Street, Urbana, IL 61801. *Toward an efficient algorithm for deciding the vanishing of local cohomology modules in prime characteristic.*

Let $R = k[x_1, \cdots, x_n]$ be a polynomial ring over a field k of characteristic $p > 0$. If I is an ideal of R, we denote $H^i_I(R)$ the i-th local cohomology module of R with support in I. We describe an algorithms to determine the vanishing of $H^i_I(R)$. The method we use is the F-module theory. (Received January 19, 2014)

1099-13-62 **Lokendra Prasad Paudel*** (lokendra@nmsu.edu), 511 Sweet Ave, Las Cruces, NM 88001. *Prüfer Overrings of Affine Domains and Realization of Lattice-Ordered Groups.*

The group of invertible fractional ideals of a Prüfer domain is a lattice-ordered group (ℓ-group). The goal of this presentation is to describe the ℓ-groups that occur as a group of invertible fractional ideals of a finite character Prüfer overring of the domain $D = k[x_1, x_2, ..., x_n]$, where k is a field and $x_1, x_2, ..., x_n$ are indeterminates for k. (Received January 23, 2014)

1099-13-66 **Thomas G Lucas*** (tglucas@uncc.edu). *(In)Stability of Divisorial Prime Ideals in Prüfer Domains.* Preliminary report.

Let P be a nonzero prime of a Prüfer domain R and let S be a ring between R and R_P. It is possible that P is a divisorial ideal of R while PS is not a divisorial ideal of S. Also it is possible for PS to be a divisorial ideal of S while P is not a divisorial ideal of R.We characterize when PS is a divisorial ideal of S for each ring $R \subseteq S \subseteq R_P$. Also we characterize when a maximal ideal M of R is such that there is no Prüfer domain $T \subseteq R$ with the same quotient field as R such that $M \cap T$ is a divisorial ideal of T. In addition, we present examples that illustrate the following behavior: it can occur that there is an ascending chain of Prüfer domains $R = S_0 \subsetneq S_1 \subsetneq S_2 \subsetneq \cdots \subsetneq R_P$ where PS_{2n} is never a divisorial ideal of S_{2n} and PS_{2n+1} is always a divisorial ideal of S_{2n+1}. Infinite descending chains $R = T_0 \supsetneq T_1 \supsetneq \cdots$ with similar behavior are also possible. In this case the ideals in question are the contractions $P \cap T_m$ with $P \cap T_{2n}$ never divisorial and $P \cap T_{2n+1}$ always divisorial. (Received January 23, 2014)

1099-13-73 **Anurag K. Singh*** (singh@math.utah.edu). *Local cohomology over the integers.*

We will discuss a duality result for graded local cohomology of a polynomial ring of prime characteristic, and show how this may be applied to the study of local cohomology of polynomial rings over the integers.

This is joint work with Gennady Lyubeznik and Uli Walther. (Received January 27, 2014)

1099-13-87 **Roger A Wiegand*** (rwiegand@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Lots of questions, and a few answers, about spectra of commutative rings of dimension two.* Preliminary report.

Can the unit square $0 \leq x, y \leq 1$ be the maximal ideal space of a two-dimensional commutative ring? Perhaps surprisingly, the unit interval *is* the maximal ideal space of a one-dimensional ring.

On the Noetherian side, suppose R and S are two-dimensional affine domains over the rational numbers $\mathbb{Q}$. Are Spec$R$ and Spec$S$ homeomorphic? If $\mathbb{Q}$ is replaced by the algebraic closure of a finite field, the answer is "yes", but over $\mathbb{C}$ it's "no".

In this talk I will mention these and several other questions and say a little about the proofs and examples that answer a few of them. (Received January 28, 2014)

1099-13-90 **Jack Jeffries** and **Jonathan Montaño*** (jmontano@math.purdue.edu), 150 N. University Street, West Lafayette, IN 47907, and **Matteo Varbaro**. *Multiplicities of Classical Varieties.*

The j-multiplicity plays an important role in the intersection theory of Stückrad-Vogel cycles, while recent developments confirm the connections between the ϵ-multiplicity and equisingularity theory. In this talk, I will report joint work with Jack Jeffries and Matteo Varbaro, where we are able to compute the j-multiplicity of all the ideals defining rational normal scrolls by establishing a relationship between the j-multiplicity of an ideal and the degree of its fiber cone. We are also able to express the j- and ϵ-multiplicity of ideals defining determinantal varieties as the integral of a polynomial over a region. (Received January 28, 2014)

1099-13-95 **Hans Schoutens*** (hschoutens@citytech.cuny.edu), 365 Fifth Avenue, NY, NY 10016. *Towards small CM modules in dimension three.*

Over a complete CM ring, Grothendieck duality enables us to study the local cohomology of a module. Moreover, the "dualizing" module is canonically defined, whence its eponymous name. Whereas duality fails over non CM rings, there is still a canonically defined module: the Matlis dual of the top local cohomology of the ring. However, the lower local cohomology modules do no longer vanish, so we should also study their Matlis duals. These are what I term the "i-th higher canonical modules"; this definition extends to modules as well.

After having proven the existence of big CM modules in equal characteristic, Hochster conjectured, with some reservation, that any complete local ring even admits a (small) maximal CM module (=module of the same depth as the dimension of the ring), but very little is known in dimensions three and higher. I will give a criterion for their existence in dimension three involving first higher canonical modules, namely, there has to be at least one module whose first higher canonical module has positive depth (of course, the higher canonical modules of a maximal CM are all zero, so the condition is clearly necessary). (Received January 29, 2014)

1099-13-102 **Mark Johnson** and **Paolo Mantero*** (mantero@math.ucr.edu). *Parametrizing liaison classes.* Preliminary report.

In the present talk we provide two different general techniques to construct a large amount of (complete intersection) liaison classes in a given ring. A somewhat surprising consequence of these results is that if I a Cohen-Macaulay ideal in a polynomial ring R and x and y are two new variables, then (I, x) and (I, y) are not in the same linkage class (if I is not licci). This is in shark contrast with a recent result of Migliore and Nagel, proving that the analogous statement for Gorenstein liaison actually holds.

We then show that the linkage classes constructed in these two ways are parametrized (in an intuitive way) on very large spaces, which illustrates mathematically the concept that "there are many complete intersection linkage class".

With these results we provide a simple way of constructing ideals that are maximal in their linkage classes starting from other ideals having the same property. For instance, if I is maximal in its linkage class, and x and y are new variables, then (I, x^2, xy, y^2) is also maximal. Ideals I that are maximal in their linkage classes are relevant as their Rees Algebras and the Rees algebras of ideals linked to them have good properties (e.g. they are Cohen-Macaulay, under mild assumptions on I). (Received January 31, 2014)

1099-13-107 **Saeed Nasseh** and **Sean Sather-Wagstaff*** (sean.satherwagstaff@ndsu.edu). *Local rings of embedding codepth at most 3 have only trivial semidualizing complexes.* Preliminary report.

A finitely generated module C over a commutative noetherian ring R is *semidualizing* if $R \cong \mathrm{Hom}_R(C, C)$ and $\mathrm{Ext}_R^{\geq 1}(C, C) = 0$. More generally, a homologically finite R-complex is *semidualizing* if $R \simeq \mathbf{R}\mathrm{Hom}_R(C, C)$ in the derived category $\mathcal{D}(R)$. We prove that a local ring R of embedding codepth at most 3 has at most two semidualizing complexes up to shift-isomorphism, namely, R itself and a dualizing R-complex if one exists. (Received February 02, 2014)

1099-13-108 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu) and **Sandra Spiroff**. *On the structure of S_2-ifications of complete local rings.* Preliminary report.

Motivated by work of Hochster and Huneke, we investigate several constructions related to the S_2-ification T of a complete equidimensional local ring R: the canonical module, the top local cohomology module, topological spaces of the form $\mathrm{Spec}(R) - V(J)$, and the (finite simple) graph Γ_R with vertex set $\mathrm{Min}(R)$ defined by Hochster and Huneke. We generalize one of their results by showing, e.g., that the number of maximal ideals of T is equal to the number of connected components of Γ_R. We further investigate this graph by exhibiting a technique for showing that a given graph G can be realized as one of the form Γ_R. (Received February 02, 2014)

1099-13-109 **Chris Francisco*** (chris@math.okstate.edu), 401 MSCS, Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Huy Tai Ha** and **Adam Van Tuyl**. *Recent work on persistence of associated primes.* Preliminary report.

Let I be a squarefree monomial ideal in $R = k[x_1, \ldots, x_n]$. One version of the persistence problem asks: If a prime $P \in \mathrm{Ass}(R/I^s)$, under what conditions is $P \in \mathrm{Ass}(R/I^{s+r})$ for all $r \geq 0$? We will survey progress on this question from the last few years. Work in which I have been involved is joint with Tài Hà and Adam Van Tuyl. (Received February 02, 2014)

1099-13-114 **Janet C. Vassilev*** (jvassil@math.unm.edu), Department of Mathematics and Statistics, Albuquerque, NM 87131. *Test Ideals, Frobenius Algebras and Hypergraphs.* Preliminary report.

For every hypergraph $\mathcal{G}$, there is an associated monomial ideal I contained in the polynomial ring R on the vertices of $\mathcal{G}$. We will discuss what properties of the hypergraph are detected by the test ideal and the Frobenius Algebra. (Received February 03, 2014)

1099-13-121 **Florian Enescu*** (fenescu@gsu.edu), Department of Mathematics and Statistics, 758 COE, Georgia State University, 30 Pryor Street, Atlanta, GA 30303, and **Yongwei Yao** (yyao@gsu.edu). *The Frobenius Complexity of a Local Ring of Prime Characteristic.* Preliminary report.

In this talk, we will discuss the number of Frobenius operators on the injective hull of the residue field of a local ring R of prime characteristic. In particular, we will define the Frobenius complexity of R and present relevant examples and results regarding this concept. (Received February 03, 2014)

1099-13-143 **Angelica Benito*** (abenitos@umich.edu), University of Michigan, Ann Arbor, MI. *Locally acyclic cluster algebras are strongly F-regular.*

In this talk we will show that locally acyclic cluster algebras defined over a field of positive characteristic are strongly F-regular. As a consequence of this result we can prove that over fields of characteristic zero, these algebras have canonical singularities. During the talk cluster algebras will be defined and some relevant examples will be shown. This is a joint work with G. Muller, J. Rajchgot, and K. Smith. (Received February 05, 2014)

1099-13-147 **Louiza Fouli*** (lfouli@math.nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003, and **Bruce Olberding**. *Reductions over rings with finite residue fields.* Preliminary report.

Let R be a Noetherian local ring with residue field k and let I be an ideal of R. When k is an infinite field then I either has infinitely many proper reductions or I is the only reduction of itself. However, when k is a finite field proper reductions may not exist. We consider the case of one-dimensional local Cohen-Macaulay rings with finite residue field. We investigate conditions under which one can guarantee the existence of principal reductions and conditions that guarantee the absence of such reductions. This is joint work with Bruce Olberding. (Received February 05, 2014)

1099-13-158 **Rebecca Egg** and **Thomas Marley*** (tmarley1@unl.edu). *Cohen-Macaulay dimension for coherent rings.* Preliminary report.

In this talk we will discuss a notion of Cohen-Macaulay (CM) dimension for finitely presented modules over coherent rings, following the work of A. Gerko in the noetherian case. We use this to define a coherent quasi-local ring to be CM if every finitely presented module has finite CM dimension. We discuss properties of such rings and how this notion of CM compares to other generalizations of Cohen-Macaulayness to coherent rings which have been studied in the literature. (Received February 06, 2014)

1099-13-173 **Lance Edward Miller***, 301 SCEN, University of Arkansas, Fayetteville, AR 72701, and **Benjamin Steinhurst**. *A concrete interpretation of a non-noetherian generalization of Witt vectors.*

Witt vectors are ubiquitous in commutative algebra and enjoy a number of generalizations. Most of these can fit into a systematic framework where one produces from each profinite group G a functor $\mathbf{W}_G$ on the category of commutative rings. Using the group $G = \mathbf{Z}_p$ of additive p-adic numbers one recovers the original Witt vector construction, which is well known to be a DVR when applied to any perfect field of characteristic $p > 0$. We give a concrete interpretation of the images of $\mathbf{W}_{\mathbf{Z}_p^2}(k)$ where k is any field of characteristic $p > 0$. This ring in particular is not noetherian. As an application of our interpretation we calculate the dimension of this ring. (Received February 07, 2014)

1099-13-174 **Lance Edward Miller***, 301 SCEN, University of Arkansas, Fayetteville, AR 72701, and **Anurag K Singh** and **Matteo Varbaro**. *Log canonical and F-pure thresholds for ideals of minors.* Preliminary report.

The F-pure threshold is a positive characteristic analog of the log canonical threshold. An important outstanding conjecture relates the log canonical threshold to the F-pure threshold under reduction. We verify this conjecture in the case of ideals defined by minors of generic matrices. (Received February 07, 2014)

1099-13-182 **Louiza Fouli**, **Andrew Kustin** and **Adela Vraciu*** (vraciu@math.sc.edu). *Regular sequences in polynomial rings.* Preliminary report.

In 2009, Conca, Krattenthaler and J. Watanabe conjectured that $x^a + y^a + z^a, x^b + y^b + z^b$, and $x^c + y^c + z^c$ form a regular sequence in the polynomial ring in three variables over a field of characteristic zero if and only if the product of the exponents is divisible by 6. We report on some recent progress on this and other related questions. (Received February 07, 2014)

1099-13-191 **Alexey Ovchinnikov*** (aovchinnikov@qc.cuny.edu) and **Michael Wibmer** (michael.wibmer@matha.rwth-aachen.de). *Tannakian categories with actions of semigroups.*

Ostrowski's theorem implies that $\log(x)$, $\log(x+1)$,... are algebraically independent over $\mathbb{C}(x)$. More generally, for a linear differential or difference equation, it is an important problem to find all algebraic dependencies among a non-zero solution y and particular transformations of y, such as derivatives of y with respect to parameters, shifts of the arguments, rescaling, etc. I will discuss a theory of Tannakian categories with semigroup actions, which could be used to attack such questions in full generality. Deligne studied actions of braid groups on categories and obtained a finite collection of axioms that characterizes such actions to apply it to various geometric constructions. In this talk, I will present a finite set of axioms that characterizes actions of semigroups that are finite free products of free finitely generated commutative semigroups on Tannakian categories. This is the class of semigroups that appear in many applications. (Received February 08, 2014)

1099-13-194 **Linquan Ma*** (lquanma@umich.edu), 610 Hidden Valley Club Dr, Apt 216, Ann Arbor, MI 48104. *F-injectivity and Buchsbaum singularities.* Preliminary report.

We prove some interesting connections between F-injective singularities and Buchsbaum singularities. We will also discuss some partial results on DB singularities. (Received February 08, 2014)

1099-13-199 **Youngsu Kim*** (kim455@purdue.edu), 150 N Univ ST, West Lafayette, IN 47907. *Tangent cones of some determinantal rings.*

For a Noetheiran local ring $(R, \mathfrak{m})$, we call $\mathrm{gr}_{\mathfrak{m}}(R) := \oplus_{i\geq 0}\mathfrak{m}^i/\mathfrak{m}^{i+1}$ the *tangent cone* of R where $\mathfrak{m}^0 = R$. If R is an epimorphic image of a regular local ring $(S, \mathfrak{n})$, i.e., $R = S/I$ for some S-ideal I, the tangent cone of R is isomorphic to $\mathrm{gr}_{\mathfrak{n}}(S)/I^*$. We call I^* the *leading ideal* of I.

It is well known that if I is principal, then I^* is principal, i.e., the tangent cone is a complete intersection ring. In general I^* is not a complete intersection ideal even if I is. Goto-Heinzer-M. Kim showed that if I is a complete intersection of codimension 2 and I^* is at most 3-generated, then the tangent cone of R is Cohen-Macaulay. We study the Cohen-Macaulayness of the tangent cone of R when I is generated by the maximal minors of a matrix of "small" size. (Received February 08, 2014)

1099-13-208 **Juan Felipe Perez*** (juanfp@umich.edu). *Lyubeznik numbers and injective dimension of local cohomology modules in mixed characteristic.*

In an effort to understand rings of mixed characteristic Luis Núñez-Betancourt and Emily Witt introduced an analogue of the Lyubeznik numbers for these rings. In this talk, we will give an overview of these numbers as well as some of their properties. We will also discuss related results on injective dimension of local cohomology over regular rings of mixed characteristic. This is joint work with Daniel Hernández, Luis Núñez-Betancourt and Emily Witt. (Received February 09, 2014)

1099-13-209 **Evan Houston*** (eghousto@uncc.edu), Dept. of Mathematics, UNC Charlotte, Charlotte, NC 28223. *Local Noetherian domains admitting only finitely many star operations.* Preliminary report.

In a previous paper, the author and M.H. Park characterized local Noetherian domains R admitting only finitely many star operations under the assumption that R has infinite residue field. In this talk, we report progress on the finite residue field case. (Received February 09, 2014)

1099-13-229 **William Heinzer** (swiegand@math.unl.edu), 2400 Sheridan Blvd, Lincoln, 68502, **Christel Rotthaus** (swiegand@math.unl.edu), Lincoln, 68502, and **Sylvia M Wiegand*** (swiegand@math.unl.edu), Dept pf Mathematics, University of Nebraska, 203 Avery Hall, Lincoln, NE 685880130. *An iterative meta-example constructed using power series.*

Let x and y be indeterminates over a field k, let $R = k[x, y]_{(x,y)}$ and let R^* be the (x)-adic completion $k[y]_{(y)}[[x]]$ of R. We first apply a simple form of a basic construction that we have developed to adjoin an element σ of $xk[[x]]$ that is transcendental over $k(x)$; for example with $k = \mathbb{Q}$, take $\sigma = e^x - 1$. For this, set $A := k(x, y, \sigma) \cap k[y]_{(y)}[[x]]$.

Then $A = C[y]_{(x,y)}$, where $C := k(x, e^x) \cap k[[x]]$, a DVR. Thus the ring A is Noetherian and a regular domain; moreover A is a nested union of localized polynomial rings in three variables that is naturally associated to A.

We iterate the construction using $\tau \in yk[[y]]$ transcendental over $k(y)$. The resulting ring $A' := k(x, y, \sigma, \tau) \cap k[[x, y]]$ is a two-dimensional regular local domain with maximal ideal $(x, y)A'$ and completion $\widehat{A'} = k[[x, y]]$. There is a nested union B' of localized polynomial rings in four variables contained in and naturally associated to A'. Depending upon the choices of σ and τ, sometimes $B' = A'$ and sometimes $B' \subsetneq A'$.

We give some insights, results and examples concerning whether $B' = A'$ and whether B' is Noetherian. (Received February 09, 2014)

1099-13-234 **Jesse Elliott*** (jesse.elliott@csuci.edu), One University Drive, Camarillo, CA 93012. *Factoring formal power series over principal ideal domains.*

We provide an irreducibility test and factoring algorithm (with some qualifications) for formal power series in the unique factorization domain $R[[X]]$, where R is any principal ideal domain. Our main tool is a generalization of the p-adic Weierstrass preparation theorem to the context of complete filtered commutative rings. (Received February 10, 2014)

1099-13-235 **Hailong Dao***, Department of Mathematics, University of Kansas, 405 Snow Hall, 1460 Jayhawk Blvd, Lawrence, KS 66045. *Higher Hilbert-Kunz theory.*

(Joint work with I. Smirnov and K. Watanabe) Let (R, m) be a ring of positive characteristic with $d = \dim R$ and I be an ideal in R which is m-primary. The classical Hilbert-Kunz multiplicity is the limit of $\frac{\lambda(R/I^{[p^e]})}{p^{de}}$ as e tends to infinity. In our work we consider any finitely generated module M, and replace the length of $R/I^{[p^e]}$ by the length of some local cohomology of the module $F^e(M)$, here F is the Peskine-Szpiro functor. This generalizes the classical notion in many ways. We can prove that the limit exists over isolated singularities (with some mild extra conditions) and more interestingly, classify when the limit is 0 over complete intersections or F-regular rings. Some applications will be discussed. (Received February 10, 2014)

1099-13-245 **D. Katz*** (dlk@math.ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045, and **J. Validashti** (jvalidas@illinois.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *A correspondence between Rees valuations.*

Let $(R, \mathfrak{m})$ be a Noetherian ring with completion $\widehat{R}$. For an ideal $I \subseteq R$, we show that there is a one-to-one correspondence between the Rees valuations of I centered on $\mathfrak{m}$ and the Rees valuations of $I\widehat{R}$ centered on $\widehat{\mathfrak{m}}$. (Received February 10, 2014)

1099-13-267 **Fatih Koksal*** (fatih.koksal@ttu.edu). *INJECTIVITY UNDER CO-BASE CHANGE.*

Let R and S be commutative Noetherian rings; assume S is an R-algebra. It is well-known that if N is an injective R-module, then $\mathrm{Hom}_R(S, N)$ is an injective S-module. The converse is not true, not even if R is local and regular, and $S = \widehat{R}$ is its completion. However, if S is faithfully flat, the projective dimension of every flat R-module is bounded by $d \geqslant 0$, and $\mathrm{Ext}_R^{\geq 0}(S, N) = 0$, then the converse is true. (Received February 10, 2014)

1099-13-269 **Daniel J. Hernández** and **Pedro Teixeira*** (pteixeir@knox.edu). *Syzygy gap fractals and F-threshold functions.* Preliminary report.

We examine F-thresholds of families of polynomials constructed with fixed "building blocks". When those building blocks are linear forms in two variables, structural results for syzygy gap fractals lead to a description of certain F-thresholds of homogenous polynomials (possibly under a non-standard grading) in two variables and yield a method for their explicit computation. (Received February 10, 2014)

1099-13-289 **K Alan Loper*** (loper.4@osu.edu), 1179 University Drive, Newark, OH 43055, and **William Heinzer**, **Bruce Olberding** and **Hans Schoutens**. *Quadratic transforms of regular local rings.* Preliminary report.

We study the structure of chains of quadratic transforms of regular local rings. Abhyankar showed that if we start with a two-dimensional ring then the union of a chain is always a valuation domain. This is not true in dimensions higher than two. We investigate how to get a valuation domain in this case and what structure we do get in the case that we not get a valuation domain. (Received February 10, 2014)

1099-13-325 **Bhargav Bhatt**, **Manuel Blickle**, **Gennady Lyubeznik**, **Anurag Singh** and **Wenliang Zhang*** (wzhang15@unl.edu), 203 Avery Hall, Department of Mathematics, University of Nebraska, Lincoln, NE 68588. *A finiteness theorem for local cohomology modules.*

i will discuss joint work with Bhargav Bhatt, Manuel Blickle, Gennady Lyubeznik, and Anurag Singh on a finiteness result for local cohomology modules. (Received February 10, 2014)

1099-13-331 **Luis Nunez-Betancourt*** (lcn8m@virginia.edu), Charlottesville, VA 22904, and **Ilya Smirnov**, Charlottesville, VA 22904. *Multiplicity and F-thresholds.*

F-thresholds are numerical invariants that measure the severity of a singularity. They are the analogue of log-canonical thresholds in positive characteristic. In this talk we will discuss connections of F-thresholds with multiplicities. This work is inspired by inequalities between multiplicities and log-canonical thresholds (in characteristic zero). (Received February 11, 2014)

1099-13-334 **Neil Epstein*** (nepstei2@gmu.edu), 4400 University Drive, MS: 3F2, Fairfax, VA 22030, and **Jay Shapiro**. *Strong Krull primes and flat modules.*

Several long-established theorems describe the intricate relationship between flatness and associated primes over commutative Noetherian rings. However, associated primes are known to act badly over non-Noetherian rings, so one needs a suitable replacement. We show that when it comes to flatness, the behavior of strong Krull primes over a general commutative ring most closely resembles that of associated primes over a Noetherian ring. For instance, a theorem of Epstein and Yao characterizing flat modules over Noetherian rings in terms of associated primes has a good analogue by replacing associated primes by strong Krull primes. Also, we get a partial generalization of a classical theorem regarding flat base change and associated primes in Noetherian rings, again by use of strong Krull primes. That is, we can show one containment in general and equality in many special cases. One application is of interest over any Noetherian ring of prime characteristic. If there is time, some limiting counterexamples will be given. (Received February 11, 2014)

1099-13-358 **Ryan Schwarz*** (rschwarz@sjcny.edu). *Finiteness Conditions in Commutative Group Rings.* Preliminary report.

The ascending chain condition, itself a finiteness condition, has given rise to the rich theory of Noetherian commutative algebra. This, however, is not the only finiteness condition which can be imposed. In this talk, we will examine some of the effects of this and other finiteness conditions on commutative group rings. (Received February 11, 2014)

1099-13-362 **Liana M Sega*** (segal@umkc.edu). *Homological properties of compressed Gorenstein local rings.*

A compressed Gorenstein local ring is a commutative artinian local ring $(R, \mathfrak{m}, k)$ whose length is maximal, given fixed integes s and t with $\mathfrak{m}^s \neq 0 = \mathfrak{m}^{s+1}$ and $\operatorname{rank}_k(\mathfrak{m}/\mathfrak{m}^2) = e$. I will present work with M. Rossi in which we establish that the Betti numbers of all finite modules over such rings satisfy specific recurrence relations. I will also discuss recent work with J. Hoffmeier, which shows that the Yoneda Ext algebra of such rings is generated in degrees 1 and 2. (Received February 11, 2014)

1099-13-365 **Alex Fink** (a.fink@qmul.ac.uk), **Jenna Rajchgot*** (rajchgot@umich.edu) and **Seth Sullivant** (smsulli2@ncsu.edu). *Frobenius splitting, matrix Schubert varieties, and Gaussian graphical models.*

In probability theory, one can ask the question of whether or not two random variables are independent of one another, or, more generally, conditionally independent of one another given a third. In the specific case of the multivariate Gaussian distribution, statements about conditional independence of sets of coordinates are equivalent to statements about ranks of submatrices of symmetric matrices. Consequently, questions about conditional independence can be studied using commutative algebra.

In this talk, I'll explain how to solve a couple of these statistical questions by constructing certain Frobenius splittings and realizing some of the compatibly split subvarieties as equivalent to conditional independence statements.

This is joint work with Alex Fink and Seth Sullivant. (Received February 11, 2014)

1099-13-373 **Sara L Malec*** (smalec@pacific.edu), University of the Pacific, Department of Mathematics, 3601 Pacific Avenue, Stockton, CA 95211. *On the Intersection Algebra of Ideals.*

Given two ideals in a Noetherian ring, the intersection algebra is an object that captures some information on the relationships between those two ideals. In this talk, we use a connection to semigroup rings to describe many properties of the intersection algebra of ideals in a UFD, including an algorithm that produces its generating set. (Received February 11, 2014)

1099-13-374 **Bryan C White*** (bcwhite64@gmail.com). *Computational Investigation of Star Operations Using Macaulay 2.* Preliminary report.

We investigate the actions of star operation of the form $J^\star = (I : (I : J))$ for some fixed fractional ideal I on numerical semigroup rings using the computer program Macaulay 2. We do this by representing our numerical semigroup ring as a quotient of a polynomial ring in several variables and then applying the colon function in Macaulay 2. We also find limitations on possible actions of arbitrary star operations using the fact that if a fractional ideal A is $\star$-closed, then so is $(A : B)$ for any fractional ideal B. (Received February 11, 2014)

14 ► Algebraic geometry

1099-14-156 **Carlos E Arreche*** (carreche@gc.cuny.edu), The Graduate Center, Mathematics Department, 365 Fifth Ave., Room 4208, New York, NY 10016. *A Picard-Vessiot topology for differential schemes.* Preliminary report.

We present a new Grothendieck topology for differential schemes X, called the Picard-Vessiot topology, in which every $\mathcal{O}_X$-coherent module with connection is locally trivial (i.e., generated by horizontal sections). The main examples of differential schemes are smooth algebraic varieties, and prime spectra of differential rings. We will discuss analogies (and contrasts) with the étale topology, as well as potential applications of the Picard-Vessiot topology to problems in algebraic geometry and differential algebra. (Received February 06, 2014)

1099-14-230 **Taylor Dupuy*** (dupuy@math.ucla.edu), **James Freitag** and **Lance E Miller**. *Arithmetic Kolchin Irreducibilty.*

The Kolchin Irreducibility theorem states that the arc space (infinite order tangent space) of an irreducible variety is irreducible. This is particularly interesting given how singular irreducible varieties have "messed up" tangent spaces at finite order leading to multiple components. We will talk about recent work concerning arithmetic variants of this theorem. (Received February 09, 2014)

1099-14-274 **David Zureick-Brown*** (david.zureick.brown@gmail.com), 628 W College Ave, Decatur, GA 30030. *Overconvergent and de Rham-Witt cohomology for Algebraic Stacks.*

I will talk about recent advances in p-adic and rigid cohomology – le Stum's overconvergent site and the de Rham-Witt complex of Davis-Langer-Zink – and related work comparing these and generalizing these to stacks. (Received February 10, 2014)

1099-14-313 **James E Freitag*** (freitag@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, 970 Evans Hall, Berkeley, CA 94720-3840, and **Thomas Scanlon**. *Differential algebra and the j-invariant.*

We will discuss a generalization of Pila's modular Ax-Lindemann-Weierstrass theorem. Namely, we will show that the differential equation satisfied by the j-function is strongly minimal and geometrically trivial. Both of these model-theoretic notions and their importance will be explained. The proof uses results of Pila and Nishioka along with stability theory. If time permits, generalizations and Shimura varieties will also be discussed. (Received February 10, 2014)

17 ► Nonassociative rings and algebras

1099-17-195 **Gregory P. Wene*** (gpwene2011@hotmail.com), The University of Texas at San Antonio, Department of Mathematics, One UTSA Circle, San Antonio, TX 78249-0624. *Lie-admissible Semifields.*

The superabundance and great variance of finite semifields has generated the need for an effective classification scheme. The concept of isotopic has proven to be too course and that of isomorphic too fine. The many references to semifields that appear in the literature refer to a specific construction: a Dickson commutative semifield, a

Hughes-Kleinfeld semifield, a Kantor semifield, etc. We explore the effectiveness of the concepts Lie-admissible and solvable. (Received February 08, 2014)

18 ► Category theory; homological algebra

1099-18-112 **Bethany Kubik*** (bethany.kubik@usma.edu) and **Sean Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu). *Path Ideals.* Preliminary report.

We explore weighted graphs and their "path ideals" which are ideals in polynomial rings that are defined based on the existing paths of the graph. We discuss the decomposition of a path ideal and Cohen-Macaulay wieghted graphs in the case of trees and complete graphs. (Received February 03, 2014)

1099-18-282 **ZBIGNIEW OZIEWICZ*** (oziewicz.zbigniew@gmail.com), Universidad Nacional Autonoma de Mexico, Facultad de Estudios Superiores Cuautitlan, CP 54714 Cuautitlan Izcalli, Estado M, Mexico. *Conceptual link among Frobenius and Lie algebras.*

We consider a binary algebra and co-algebra within abelian monoidal category of operad of graphs. We note that an arbitrary algebra possesses a priori five different trace-form (tensors - also called scalar products 2 ->0). Among them two are the Cartan-Killing trace-forms (introduced by Elie Cartan in his These in 1894 for the particular case of a Lie algebra). For Lie algebra these two trace-forms are equal. Namely from the left and the right regular representations of arbitrary algebra one can construct five a priori different trace-form. We are interested in utility and relations among these trace-forms assigned to every binary algebra. As a corollary we point that semi-simple Lie algebra is a non-associative Frobenius algebra. This work generalize considerations by Jerzy Kocik in his Ph. D, Thesis at Southern Illinois University at Carbondale in 1989. (Received February 10, 2014)

20 ► Group theory and generalizations

1099-20-105 **Robin D Tucker-Drob*** (rtuckerd@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019. *On the cost of generating an inner amenable group.*

I will discuss recent results on structural properties of groups which possess an atomless inner invariant mean, and I will sketch how these properties imply that all free measure preserving actions of ICC inner amenable groups have cost 1. (Received February 02, 2014)

1099-20-157 **Sang-hyun Kim** and **Thomas Koberda*** (thomas.koberda@gmail.com), PO Box 208283, New Haven, CT 06520-8283. *Flat structures on surfaces and one-ended subgroups of right-angled Artin groups.* Preliminary report.

We will discuss flat structures on surfaces coming from CAT(0) geometry and right-angled Artin groups. The main result is that closed surface subgroups of right-angled Artin groups are generated by elliptic elements. As a corollary, we show that closed surface subgroups of mapping class groups which factor through right-angled Artin groups are generated by reducible mapping classes. (Received February 06, 2014)

1099-20-354 **Sinead Lyle** and **Oliver Ruff*** (oruff@kent.edu), 6000 Frank Ave NW, North Canton, OH 44720. *On Graded Decomposition Numbers for Ariki-Koike Algebras.*

The Ariki-Koike algebras $\mathcal{H}_{n,r}$ generalize the Hecke algebras of type A and B and arise in a variety of other natural contexts, including categorification of Kac-Moody algebras. The main open problem in their representation theory is to calculate the decomposition numbers, which is to say the composition multiplicity of the simple modules in each Specht module. In general, these are difficult to calculate.

The *weight* of a block, defined by Fayers, gives a measure of its complexity (generalizing the classical notion of "weight" in type A). When $r = 2$, which is when $\mathcal{H}_{n,r}$ coincides with the Hecke algebra of type B, Fayers has also considered the decomposition numbers for blocks of weight 2. We deal with the case when $r > 2$ and complete the picture for the blocks of weight 2, as well obtaining information about a certain class of blocks having higher weight. Our work includes an explicit combinatorial description of each block's contents as well as a closed formula for some of the decomposition numbers. (Received February 11, 2014)

22 ► Topological groups, Lie groups

1099-22-23 **Michael P Cohen*** (michael.cohen@ndsu.edu), P.O. Box 6050, Fargo, ND 58108, and **Robert R Kallman**, 1155 Union Circle #311430, Denton, TX 76203. *A conjecture of Gleason on the foundations of geometry.*

In a 1957 paper, Gleason made a very general conjecture that if an abstract (un-topologized) group G acts on a Polish space M by homeomorphisms, and the action satisfies a few weak geometrically motivated assumptions, then G may always be assigned a Polish topology in which G acts continuously on M. Gleason proved his conjecture in a special case. Using some automatic-continuity-type theorems, we show that the conjecture is false in general, and that its conclusion may only be achieved under very strong hypotheses. Along the way we observe an automatic "almost everywhere" continuity result for a class of functions that behave like but are distinct from functions of Baire class 1. (Received December 02, 2013)

1099-22-24 **Jose A Franco***, 1 UNF Drive, Jacksonville, FL 32224, and **Mark R Sepanski**. *Global Representations of the Schrödinger Equation with Singular Potential.*

We study the n-dimensional Schrödinger equation with singular potential $V_\lambda(x) = \lambda|x|^{-2}$. Its solution space is studied as a global representation of $\widetilde{SL(2,\mathbb{R})} \times O(n)$. A special subspace of solutions for which the action globalizes is constructed via nonstandard induction outside the semisimple category. The space of K-finite vectors is calculated, obtaining conditions for λ so that this space is non-empty. The direct sum of solution spaces, over such admissible values of λ is studied as a representation of the $2n+1$-dimensional Heisenberg group. (Received December 06, 2013)

26 ► Real functions

1099-26-216 **Alexander Reznikov*** (rezniko2@msu.edu), 619 Red Cedar Road, Wells Hall, East Lansing, MI 48823, and **Vasiliy Vasyunin** and **Alexander Volberg**. *Extremizers and Bellman function for martingale weak type inequality.*

We give an exact formula for the Bellman function of the weak type of martingale transform. We also give the extremal functions (actually extremal sequences of functions). We find them using the precise form of the Bellman function. The extremal examples have a fractal nature as it often happens in that kind of problems. This article is devoted to the unweighted weak type estimate. (Received February 09, 2014)

1099-26-359 **Armen Vagharshakyan*** (avaghars@kent.edu), 1300 University Esplanade, Dept of Math Sciences, Kent, OH 44242. *Lower bounds for L_1 discrepancy.*

We find the best constant of the leading term of the asymptotical lower bound for the L_1 norm of two-dimensional discrepancy that can be obtained by K. Roth's "test function" method. (Received February 11, 2014)

28 ► Measure and integration

1099-28-288 **G. Knese**, **J. E. McCarthy** and **K. Moen*** (kabe.moen@ua.edu). *Unions of L^p spaces and A_1 majorants.*

We show that unions of Lebesgue spaces are intimately related to the Hardy-Littlewood maximal function and the theory of weighted Lebesgue spaces. A key idea is the notion of an A_1 majorant. We give several simple characterizations of when a function belongs the union Lebesgue spaces on both local and global settings. This presentation will be based on a joint work with Greg Knese and John McCarthy. (Received February 10, 2014)

30 ► Functions of a complex variable

1099-30-299 **Mishko Mitkovski*** (mmitkov@clemson.edu). *Toeplitz operators and basis properties of non-harmonic families of special functions.*

I will present a unified treatment of the basis properties of non-harmonic complex exponentials and other families of special functions in terms of the densities of their frequencies. Toeplitz operators and the Hilbert transform play a crucial role in this approach. (Received February 10, 2014)

1099-30-314 **Mohammed A. Qazi*** (qazima@aol.com), Dept. Of Mathematics, Tuskegee, AL 36088. *A Mean Value Theorem for Quadrinomials.*

We will discuss possible extensions of the classical Mean Value Theorem to Complex-Valued Functions. (Received February 10, 2014)

1099-30-391 **Kourosh Tavakoli*** (ktavakoli@okcu.edu). *On Analytic Complex Functions, Iterations, and Geometry of Domains.*

In this talk, I will consider several self maps consisting of analytic complex functions defined on different domains in the plane. For each map, I will form a sequence of functions by the self compositions of the analytic function. I will find the limit functions and show how they are related to the geometry of the domains. (Received February 11, 2014)

31 ► Potential theory

1099-31-188 **Marius Mitrea*** (mitream@missouri.edu), University of Missouri, Department of Mathematics, Columbia, MO 65211. *The directional derivative problem without transversality.* Preliminary report.

The origin of the directional derivative problem goes back to the work of H. Poincare on the theory of tides. Ever since this groundbreaking work, it has been of interest to consider this problem in an as general geometric measure theoretic setting as possible. In my talk, I will discuss the version of this problem without the familiar transversality condition typically imposed on the direction vector field used to formulate the boundary condition. (Received February 08, 2014)

32 ► Several complex variables and analytic spaces

1099-32-256 **Irina Mitrea***, 442 Wachman Hall, Department of Mathematics, Temple University, 1805 N. Broad Street, Philadelphoa, PA 19122, and **Marius Mitrea** and **Michael Taylor**. *Szegö Projections and Kerzman-Stein Formulas.*

In this talk I will address the question whether the orthogonal projection P of the Hilbert space $L^2(\Sigma)$ onto the closed subspace $\mathcal{H}^2_+(\Sigma)$ (or $\mathcal{H}^2_-(\Sigma)$) has a bounded extension as an operator on $L^p(\Sigma)$ with $p \neq 2$. This is a rather delicate issue, which interfaces tightly with the geometric character of Σ.The main tools are a new generation of commutator estimates and a far-reaching extension of the so-called Kerzman-Stein formula from Complex Analysis. (Received February 10, 2014)

33 ► Special functions

1099-33-83 **Constanze Liaw***, One Bear Place #97328, Waco, TX 76798, and **Lance Littlejohn**, **Jessica Stewart** and **Quinn Wicks**. *Spectral Analysis of the Exceptional Jacobi Differential Expression for Extreme Parameter Choices.*

The Bochner Classification Theorem (1929) characterizes the polynomial sequences $\{p_n\}_{n=0}^\infty$, with $\deg(p_n) = n$ that simultaneously form a complete set of eigenstates for a second order differential operator and are orthogonal with respect to a positive Borel measure having finite moments of all orders: Hermite, Laguerre, Jacobi and Bessel polynomials. In 2009, Gómez-Ullate, Kamran, and Milson found that for sequences $\{p_n\}_{n=1}^\infty$, with $\deg(p_n) = n$ (i.e. without the constant polynomial) the only such sequences are the *exceptional* Laguerre and Jacobi polynomials. We discuss the corresponding exceptional Jacobi differential expression for a certain extreme parameter choice. The resulting self-adjoint operator can be studied in two spaces – one of which falls into the classical Glazman, Krein, Naimark theory; the other applies the left-definite theory introduced by Littlejohn and Wellman. In each case, the operator will have a complete set of eigenfunctions. (Received January 28, 2014)

1099-33-93 **fadel khalladi*** (hamid201254@yahoo.fr), 100 logts city, N°95, Adrar, 01000 Adrar, Algeria. *A new asymptotic gamma function formula and an exact solution of one case of confluent hyper-geometric function.*

In this present work, we will apply a new geometric model to find the asymptotic of the gamma function. This model allows an analytical formla of asymptotic gamma function with a high precision. I also give the asymptotic formula of Psi (Di-gamm) function. In the second part, we present an exact solution of one particular case of confluent hyper-geometric functions. These expressions often and simplify many related formulas and contribute a high accuracy in calculus. (Received January 29, 2014)

34 ► Ordinary differential equations

1099-34-258 **Rudi Weikard***, Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294-1170. *Spectral theory for left-definite problems.*

In this talk we consider spectral, inverse spectral and inverse scattering for the differential equation

$$-u'' + qu = \lambda wu$$

where $q \geq 0$ but where w is only required to be real and locally integrable but not positive.

Applications include solving the Cauchy problem for the Camassa-Holm equation. (Received February 10, 2014)

1099-34-306 **Sergii M. Torba*** (storba@math.cinvestav.edu.mx). *On a new method of approximation of transmutation operators for Sturm-Liouville equations.*

An operator T is called a transmutation operator for the pair of operators A and B if it is continuous, continuously invertible on a suitable topological space and satisfy $AT = TB$.

When $A = -\partial^2 + q(x)$ and $B = -\partial^2$, a transmutation operator T can be realized in the form

$$Tu(x) = u(x) + \int_{-x}^{x} K(x,t)u(t)dt$$

with the integral kernel K satisfying a Goursat problem. Due to the transmutation property the general solution of the equation $Au = w^2 u$ is a linear combination of the images of functions $\cos wx$ and $\sin wx/w$ under the action of T.

We propose a method of approximation of the integral kernel $K(x,t)$ in the form of a polynomial in t whose coefficients are functions of x. Due to the form of the approximation all the integrals appearing during the calculation of $T \sin wx$ and $T \cos wx$ with the approximated kernel can be evaluated explicitly. The method starts from a particular solution f of the equation $Af = 0$ and reduces the approximation of K to the solution of two one-dimensional approximation problems. All the steps of the method are suitable for numerical implementation leading to a highly efficient method of the solution of Sturm-Liouville spectral problems.

The talk is based on joint works with V. V. Kravchenko. (Received February 10, 2014)

35 ► Partial differential equations

1099-35-19 **Granville Sewell*** (sewell@utep.edu), Mathematics Dept., UTEP, El Paso, TX 79968. *Mathematical Finance Applications of PDE2D.*

PDE2D (www.pde2d.com) is a very general-purpose partial differential equation solver which has been used for a wide range of mathematical finance applications, for example, Juergen Topper's book *Financial Engineering with Finite Elements* [John Wiley 2005] uses it in almost every section of the book.

Here we look at the use of PDE2D to solve problems in two papers,

1. "Numerical Schemes for Option Pricing in Regime-Switching Jump Diffusion Models", I.Florescu, R. Liu, M.Mariani and Granville Sewell, to appear in International Journal of Theoretical and Applied Finance.
2. "Numerical Methods applied to Option Pricing Models with Transaction Costs and Stochastic Volatility," M.Mariani, I.SenGupta and Granville Sewell, to appear in Quantitative Finance.

The PDE systems in the first paper are actually time-dependent partial integro-differential involving integrals of the unknown functions. In the second paper, a very highly nonlinear PDE is solved, which involves square roots of second derivatives.

(Received November 22, 2013)

1099-35-34 **Shibin Dai*** (sdai@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003, and **Qiang Du**, Department of Mathematics, Penn State University, University Park, PA 16802. *Motion of Interfaces Under the Cahn-Hilliard Equation with One or Two Sided Degenerate Diffusion Mobility.*

We use the asymptotic matching method to study the motion of interfaces in two phase systems governed by the Cahn-Hilliard equation with one or two-sided degenerate diffusion mobilities. We find that there is a nonlinear diffusion process that solves a quasi-stationary porous medium equation in the phase(s) where the mobility degenerates, which is the mechanism for such systems to coarsen. When the mobility is disparate, scaling arguments suggest that the coarsening rate depends on the volume fraction of the phases. We will also show numerical simulations to justify our analytical results. (Received January 04, 2014)

1099-35-36 **Gustavo Ponce*** (ponce@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *The IVP for the Benjamin-Ono equation in weighted Sobolev spaces.*

We shall discuss results concerning the well posedness and some optimal uniqueness properties of the solutions to the IVP associated to the Benjamin-Ono equation. These results include some persistence property of the solution flow in weighted Sobolev spaces and some uniqueness properties of these solutions under conditions involving two and three different times. These results have been established in joint works with G. Fonseca and F. Linares, and in a recent work of Cynthia Flores. (Received January 09, 2014)

1099-35-44 **Roy Goodman**, **Michael I Weinstein** and **Jeremy L Marzuola*** (marzuola@math.unc.edu), Department of Mathematics, CB #3250, Chapel Hill, NC 27599. *The long-time existence of self-trapping and Josephson tunneling solutions to the nonlinear Schrödinger Equation.*

We discuss recent work with Roy Goodman and Michael Weinstein to describe large scale dynamics that move mass from one well to another in a nonlinear Schrödinger equation with a double-well potential, V. Specifically, we study the long time exchange of mass that can occur given initial data taken to be a particular complex, linear combination of linear modes of the Schrödinger operator $H = -\Delta + V$, for which will assume there exists a symmetric ground state, ψ_0, and an anti-symmetric excited state, ψ_1. The recent work expands our understanding of the finite dimensional dynamical system that arises from taking the ansatz,

$$u(x,t) = c_0(t)\psi_0 + c_1(t)\psi_1 + \text{error},$$

and studying the resulting equations for c_0, c_1. Once we have controlled the finite dimensional dynamics on long time scales, we work to prove that even for relatively large orbits, the infinite dimensional dynamics can be controlled by the shadowing theorem proved by Weinstein and myself for a limited family of finite dimensional orbits. (Received January 14, 2014)

1099-35-46 **Yaniv Almog*** (almog@math.lsu.edu), Department of Mathematics, Lockett Hall, LSU, Baton Rouge. *Completeness of the eigenspace of some non-self-adjoint operators.*

We consider the eigenspace of $\mathcal{P} : D \to L^2(\Omega)$, where

$$\mathcal{P} = -\mathcal{P}_0^2 + V\,,$$

in which

$$\mathcal{P}_0 = \sum_{k=1}^{d} e^{i\alpha_k}\Big(\frac{\partial}{\partial x_k} - iA_k\Big)\hat{i}_k\,.$$

In the above $A = (A_1, \dots, A_d)$ is a smooth magnetic field, and V is a complex potential. The domain Ω is a smooth unbounded subset of $\mathbb{R}^d$, and D is a subset of $H_0^1(\Omega)$. We then apply the results to the linearized Ginzburg-Landau operator in a half-space.

Joint work with Bernard Helffer (Received January 15, 2014)

1099-35-54 **Patricia Bauman** (bauman@math.purdue.edu) and **Daniel Phillips*** (phillips@math.purdue.edu). *Properties of minimizers to the Maier-Saupe energy for liquid crystals.* Preliminary report.

We prove regularity properties and determine bounds for local minimizers to an energy derived from Maier–Saupe theory that is used to characterize order in nematic liquid crystal materials. (Received January 20, 2014)

1099-35-60 **Daewon Chung*** (chdaewon@inha.ac.kr), Department of Mathematics, Inha University, Incheon, South Korea, and **Hyeonbae Kang**, **Kyoungsun Kim** and **Hyundae Lee**. *Cloaking due to anomalous localized resonace in plasmonic structures.*

If a core of dielectric material is coated by a plasmonic structure of negative dielectric material with non-zero loss parameter, then anomalous localized resonance may occur as the loss parameter tends to zero and the source outside the structure can be cloaked. It has been proved that the cloaking due to anomalous localized resonance (CALR) takes place for structures of concentric disks and the critical radius inside which the sources are cloaked has been computed. In this talk, it will be presented that CALR takes place for structures of confocal ellipses and the critical elliptic radii are computed. The method of this talk uses the spectral analysis of the Neumann-Poincaré type operator associated with two interfaces (the boundaries of the core and the shell). It will be also discussed that the case of multilayer structures. (Received January 22, 2014)

1099-35-71 **Ibrahim Fatkullin***, 617 N Santa Rita Ave, Tucson, AZ 85721, and **Valeriy Slastikov**.
Diffusive transport in two-dimensional nematics.

I will discuss a dynamical theory for nematic liquid crystals describing the stage of evolution in which the hydrodynamic fluid motion has already equilibrated and the subsequent evolution proceeds via diffusive motion of the orientational degrees of freedom. This diffusion induces a slow motion of singularities of the order parameter field. Using asymptotic methods for gradient flows, I will establish a relation between the Doi-Smoluchowski kinetic equation and vortex dynamics in two-dimensional systems. I will also discuss moment closures for the kinetic equation and Landau-de Gennes-type free energy dissipation. (Received January 26, 2014)

1099-35-74 **Matthew Pennybacker*** (pennybacker@math.unm.edu). *Fronts in Fibonacci Phyllotaxis.*
Some of the most spectacular patterns in the natural world can be found on members of the plant kingdom. Furthermore, the regular configurations of organs on plants, collectively called phyllotaxis, exhibit a remarkable predisposition for Fibonacci and Fibonacci-like progressions. Starting from a biochemical and mechanical growth model based on the pioneering work of Meyerowitz and Traas, we derive a PDE similar to the classic Swift-Hohenberg equation. Amazingly, we find that nearly every property of Fibonacci phyllotaxis can be explained as the propagation of a pushed pattern-forming front. (Received January 27, 2014)

1099-35-88 **Panayotis G. Kevrekidis*** (kevrekid@gmail.com), 710 N. Pleasant Street, Department of, Mathematics and Statistics, University of, Massachusetts, Amherst, MA 01003.
Dynamics of Nonlinear Waves in Granular Crystals.

In this talk, we will provide an overview of results in the setting of granular crystals, consisting of beads interacting through Hertzian contacts. We will start from the simplest setting of one- dimensional, monoatomic chains where highly localized traveling waves exist and we will also examine states in the form of (dark) discrete breathers and shock waves therein. Wherever possible, we will corroborate these considerations with recent experimental results. We will then extend our considerations to the case of diatomic chains and examine how the properties of traveling waves and also of discrete breathers are modified in the latter setting. More highly heterogeneous chains will be briefly examined as well. In addition to considering the purely Hamiltonian case, select examples of the damped-driven variant of the system and its rich phenomenology, including chaotic response and bistability/hysteresis will also be shown. Finally, the results will be extended to two dimensions and some prototypical examples thereof in hexagonal, as well as square chains will be provided. (Received January 28, 2014)

1099-35-94 **Patricia Bauman*** (bauman@math.purdue.edu), Purdue University-Math Dept., 150 No. University Street, West Lafayette, IN 47907, and **Andrea Rubiano**, Princeton Consultants, 2 Research Way, Princeton, NJ 08540. *Energy-Minimizing Nematic Elastomers.* Preliminary report.

We prove weak lower semi-continuity and existence of energy-minimizers for a free energy describing stable deformations and the corresponding director configuration of an incompressible nematic liquid-crystal elastomer subject to physically realistic boundary conditions. The energy is a sum of the trace formula developed by Warner, Terentjev and Bladon (coupling the deformation gradient and the director field) and the bulk term for the director with coefficients depending on temperature. A key step in our analysis is to prove that the energy density has a convex extension to non-unit length director fields. Our results apply to the setting of physical experiments in which a thin incompressible elastomer in R^3 is clamped on its sides and stretched perpendicular to its initial director field, resulting in shape-changes and director re-orientation. (Received January 29, 2014)

1099-35-103 **Ngoc T Do*** (dothanh@math.tamu.edu) and **Peter Kuchment**. *Quantum graph model of a graphyne and graphyne nanotubes.*

Graphynes, which are non-honeycomb monolayers of carbon allotropes, are expected to be sometimes even better than graphene in terms of electronics properties. Nanotube, although appeared much earlier than graphene, can be viewed as sheets of graphene rolled onto a cylinder. It is thus natural to look at the nanotubes obtained by folding a sheet of a graphyne. In this talk, we will present a study of spectra of Schrödinger operator on a particular graphyne structure and its nanotubes. (Received January 31, 2014)

1099-35-104 **Alexey Miroshnikov***, miroshnikov@math.umass.edu, and **Konstantina Trivisa**, trivisa@math.umd.edu. *Relative Entropy in Hyperbolic Relaxation of Balance Laws.*

We present a general framework for the approximation of systems of hyperbolic balance laws. The novelty of the analysis lies on the construction of suitable relaxation systems and the derivation of a relative entropy identity. We provide a direct proof of convergence in the smooth regime for a wide class of physical systems. We present results for systems arising in materials science, where the presence of source terms presents a number of additional challenges and requires delicate treatment. Our analysis is in the spirit and continuity of the previous work of A. Tzavaras (Comm. Math. Sci. 2005) for systems of hyperbolic conservation laws. (Received February 01, 2014)

1099-35-115 **Zaher Hani***, 251 Mercer Street, New York, NY 10012, and **Benoit Pausader**, **Nikolay Tzvetkov** and **Nicola Visciglia**. *Modified Scattering and infinite cascades for the cubic Schroedinger equation on product spaces.*

We consider nonlinear Schroedinger equations posed on various quotients of Euclidean space. Depending on the strength of the dispersion (measured in terms of the decay of linear solutions), the asymptotic behavior can vary dramatically between scattering (asymptotically linear behavior) to the "terra incognita" of the long-time dynamics of dispersive equations on compact domains. We will focus on the "in-between" case of non-compact quotients that exhibit slowest decay. The key feature is the important role played by the resonant dynamics in this case, which can modify the asymptotic behavior substantially away from linear dynamics. One consequence of this analysis is the construction of global solutions to the defocusing and focusing problems with infinitely growing high Sobolev norms (signalling infinite forward energy cascade). This work is based on joint work with Benoit Pausader as well as (for the cubic case) Nikolay Tzvetkov and Nicola Visciglia. (Received February 03, 2014)

1099-35-131 **Dat Tien Cao*** (`dtcznb@mail.missouri.edu`), Mathematics Department, University of Missouri, Columbia, MO 65211, and **Igor E. Verbitsky** (`verbitskyi@missouri.edu`), Mathematics Department, University of Missouri, Columbia, MO 65211. *Existence and Pointwise Estimates of solutions to subcritical Quasilinear elliptic equations.*

In this paper we study the following problem

$$\begin{cases} -\Delta_p u = \sigma u^q & \text{in } \mathbb{R}^n \\ \inf_{x\in\mathbb{R}^n} u(x) = s,\ s \geq 0, \end{cases}$$

where $\Delta_p u = \nabla \cdot (\nabla u|\nabla u|^{p-2})$ is the p-Laplacian, $1 < p < n$ and $0 < q < p-1$, σ is a locally finite nonnegative Borel measure. We give necessary and sufficient conditions for the existence of a positive solution, bilateral pointwise estimates of solutions in terms of Wolff's potential. These will extend the results of Brezis and Kamin to the case $p \neq 2$.
(Received February 04, 2014)

1099-35-148 **Leonid Friedlander*** (`friedlan@math.arizona.edu`), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *Asymptotics of the Steklov eigenvalues.*

Let Ω be a bounded planar domain with a smooth boundary Γ. We consider the following problem: $(-\Delta+\mu^2)u = 0$ in Ω; $(\partial u/\partial\mathbf{n})u = \nu u$ on Γ. Here $\mathbf{n}$ is the outward unit normal vector to Γ, μ is a parameter, and ν is the spectral parameter, Let $\nu_k(\mu)$ be the k-th eigenvalue of the problem. We derive asymptotics of $\nu_k(\mu)$ as $\mu \to \infty$.
(Received February 05, 2014)

1099-35-159 **Philip T Gressman** (`gressman@math.upenn.edu`), University of Pennsylvania, David Rittenhouse Laboratory, 209 South 33rd Street, Philadelphia, PA 19104, **Vedran Sohinger*** (`vedranso@math.upenn.edu`), University of Pennsylvania, David Rittenhouse Laboratory, 209 South 33rd Street, Philadelphia, PA 19014, and **Gigliola Staffilani** (`gigliola@math.mit.edu`), Massachusetts Institute of Technology, 77 Massachusetts Avenue, Building E17, Cambridge, MA 02139. *The Gross-Pitaevskii hierarchy on the three-dimensional torus.*

In this talk, we will study the Gross-Pitaevskii hierarchy on the spatial domain $\mathbb{T}^3$. In the first part of the talk, we will prove a conditional uniqueness result for the hierarchy. As a result of our analysis, it will be possible to obtain a sharp range of integrability exponents in the key spacetime estimate.

In the second part of the talk, we will add randomness into the problem by randomizing the collision operators on the Fourier domain. For such collision operators, we will show that the spacetime estimate holds for a wider range of regularity exponents, provided that one takes averages in the randomization parameter. In addition, we will study the limiting behavior of Duhamel iteration terms in a low-regularity context. Finally, we will construct local-in-time solutions to the obtained randomized hierarchies. This talk is based on joint work with Philip Gressman and Gigliola Staffilani. (Received February 06, 2014)

1099-35-163 **John A Helms*** (johnhelms@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106-3080, and **Jason L Metcalfe** (metcalfe@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Almost Global Existence for 4-Dimensional Quasilinear Wave Equations in Exterior Domains.*

This is joint work with Professor Jason Metcalfe (UNC Chapel Hill). This talk will be about quasilinear wave equations in 4 spatial dimensions in the exterior of a smooth, bounded domain. The nonlinearity is allowed to depend the solution itself at the quadratic level as well as the first and second derivatives of the solution. This work follows the original proof by Hörmander in which he proved the lifespan bound of $T_\epsilon \gtrsim \exp(c/\epsilon)$ in Minkowski space $\mathbb{R}^{1+4}$. Du, Sogge, Zhou and Metcalfe have showed that this inequality also holds in the exterior of star-shaped domains. In our work, we only require that the geometry of the exterior domain allow for a sufficiently rapid decay of local energy for solutions to linear homogeneous wave equations. This demonstrates that the lifespan bound of Hörmander holds in certain exterior domains in which there are trapped rays. We use the boundary term estimates of Metcalfe and Sogge in conjunction with a variant of the estimate of Klainerman and Sideris. This estimate will be obtained via the Sobolev inequality of Du and Zhou. (Received February 06, 2014)

1099-35-168 **Philippe Sosoe*** (psosoe@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08540, and **Tadahiro Oh** and **Jeremy Quastel**. *On infinite volume Gibbs measures for the defocusing NLS.*

In this talk, I will revisit work by Bourgain on global solutions to the defocusing nonlinear Schroedinger equation in one dimension, with initial data chosen according to a Gibbs-type measure on paths on the entire real line. I will explain an alternative, simplified approach to Bourgain's result, which uses a more precise description of the probability measure on the initial data. This will allow us to extend the uniqueness part of his results to higher power nonlinearities than cubic. Joint work with Tadahiro Oh and Jeeremy Quastel. (Received February 06, 2014)

1099-35-171 **Nathan Glatt-Holtz** and **Roger Temam** (wang211@umail.iu.edu), Blooimgton, IN 47408, and **Chuntian Wang*** (wang211@umail.iu.edu), Rawles Hall, 831 East 3rd St, Blooimgton, IN 47405. *Martingale and Pathwise Solutions to the Stochastic Zakharov-Kuznetsov Equation with Multiplicative Noise.*

We study in this article the stochastic Zakharov-Kuznetsov equation driven by amultiplicative noise. We establish, in space dimensions two and three the global existence of martingale solutions, and in space dimension two the global pathwise uniqueness and the existence of pathwise solutions. New methods are employed to deal with a special type of boundary conditions an to verify the pathwiseuniqueness of martingale solutions with a lack of regularity, where both difficulties arise due to the partly hyperbolic feature of the model. (Received February 06, 2014)

1099-35-175 **Julian Edward*** (edwardj@fiu.edu), Department of Mathematics and Statistics, Florida International University, Miami, FL 33199, and **Steve Hudson** and **Mark Leckband**. *Existence problems for the p-Laplacian: Dirichlet and Neumann boundary conditions.*

The authors consider a number of boundary value problems involving the p-Laplacian. The model case is $-\Delta_p u = V|u|^{p-2}u$ for $u \in W^{1,2}(D)$ with D a bounded domain in $\mathbf{R}^n$. The function u is assumed to satisfy either Dirichlet boundary conditions or appropriately formulated Neumann boundary conditions. We derive necessary conditions for the existence of nontrivial solutions. These conditions usually involve a lower bound for a product of powers of the norm of V, the measure of D, and a sharp Sobolev constant. In most cases, these inequalities are best possible. (Received February 07, 2014)

1099-35-180 **Sookyung Joo*** (sjoo@odu.edu), Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529, and **Carlos J Garcia-Cervera**. *Field response of smectic A liquid crystals.*

We study the Landau-de Gennes free energy to describe the undulatory instability in smectic A liquid crystals subjected to magnetic fields. We prove this phenomena by the bifurcation theory to the nonlinear system of Landau-de Gennes model for smectic liquid crystals. We find the critical field and oscillatory description of the undulations which are consistent with experimental results. When the applied field is sufficiently large, the smectic states are maintained, with the director parallel to the field. We perform numerical simulations to illustrate the results of our analysis and demonstrate the tilted layers and directors near the boundary at the equilibrium state. The three dimensional study for smectic liquid crystals under the magnetic field will be also discussed. (Received February 07, 2014)

1099-35-185 **Mihaela Ifrim*** (ifrim@berkeley.edu) and **Daniel Tataru**. *Global bounds for the cubic nonlinear Schrödinger equation in one space dimension.*

This article is concerned with the small data problem for the cubic nonlinear Schrödinger equation (NLS) in one space dimension, and short rang modifications of it. We provide a new approach in order to prove that global solutions exist for data which is small in $H^{0,1}$. (Received February 07, 2014)

1099-35-186 **Mihaela Ifrim** (ifrim@math.berkeley.edu) and **Daniel Tataru*** (tataru@math.berkeley.edu). *Global solutions for two dimensional gravity water waves.*

We consider the infinite depth water wave equation in two space dimensions in the presence of gravity. We consider this problem expressed in position-velocity potential holomorphic coordinates, and prove that small localized data leads to global solutions. This improves and simplifies earlier results on this problem. (Received February 07, 2014)

1099-35-197 **Hakima Bessaih***, University Avenue, Laramie, WY 82071, and **Yalchin Efendiev** and **Florin Maris**. *Homogenization of the evolution Stokes equation in a perforated domain with a stochastic Fourier boundary condition.* Preliminary report.

The evolution Stokes equation in a perforated domain subject to Fourier boundary condition on the boundaries of the holes is considered. We assume that the dynamic is driven by stochastic perturbations on the interior of the domain and on the boundaries of the holes. The macroscopic (homogenized) equation is derived as another stochastic partial differential equation, defined in the whole non perforated domain. Here, the initial stochastic perturbation on the boundary becomes part of the homogenized equation as another stochastic force. We use the two-scale convergence method after extending the solution with 0 in the wholes to pass to the limit. By Itô stochastic calculus, we get uniform estimates on the solution in appropriate spaces. In order to pass to the limit on the boundary integrals, we rewrite them in terms of integrals in the whole domain. In particular, for the stochastic integral on the boundary, we combine the previous idea of rewriting it on the whole domain with the assumption that the Brownian motion is of trace class. Due to the particular boundary condition dealt with, we get that the solution of the stochastic homogenized equation is not divergence free. However, it is coupled with the cell problem that has a divergence free solution. (Received February 08, 2014)

1099-35-202 **Alim Sukhtayev*** (alim@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368, and **Graham Cox**, **Christopher Jones** and **Yuri Latushkin**. *On Morse and Maslov indices for multidimensional elliptic problems.*

In this talk we discuss some recent results on connections between the Maslov and the Morse indices for differential operators. The Morse index is a spectral quantity defined as the number of negative eigenvalues counting multiplicities while the Maslov index is a geometric characteristic defined as the signed number of intersections of a path in the space of Lagrangian planes with the train of a given plane. The problem of relating these two quantities is rooted in Sturm's Theory and has a long history going back to the classical work by Arnold, Bott, Duistermaat, Smale, and to a more recent paper by Deng and Jones. We will address the case of the Schroedinger operator acting on a family of multidimensional domains obtained by shrinking a star-shaped domain to a point and equipped with either Dirichlet or quite general Robbin boundary conditions. This is a joint work with G. Cox, C. Jones, Y. Latushkin. (Received February 08, 2014)

1099-35-217 **P Laul**, **J Metcalfe**, **S Tikare** and **M Tohaneanu*** (mtohanea@math.jhu.edu). *Localized energy estimates on Myers-Perry space-times.*

We prove local energy estimates on $(1+4)$-dimensional Myers-Perry black hole backgrounds with small angular momenta. The Myers-Perry space-times are higher dimensional generalizations of the $1+3$ Kerr backgrounds where additional planes of rotation are available while still maintaining axial symmetry. Once it is determined that all trapped geodesics have constant r, the method developed by Tataru and the fourth author, which perturbs off of the Schwarzschild case by using a pseudodifferential multiplier, can be adapted. (Received February 09, 2014)

1099-35-248 **Anna Mazzucato*** (alm24@psu.edu). *Green's functions for Fokker-Planck equations.*
I will discuss a method to construct explicit approximate Green's functions for Fokker-Planck equations. Under some conditions, the coefficients can be degenerate and time-dependent. This is joint work with several co-authors. (Received February 10, 2014)

1099-35-272 **Jacob Sterbenz*** (jsterben@math.ucsd.edu), **Jesus Oliver** and **Daniel Tataru**. *Decay estimates on black hole backgrounds.*
We discuss recent work with Daniel Tataru and Jesus Oliver concerning decay estimates for hyperbolic equations on Lorentzian manifolds of "black hole" type. This includes local energy decay as well as more refined L^∞ estimates. Some applications to nonlinear problems will be mentioned. (Received February 10, 2014)

1099-35-286 **Olga Trichtchenko*** (ota6@uw.edu), Lewis Hall #202, Box 353925, Seattle, WA 98195-3925. *Stability of Near-Resonant Gravity-Capillary Waves.* Preliminary report.
I will present results on the computation and stability of periodic surface gravity-capillary waves that are in a near-resonant regime. In the zero amplitude limit, the parameters defining these solutions almost satisfy the resonance condition that leads to Wilton ripples. This manifests itself as a small divisor problem in the Stokes expansion for these solutions. We compute such solutions and investigate their stability using Hill's method. (Received February 10, 2014)

1099-35-295 **Oleksandr Misiats*** (omisiats@purdue.edu), 150 N University str, West Lafayette, IN 47907, and **Aaron Yip**. *Analysis of a discrete curvature-driven flow.*
In this talk, we consider a semi-discrete version of Bence et.al. approximation to mean curvature flows. In particular, we study the evolution of the level curves of a continuous in time and discrete in space heat equations, which are reinintialized after short time steps. We prove that in the subcritical case, when the reinitilazation step t is asymptotically much larger than the space step h, the scheme is convergent to a classical mean curvature motion. We next derive the flow velocity in the critical case $t \approx h$, which is essentially different from mean curvature, yet exhibits a nonlinear dependence on the curvature. In the supercritical case $t << h$ we show the velocity is identically 0. The transition between the critical and subcritical cases is also studied in the work. (Received February 10, 2014)

1099-35-300 **Svitlana Mayboroda*** (svitlana@umn.edu), University of Minnesota, School of Mathematics, 206 Church st SE, Minneapolis, MN 55455, and **Steve Hofmann**, **Carlos Kenig** and **Jill Pipher**. *Rellich identity and elliptic boundary problems.*
One of the simplest and the most important results in elliptic theory is the maximum principle. It provides sharp estimates for the solutions to elliptic PDEs in L^∞. It holds on arbitrary domains for all (real) divergence form elliptic operators. The well-posedness of boundary problems in L^p, $p < \infty$, is a far more intricate and challenging question, and without additional assumptions on the operator L^p bounds can fail for any finite p.

As it turns out, the matters come down to the fundamental Rellich inequalities. The Rellich identity ascertains that the tangential and normal traces of a harmonic function have equal L^2 norms. For the Laplacian and for more general symmetric elliptic operators Rellich identity is a result of a short and elegant integration by parts argument. However, already for very special complex matrices of a block form Rellich is equivalent to the celebrated profound Kato square root problem of the operator theory. I will discuss the recent (one-sided) Rellich estimates for real non-symmetric operators, the novel analysis techniques leading to them, perplexing counterexamples, as well as challenging open problems in the theory. (Received February 10, 2014)

1099-35-309 **Benjamin H Harrop-Griffiths*** (benhg@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720. *Long time behaviour of solutions to the mKdV.*
We consider the long time behaviour of solutions to the modified Korteweg-de Vries equation on R. For sufficiently small, smooth, rapidly-decaying initial data we prove global existence and derive asymptotics without relying on the completely integrable structure. This problem was previously considered by Hayashi and Naumkin. Using a stationary phase argument similar to the work of Kato and Pusateri on the cubic NLS, we are able to provide a more straightforward proof in the case of the mKdV, and to handle certain short-range perturbations. (Received February 11, 2014)

1099-35-317 **Andrea R Nahmod*** (nahmod@math.umass.edu), Department of Mathematics, Lederle GRT, 710 N. Pleasant Street, Amherst, MA 01003. *Bilinear estimates in Fourier Lebesgue spaces for the $Q_{\mu\nu}$ null forms in 2D and applications to almost critical local well posedness for the Ward system.*

In this talk we show how to prove optimal bilinear estimates for free waves in 2D in suitable Fourier Lebesgue spaces, which are sufficient to close the gap to critical regularity left in the Sobolev scale. As a consequence we obtain optimal local well-posedness result for the 1+2 dimensional system of nonlinear wave equations (NLW) with quadratic null-form derivative nonlinearities $Q_{\mu\nu}$. The Cauchy problem for these equations is known to be ill-posed for data in the Sobolev space H^s with $s \leq 5/4$ for all the basic null-forms, except Q_0, thus leaving a gap to the critical regularity of $s_c = 1$. Using appropriate multiplicative properties of the solution spaces, and relying on bilinear estimates for the $Q_{\mu\nu}$ forms, we then prove almost critical local well-posedness for the Ward wave map problem as well. This is joint work with Viktor Grigoryan. (Received February 10, 2014)

1099-35-327 **Matthew D Blair*** (blair@math.unm.edu). *On Strichartz and localized energy estimates in exterior 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 will review positive results in this area, including a joint work with H. Smith and C. Sogge. Furthermore, for strictly concave domains, we will examine the role of a family of localized energy estimates in establishing these inequalities. (Received February 10, 2014)

1099-35-333 **Svetlana Roudenko***, Department of Mathematics, Washington, DC 20052. *Contracting sphere blow-up dynamics in the focusing 3d cubic NLS equation.*

We rigorously construct radial H^1 solutions to the 3d cubic focusing NLS equation that blow-up along a contracting sphere. With blow-up time set to $t = 0$, the solutions concentrate on a sphere at radius $\sim t^{1/3}$ but focus towards this sphere at the faster rate $\sim t^{2/3}$. Such blow-up solutions can have an arbitrarily large mass. This is a joint work with Justin Holmer and Galina Perelman. Such dynamics were originally proposed heuristically by Degtyarev-Zakharov-Rudakov in 1975. (Received February 11, 2014)

1099-35-337 **Chengbo Wang*** (wangcbo@zju.edu.cn), Department of Mathematics, Zhejiang University, Hangzhou, Zhejiang 310027, Peoples Rep of China. *Recent works on the Glassey conjecture.*

In this talk, we will discuss the recent advances on the global existence vs blow up for small solutions to certain semilinear wave equations of type $u_{tt} - \Delta u = a|u_t|^p + b|\nabla u|^p$, in relation with the Glassey conjecture. The critical index is conjectured to be $pc = 1 + 2/(n-1)$. It's known to admit global small solutions for $p > pc$ when the spatial dimension is two or three, and generic small solutions blow up for $p \leq pc$.

In collaboration with Kunio Hidano and Kazuyoshi Yokoyama, we verified the Glassey conjecture in the radial case (global existence for $p > pc$). Such results have also been generalized to the settings including asymptotically flat manifolds and exterior domains. If time permitted, we'd also like to discuss the corresponding works with low regularity. (Received February 11, 2014)

1099-35-348 **Dean Baskin*** (dbaskin@math.northwestern.edu). *Wave decay on conic manifolds.*

We consider manifolds with conic singularities that are isometric to $\mathbb{R}^n$ outside a compact set. Under natural geometric assumptions on the cone points, we prove the existence of a logarithmic resonance-free region for the cut-off resolvent. The estimate also applies to the exterior domains of non-trapping polygons via a doubling process.

The proof of the resolvent estimate relies on the propagation of singularities theorems of Melrose and Wunsch to establish a "very weak" Huygens' principle.

As applications of the estimate, we obtain an exponential local energy decay and a resonance wave expansion in odd dimensions, as well as a lossless local smoothing estimate for the Schrödinger equation. We also obtain Strichartz estimates for the Schrödinger equation on non-trapping exterior polygonal domains.

This is joint work with Jared Wunsch and the Strichartz estimates are also joint with Jeremy Marzuola. (Received February 11, 2014)

1099-35-353 **Stan Alama**, **Lia Bronsard*** (bronsard@mcmaster.ca), **Andres Contreras** and **Dmitry Pelinovsky**, Dept of Math and Stats, McMaster University, Hamilton, ON L8S 4K1, Canada. *Domain walls for Gross-Pitaevskii systems.*

A thorough study of domain wall solutions in coupled Gross-Pitaevskii equations on the real line is carried out including existence of these solutions; their spectral and nonlinear stability; their persistence and stability under a small localized potential. The proof of existence is variational and is presented in a general framework: we show that the domain wall solutions are energy minimizing within a class of vector-valued functions with nontrivial conditions at infinity. The admissible energy functionals include those corresponding to coupled Gross–Pitaevskii equations, arising in modeling of Bose-Einstein condensates. The results on spectral and nonlinear stability follow from properties of the linearized operator about the domain wall. The methods apply to many systems of interest and integrability is not germane to our analysis. Finally, sufficient conditions for persistence and stability of domain wall solutions are obtained to show that stable pinning occurs near maxima of the potential, thus giving rigorous justification to earlier results in the physics literature. (Received February 11, 2014)

1099-35-356 **Vlad C Vicol***, Fine Hall 907, Washington Road, Princeton, NJ 08544. *On moments for high Sobolev norms.*

We consider a number of SPDEs arising in fluid dynamics. They have the common feature that moments for weak norms of the solutions, such as the L^2 norm, are fairly direct to obtain, since the nonlinear terms vanish. For estimates in higher order Sobolev norms, the nonlinearity does not vanish, and obtaining moment bounds up to a deterministic time becomes non-trivial. The results presented here cover the 2D stochastic Navier-Stokes equation, the 3D stochastic primitive equations, and a fractionally damped stochastic 2D Euler equation. (Received February 11, 2014)

1099-35-377 **Nicola Garofalo*** (rembrandt54@gmail.com). *Volume and distance comparison theorems for sub-Riemannian manifolds.* Preliminary report.

In this talk I will discuss global distance estimates and uniform local volume estimates in a large class of sub-Riemannian manifolds. The main tools are the generalized curvature dimension inequality introduced by F. Baudoin and the speaker, and its systematic use in obtaining sharp inequalities for solutions of the sub-Riemannian heat equation. As a consequence, we obtain a Gromov type precompactness theorem for the class of sub-Riemannian manifolds whose generalized Ricci curvature is bounded from below. The results presented in this talk are joint with F. Baudoin, M. Bonnefont and I. H. Munive. (Received February 11, 2014)

1099-35-387 **Mickaël D. Chekroun**, Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, **Honghu Liu***, Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, and **Shouhong Wang**, Department of Mathematics, Indiana University, Bloomington, IN 47405. *Non-Markovian Reduced Equations for Stochastic PDEs.*

In this talk, a new approach to deal with the parameterization problem of the “small” scales by the “large” ones for stochastic partial differential equations will be discussed. This approach relies on stochastic parameterizing manifolds (PMs) which are random manifolds aiming to provide—in a mean square sense—approximate parameterizations of the small scales by the large ones. Backward-forward systems will be introduced to give access to such PMs as pullback limits depending—through the nonlinear terms—on the time-history of the dynamics of the low modes. It will be shown that the corresponding pullback limits can be efficiently determined in practice, leading in turn to an operational procedure for the derivation of non-Markovian reduced equations able to achieve good modeling performances. A stochastic Burgers-type equation will serve to illustrate that the memory effects conveyed by such reduced systems play a key role to capture noise-induced transitions or large excursions caused by the noise. This talk is based on a joint work with Mickaël D. Chekroun (UCLA & Univ. of Hawaii at Manoa) and Shouhong Wang (IU). (Received February 11, 2014)

1099-35-394 **Vladimir Zakharov*** (zakharov@math.arizona.edu), Department of Mathematics, The University of Arizona, 617 N. Santa Rita Ave., Tucson, AZ 85721, and **Dmitry Zakharov**. *Knoidal wave via dressing method.* Preliminary report.

We study bounded solutions of the KdV equation. We show that the corresponding wave functions, the compatible solutions of auxiliary system of linear equation, are analytic on the plane of spectral parameter with exception of symmetric set of cuts on the real axis. On these cuts they satisfy certain Riemann-Hilbert and corresponding singular integral equation. The case of knoidal wave is used as a test bed. (Received February 11, 2014)

1099-35-408 **Dmitry Golovaty*** (dmitry@uakron.edu). *On minimizers of a Ginzburg-Landau variational problem in a domain with a vanishingly small hole.*
We consider minimizers of the Ginzburg-Landau functional over a circular domain with a vanishingly small hole. Assume that the radius of the hole is much larger than the Ginzburg-Landau parameter, and that the magnetic field does not exceed the value needed to generate bulk vortices. We demonstrate that the degree of the vortex located inside the hole coincides with the degree of a minimizer of a corresponding harmonic map problem. (Received February 13, 2014)

37 ► Dynamical systems and ergodic theory

1099-37-2 **Anton Gorodetski*** (asgor@math.uci.edu). *Hyperbolic dynamics and spectral properties of one-dimensional quasicrystals.* Preliminary report.
Dynamical properties of hyperbolic maps (such as Smale horseshoe or Anosov diffeomorphisms) are currently very well studied. It turns out that these properties are closely related to the spectral properties of discrete Schrodinger operators with potentials that are used in physics to model quasicrystallic structures. This connection allows to provide detailed and explicit description of spectral characteristic (fractal dimension of spectrum, density of states measure, optimal Holder exponent, transport exponents etc.) of one-dimensional quasicrystals in terms of dynamical characteristics of a hyperbolic horseshoe (fractal dimension of the hyperbolic set, topological entropy, measure of maximal entropy, Lyapunov exponents, multipliers of periodic orbits). This leads to rigorous proofs of heuristic statements and numerical results that appeared in physics papers in 80s. This is a joint project with David Damanik.
(Received May 07, 2013)

1099-37-6 **In-Jee Jeong*** (ijeong@princeton.edu), 304 Fine Hall, Dept. of Math., Princeton, NJ 08544. *Outer Billiards with Contraction.*
The dynamics of polygonal outer billiard can be sometimes reduced to the dynamics of an interval exchange map. This happens, for example, when the polygon is a trapezoid. (D. Genin's thesis) We consider the outer billiard map outside polygons but now composed with linear contraction. While it is expected that all orbits are asymptotic to a periodic one for almost every choice of parameters, it turns out that in certain cases, the dynamics is conjugate to an injective piecewise contraction of the interval, which is a close relative of a nontransitive circle homeomorphism. From this analysis we conclude existence of an attracting Cantor set. (Received January 06, 2014)

1099-37-43 **Maxim Arnold** and **Vadim Zharnitsky*** (vz@math.uiuc.edu). *Energy growth in switching Hamiltonian systems of Fermi-Ulam type.*
A natural example of a switching Hamiltonian system of Fermi-Ulam type (a particle bouncing between two oscillating walls) is considered. A corresponding smooth in time system would possess invariant KAM tori which would prevent energy growth. Numerical simulations suggest that energy does not grow even in the discontinuous case. We explain this phenomenon using relation with another problem considered earlier by Kesten. (Received January 14, 2014)

1099-37-89 **Scott R Kaschner*** (skaschner@math.arizona.edu) and **Roland K.W. Roeder**. *Superstable Manifolds of Invariant Circles.*
In this talk, I will discuss the dynamics of dominant, meromorphic self-maps of complex manifolds of dimension $n > 1$. Specifically, I will focus on the situation in which there is an invariant embedded copy of $\mathbb{CP}^1$ that also contains an invariant real circle. I will describe the regularity the of superstable manifolds of this circle and how they relate to global properties of the embedded $\mathbb{CP}^1$. Also, there is a physical interpretation to one of the maps described; I will explain how this is related and how it motivated this work. (Received January 28, 2014)

1099-37-100 **David Damanik*** (damanik@rice.edu), Rice University, Houston, TX 77005. *The spectrum and the density of states measure of the Fibonacci Hamiltonian.*
We describe recent work on the spectrum and the density of states measure of the Fibonacci Hamiltonian. (Received January 31, 2014)

1099-37-113 **Martin J Schmoll*** (schmoll@clemson.edu), 1612 S. Arlington Dr., Seneca, SC 29672. *Dynamics on Panov planes.*
We will report on work in progress with my student Chris Johnson. Particularly we will speak about dynamics on complex planes equipped with a doubly periodic singular flat metric. The talk will include an overview of

background results from topological dynamics. We compare those results to Teichmueller theory techniques usually employed to study translation surfaces. We further present our results. (Received February 03, 2014)

1099-37-136 **Lennard Bakker** and **Todd Fisher*** (tfisher@math.byu.edu), 274 TMCB, Provo, UT 84602. *Open sets with trivial centralizers.*

We will examine the set of diffeomorphisms with trivial centralizer. Smale has asked whether the set of diffeomorphisms of a manifold M with trivial centralizer is open and dense in the C^r topology for $1 \leq r \leq \infty$. Recently, Bonatti, Crovisier, and Wilkinson have shown that there is a dense set of diffeomorphisms with trivial centralizer in the C^1 topology for any manifold. However, Bonatti, Crovisier, Vago, and Wilkinson have shown that there is always a C^1 open set of diffeomorphisms $\mathcal{U}$ and a dense set $\mathcal{D} \subset \mathcal{U}$ such that each diffeomorphism in $\mathcal{D}$ has nontrivial centralizer. It is natural to then ask if there are C^1 open sets of diffeomorphisms with trivial centralizer. We prove that on the n-torus for $2 \leq n \leq 4$ that there is a a C^1 open set of diffeomorphisms with trivial centralizer. (Received February 04, 2014)

1099-37-145 **Wen Huang** (wenh@mail.ustc.edu.cn), Department of Mathematics, University of Science and Technology of China, Hefei, Anhui 230026, Peoples Rep of China, and **Kening Lu*** (klu@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *Entropy, Chaos and Weak horseshoe for Infinite Dimensional Random Dynamical Systems.*

In this talk, we give an answer to the problem on the implication of positive entropy of a random dynamical system. We show that if a random dynamical system has a compact random invariant set such as random attractor with positive topological entropy, then the system is chaotic and has a weak horseshoe. As a corollary, we have the same conclusion for a deterministic dynamical system with a compact invariant set of positive topological entropy. The chaotic behavior we have here is due to the positive entropy, not the randomness of the system. (Received February 05, 2014)

1099-37-205 **Romain Aimino**, **Huyi Hu**, **Matthew Nicol**, **Andrew Török*** (torok@math.uh.edu) and **Sandro Vaienti**. *Polynomial loss of memory for maps of the interval with a neutral fixed point.*

We give an example of a sequential dynamical system consisting of intermittent-type maps which exhibits loss of memory (the counterpart, for non-stationary systems, of decay of correlations) at a polynomial rate. The maps may be chosen in any sequence from the given family. Decay of correlations for iterates of a single map from this family is (sharp) polynomial as well. (Received February 09, 2014)

1099-37-211 **Charles Christopher Johnson*** (ccjohns@clemson.edu), SC , and **Martin Schmoll**. *Eigenfoliations of half-translation tori and their universal covers.*

Universal covers of half-translation tori, called Panov planes, admit interesting directional dynamics. In particular, the eigendirections of an affine pseudo-Anosov diffeomorphism on the torus give rise to directions on the Panov plane whose foliations are either minimal or confined to an infinite strip. Furthermore, these two cases can be distinguished by the original pseudo-Anosov's action in the torus' first homology group.

In this talk we will present results relating to eigendirection dynamics on Panov planes, and also describe how Panov planes are related to the periodic Ehrenfest wind-tree model. This relationship opens the door to making statements about billiards in the wind-tree by studying the corresponding Panov planes, a topic which is still in its infancy. (Received February 09, 2014)

1099-37-224 **Joshua Bowman*** (joshua.bowman@gmail.com), Department of Mathematics and Statistics, Clark Science Center, Smith College, Northampton, MA 01063. *Dynamics on Homothety Surfaces.* Preliminary report.

A homothety surface may be constructed from a collection of Euclidean polygons in the plane by identifying pairs of edges via *homotheties*, which are compositions of translations and scaling. Many dynamical questions that have been well-studied in the case of translation surfaces remain unanswered in the case of homothety surfaces. I will describe work done at Smith College with student research groups to explore linear flow on homothety surfaces. This is joint work with Leah Balay-Wilson, Katherine Koch, Jasmine Osorio, Katherine Phillips, and Judy Wang. (Received February 09, 2014)

1099-37-249 **William Yessen*** (yessen@rice.edu). *The Newhouse Phenomenon in the Fibonacci Trace Map.*

The Fibonacci trace map (FTM) is a conservative polynomial map of degree two acting diffeomorphically on the three-dimensional Euclidean (real or complex) space. This map is related to a number of problems in physics, geometry, algebra and dynamical systems. It turns out that the FTM preserves a family of algebraic surfaces, which are the level surfaces of a polynomial function, called the Fricke-Vogt invariant. For some values of the Fricke-Vogt invariant, the corresponding surfaces have a compact component in the form of a topological sphere, also preserved by the FTM. We show that the FTM, when restricted to the compact components of the Fricke-Vogt invariant, is a conservative map exhibiting the Newhouse phenomenon. We discuss the implications of our findings. In particular, the FTM mirrors all the essential properties of the well known Taylor-Chirikov standard map and provides an example of a simple conservative map with nontrivial dynamics. We shall also present a number of open problems.

This is joint work with Anton Gorodetski. (Received February 10, 2014)

1099-37-260 **Jacopo De Simoi*** (jacopods@math.utoronto.ca), Department of Mathematics, University of Toronto, 40 St George St, Toronto, Ontario M5S 2E4, Canada. *Dynamics of piecewise smooth Fermi–Ulam models.*

Fermi–Ulam models are simple one-and-a-half degree of freedom mechanical systems which describe the dynamics of a ball bouncing freely between two oscillating walls. KAM theory implies, if the motion of the walls is sufficiently smooth, existence of invariant tori which prevent any form of diffusion to high energies. In a joint ongoing project with D. Dolgopyat we describe the dynamics of such systems assuming only piecewise smoothness of the wall motions. We are able to give an essentially complete description of the high energy dynamics which turns out to be either hyperbolic (i.e. diffusive) or dominated by elliptic islands. Time permitting I will also explain some work in progress regarding so-called dispersing Fermi–Ulam models and our strategy to attack the problem of ergodicity of this and related models. (Received February 10, 2014)

1099-37-311 **Yuki Takahashi*** (takahasy@uci.edu), Department of Mathematics, University of California, Irvine, CA 92697. *Products of Cantor sets and Spectral Properties of Labyrinth Model.* Preliminary report.

We prove that the product of two Cantor sets of large thickness is an interval in the case when one of them contains the origin. We apply this result to the Labyrinth model of a two-dimensional quasicrystal, where the spectrum is known to be the product of two Cantor sets, and show that the spectrum becomes an interval for small values of the coupling constant. We also consider the density of states measure of the Labyrinth model, and show that it is absolutely continuous with respect the Lebesgue measure for most values of coupling constants. (Received February 10, 2014)

1099-37-320 **Scott Northrup*** (snorthru@math.uci.edu). *A Very Brief History on Arithmetic Sums of Cantor Sets.*

Dynamically defined Cantor sets on the Real line play an important role in Dynamical Systems and some problems in Number Theory. A key question regarding dynamically defined Cantor sets is when when the arithmetic sum of these sets will contain an interval; Palis conjectured that the sum will contain an interval when the sum of their Hausdorff dimensions is greater than one. In this talk we will discuss results related to Palis's conjecture, including a new result from the speaker and Gorodetski regarding sums of affine Cantor sets. (Received February 10, 2014)

1099-37-406 **Clement Boateng Ampadu*** (drampadu@hotmail.com), 31 Carrolton Road, Boston, MA 02132. *Cone G-Metric Spaces with w-distance.*

Huang Long-Guang, Zhang Xian [Cone metric spaces and fixed point theorems of contractive mapping, J. Math. Appl., 332(2007) 1468-1476] introduced the concept of cone metric spaces. On the other hand the concept of a w-distance was introduced by Osama Kada, Tomonari Suzuki, and Wataru Takahashi [Nonconvex minimization theorems and fixed point theorems in complete metric spaces, Math. Japonica, 44 (1996) 381-591], and Naoki Shioji, Tomonari Suzuki, and Wataru Takahashi[Contractive mappings, Kannan mappings and metric completeness, Bull. Amer. Math. Soc. 10(1998) 3117-3124]

In this talk a notion of cone G-metric spaces with w-distance is introduced, and the proof of some Banach type fixed point theorems are sketched. (Received February 12, 2014)

40 ► Sequences, series, summability

1099-40-106 **Stephen A. Fulling** and **Yunyun Yang*** (yyang18@math.lsu.edu). *Some subtleties in the relationships among heat kernel invariants, eigenvalue distributions, and quantum vacuum energy.*

Let $-H$ be the Laplacian on scalar functions in a compact region in $\mathbf{R^3}$ with smooth Dirichlet boundary; define the kernel traces $K(t) = \operatorname{Tr} e^{-tH}$ and $T(t) = \operatorname{Tr} e^{-t\sqrt{H}}$ and the eigenvalue counting function $N(\omega^2)$. Loosely speaking, the small-t asymptotics of K and T are in close correspondence with the averaged large-ω asymptotics of N, but some confusing subtleties exist. (1) Nonnegative integer powers of t in the expansion of K give rise to terms $\delta^{(n)}(\omega^2)$ in the *moment asymptotic expansion* of $dN/d(\omega^2)$ as a distribution. (2) The expansions of T and $dN/d\omega$ contain additional, nonlocal spectral invariants, related to Casimir energy in quantum field theory. (3) Because of an algebraic accident, the term of order t^{-1} in T vanishes; we clear up some confusion and controversy in the physics literature over the significance of this fact. (Received February 02, 2014)

41 ► Approximations and expansions

1099-41-226 **Michael B. Wakin*** (mwakin@mines.edu), EECS Department, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401. *Applications of Discrete Prolate Spheroidal Wave Functions in Sparse Recovery Problems.*

The discrete prolate spheroidal wave functions (DPSWFs) and discrete prolate spheroidal sequences (DPSSs) studied by Slepian et al. are remarkable for their time/frequency concentration properties. In this talk we highlight two modern applications of these functions in regularizing ill-posed inverse problems. First, we describe how DPSSs can be used to construct an efficient dictionary for reconstructing samples of sparse analog multiband signals from discrete compressive sensing measurements. Second, we describe how DPSWFs can be used in a new greedy algorithm for super-resolution, where given the low-frequency part of the spectrum of a sequence of impulses, the objective is to estimate their positions. This is joint work with Mark Davenport and Armin Eftekhari. (Received February 09, 2014)

1099-41-364 **Jacob S Christiansen*** (stordal@maths.lth.se), Lund University, Lund, Sweden. *Polynomial asymptotics.* Preliminary report.

In the talk, I'll discuss different types of asymptotics for orthogonal polynomials (on the real line). The approach relies on the underlying difference equation. Among other things, the role of the Szego condition will be discussed. (Received February 11, 2014)

42 ► Fourier analysis

1099-42-38 **Indranil SenGupta*** (indranil.sengupta@ndsu.edu), Department of Mathematics, NDSU Dept # 2750, Minard Hall 408E12, Fargo, ND 58108-6050. *Radial concentration problem using Radon transform.* Preliminary report.

The concentration problem of maximizing signal strength of bandlimited and timelimited nature is important in communication theory. In this presentation we consider a different type of concentration problem for the bandlimited signals in a particular direction. This types of problem has applications in geophysics. Basic theoretical properties and numerical algorithms for solution and convergence theorems will be proved. (Received January 10, 2014)

1099-42-52 **Francesco Di Plinio** (diplinio@mat.uniroma2.it) and **Andrei K. Lerner*** (lernera@math.biu.ac.il). *On weighted norm inequalities for the Carleson operator.*

We discuss a recent result establishing weighted $L^p(w)$ bounds for the Carleson operator in terms of the A_q constants $[w]_{A_q}$ for $1 \le q \le p$. In particular, in the case $1 \le q < p$ these bounds are linear in $[w]_{A_q}$, exactly as for the Hilbert transform. In the case $q = p$ the sharpness is related to certain conjectures about the behavior of Fourier series near L^1. (Received January 19, 2014)

1099-42-59 **Daewon Chung*** (chdaewon@inha.ac.kr), Department of Mathematics, Inha University, Incheon, South Korea, and **Oleksandra Beznosova**, **Jean Carlo Moraes** and **Maria Cristina Pereyra**. *On a two weight estimate for the dyadic operators.* Preliminary report.

In this talk, sufficient conditions of a pair of weights (u, v) so that the dyadic operators (the paraproduct, the square function, the Martingale transform, and the Hilbert transform) are bounded from $L^2(u)$ into $L^2(v)$ will be provided. Using these conditions, we discuss some relations between the two weight inequality of the Maximal function and the dyadic operators. (Received January 22, 2014)

1099-42-64 **Arpad Benyi***, Department of Mathematics, 516 High St, Bellingham, WA 98225, and **Tadahiro Oh** and **Oana Pocovnicu**. *Probabilistic Strichartz estimates and applications.*

We introduce a randomization of a function on $\mathbb{R}^d$ that is naturally associated to the Wiener decomposition and, intrinsically, to the modulation spaces. This Wiener randomization leads to an improvement of the Strichartz estimates for the Schrödinger equation, which, in turn, yields almost sure well-posedness results for the nonlinear Schrödinger equation (NLS). As an example, we indicate why the energy-critical cubic NLS on $\mathbb{R}^4$ is almost surely locally well-posed with respect to randomized initial data below the energy space. (Received January 23, 2014)

1099-42-70 **Yi Hu*** (yihu@georgiasouthern.edu), Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30460, and **Xiaochun Li**. *Discrete Fourier restriction associated with some dispersive equations on torus.*

When solving the local wellposedness of nonlinear Schrödinger equations (NLS), one needs the Strichartz estimate to control the nonlinear term. When we consider the NLS on torus, however, the exact periodic analogue of the continuous Strichartz estimate fails, which forces us to find some new inequalities of the same type. In this talk, some results for this type of restriction as well as some other related topics will be presented, including similar results for KdV equations on torus. (Received January 26, 2014)

1099-42-91 **Steve Hofmann*** (hofmanns@missouri.edu), Dept. of Mathematics, University of Missouri, Columbia, MO 65211. *Uniform Rectifiability and Elliptic Equations.* Preliminary report.

We discuss recent progress on an ongoing project to understand the relationship between estimates for harmonic functions (or more generally, solutions of divergence form elliptic equations) in an open set $\Omega \subset \mathbb{R}^d$, and quantitative rectifiability properties of $\partial\Omega$. (Received January 28, 2014)

1099-42-97 **James Michael Wilson*** (jmwilson@uvm.edu), Department of Mathematics, 16 Colchester Avenue, University of Vermont, Burlington, VT 05405. *Invariance of almost-orthogonal systems between A_∞ weighted spaces.*

We present recent results on the invariance of almost-orthogonal systems across A_∞-weighted spaces $L^2(w)$. For systems of functions adapted to the dyadic cubes, and satisfying mild smoothness and decay conditions, the functions do not change (except for trivial normalizing factors) when moving between ordinary L^2 and $L^2(w)$ ($w \in A_\infty$). We will describe the extent to which having $w \in A_\infty$ is necessary for this "invariance". Time permitting, we will sketch some related results on wavelet representations of Calderón-Zygmund singular integral operators, showing that, in a natural sense, such operators are stable when their representing kernels suffer small errors in translation and dilation. (Received January 30, 2014)

1099-42-99 **Lesley A. Ward*** (lesley.ward@unisa.edu.au). *Connections between Continuous and Dyadic Function Spaces on Spaces of Homogeneous Type.*

The function spaces of harmonic analysis, such as BMO, VMO, H^1, and the classes of A_p weights and reverse-Hölder weights, come in both continuous and dyadic flavours. We know of two types of connections between the continuous and dyadic versions of such a space: first, averaging procedures take us from the dyadic to the continuous version, and second, the continuous version can be written as an intersection (for BMO, VMO, A_p and RH_p), or a sum (for H^1), of finitely many dyadic versions. We present recent work extending these connections from the Euclidean world to the setting of spaces of homogeneous type (X, d, μ) in the sense of Coifman and Weiss, in both the one-parameter and product situations. Our results build on earlier work by Garnett, Jones, Pipher, Ward, Treil, Xiao, and Li. This is joint work with P. Chen, A. Kairema, J. Li, and M.C. Pereyra. See also the related talk in this special session by J. Li. (Received January 30, 2014)

1099-42-127 **Jodi Herbert** and **Virginia Naibo***, Kansas State University, Department of Mathematics, Manhattan, KS 66506. *Bilinear pseudodifferential operators: boundedness properties and regularity of their symbols.*

The notion of bilinear pseudodifferential operators motivated by the study of commutators, paraproducts and fractional Leibniz-type rules will be introduced. New results in relation to their boundedness properties in Lebesgue spaces will be presented as well as a discussion on minimal regularity conditions for their symbols that imply such properties. (Received February 04, 2014)

1099-42-130 **Stephen D. Casey*** (scasey.american@gmail.com), Math/Stat Dept., American University, 4400 Massachusetts Ave., NW, Washington, DC 20016-8050. *The Analysis of Periodic Point Processes.* Preliminary report.

Our talk addresses the problems of extracting information from periodic point processes. These problems arise in numerous situations, from radar PRI analysis to bit synchronization. We divide our analysis into two cases – periodic processes created by a single source, and those processes created by several sources. We wish to extract the fundamental period of the generators, and, in the second case, to deinterleave the processes.

We first present very efficient algorithm for extracting the fundamental period from a set of sparse and noisy observations of a single source periodic process. The procedure is computationally straightforward and converges quickly. Its use is justified by a probabilistic interpretation of the Riemann zeta function. We then build upon this procedure to deinterleave and then analyze data from multiple source periodic processes. This relies both on the the probabilistic interpretation of the Riemann zeta function, the equidistribution theorem of Weyl, and Wiener's periodogram. We close by demonstrating simulations of the procedures, which were developed jointly by the speaker and Kevin Duke of American University. (Received February 04, 2014)

1099-42-132 **Doug Cochran*** (cochran@asu.edu), Arizona State University, PO Box 855706, Tempe, AZ 85287-5706. *Phase Space Analysis for Finite Abelian Groups.*

This presentation will begin with a survey of basic phase space analysis for finite groups, focusing on two particular cases: (1) cyclic groups of odd order, and (2) groups of the form G^n where G is a cyclic group of odd prime order. After establishing the necessary foundations, connections between important sequences in communications engineering and maximal isotropic subgroups of phase space for these groups will be discussed. This is joint work with Stephen Howard and Bill Moran. (Received February 04, 2014)

1099-42-138 **Wilfredo O Urbina*** (wurbinaromero@roosevelt.edu), Dep. of Mathematics and Actuarial Sciences, Roosevelt University 430 S Michigan Ave, Chicago, IL 60626, and **Eduard Navas** (eduard.navas@gmail.com), Universidad Experimental Francisco de Miranda, Punto Fijo, Venezuela. *A transference result of the Lp continuity from Jacobi Riesz transform to the Gaussian and Laguerre Riesz transforms.*

In this work we develop a transference method to obtain the Gaussian-Riesz transform's Lp-continuity and the Laguerre-Riesz transform's Lp-continuity from the Lp-continuity of the Jacobi-Riesz transform, in dimension one, using the well known asymptotic relations between Jacobi polynomials and Hermite and Laguerre polynomials (Received February 05, 2014)

1099-42-141 **Michael T Lacey*** (lacey@math.gatech.edu), School of Math, 0160, Georgia Institute of Technology, Atlanta, GA 30030. *Cora Sadosky infulence on my work.*

I will survey some of my work that were heavily influenced by Cora Sadosky. These are principally the characterization of product BMO by commutators, and a characterization of two weight inequalities for the Hilbert and Cauchy operators. These themes remain active, and have several contributors in recent years. (Received February 05, 2014)

1099-42-144 **Paul Hagelstein*** (paul_hagelstein@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798. *Solyanik Estimates in Harmonic Analysis.*

Let $\mathcal{B}$ denote a collection of measurable sets in $\mathbb{R}^n$, and define the corresponding maximal operator $M_{\mathcal{B}}$ by

$$M_{\mathcal{B}}f(x) = \sup_{x\in R\in\mathcal{B}} \frac{1}{|R|}\int_R |f| \,.$$

For $0 < \alpha < 1$, let $C_{\mathcal{B}}(\alpha)$ denote the sharp Tauberian constant of $\mathcal{B}$ with respect to α, defined by

$$C_{\mathcal{B}}(\alpha) = \sup_{E\subset\mathbb{R}^n : 0<|E|<\infty} \frac{1}{|E|}|\{x : M_{\mathcal{B}}\chi_E(x) > \alpha\}| \,.$$

If $\lim_{\alpha\to 1^-} C_{\mathcal{B}}(\alpha) = 1$, we say that the maximal operator $M_{\mathcal{B}}$ satisfies a *Solyanik estimate*. In this talk, we will discuss conditions on a basis $\mathcal{B}$ that imply that $M_{\mathcal{B}}$ satisfies a Solyanik estimate. Questions regarding *sharp* Solyanik estimates will also be considered, and open problems regarding Solyanik estimates will be provided. The results presented will be recent ones joint with Oleksandra Beznosova and Ioannis Parissis. (Received February 05, 2014)

1099-42-153 **Loukas Grafakos**, **Diego Maldonado** and **Virginia Naibo*** (vnaibo@math.ksu.edu). *A remark on an endpoint Kato-Ponce inequality.*

Kato-Ponce inequalities, also known as fractional Leibniz rules, play an important role in the study of solutions to partial differential equations such as Euler, Navier-Stokes and Korteweg-de Vries. Bilinear estimates intended as a step towards an L^∞-endpoint fractional Leibniz rule will be introduced. In particular, a bilinear version of the classical Gagliardo-Nirenberg interpolation inequalities for a product of functions will be presented. (Received February 06, 2014)

1099-42-190 **Stefanie Petermichl**, **Kelly Bickel** and **Brett D. Wick*** (wick@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332-0160. *Bounds for the Hilbert Transform with Matrix Muckenhoupt Weights.*

Let W denote a matrix A_2 weight. In this talk we will implement the scalar proof for the square function to deduce related results for vector-valued functions on $L^2(\mathbb{R},\mathbb{C}^d)$. These results are then used to study the boundedness of the Hilbert transform and Haar multipliers on $L^2(\mathbb{R},\mathbb{C}^d)$. In particular, we prove that:

$$\begin{aligned}\|Hf\|_{L^2(W)} &\lesssim [W]_{A_2}^{\frac{3}{2}}\log{[W]_{A_2}}\|f\|_{L^2(W)}\\ \|T_\sigma f\|_{L^2(W)} &\lesssim [W]_{A_2}^{\frac{3}{2}}\log{[W]_{A_2}}\,\|\sigma\|_\infty\,\|f\|_{L^2(W)}.\end{aligned}$$

(Received February 08, 2014)

1099-42-218 **Li-An Daniel Wang*** (daniel.wang@trincoll.edu), Department of Mathematics, 300 Summit Street, Hartford, CT 06106, and **David Cruz-Uribe** (david.cruzuribe@trincoll.edu), Department of Mathematics, 300 Summit Street, Hartford, CT 06106. *Weighted norm extrapolation in variable Lebesgue spaces.*

We apply the theory of weighted norm extrapolation techniques to the setting of unweighted and weighted variable Lebesgue spaces, extending known results in the classical weighted setting. (Received February 09, 2014)

1099-42-219 **Ji Li*** (ji.li@mq.edu.au), Department of Mathematics, Macquarie University, North Ryde, NSW 2109, Australia. *Hardy space theory on spaces of homogeneous type in the sense of Coifman and Weiss via orthonormal wavelet bases.*

Spaces of homogeneous type (X,d,μ) were introduced by Coifman and Weiss in the early 1970s. However, for some applications, additional assumptions were imposed, because the quasi-metric d may have no regularity and quasi-metric balls may not be open.

Using the remarkable orthonormal wavelet basis constructed recently by Auscher and Hytönen, we establish the theory of product Hardy spaces on spaces $\widetilde{X}=X_1\times X_2\times\cdots\times X_n$, where each factor X_i is a space of homogeneous type in the sense of Coifman and Weiss. The main tool we develop is the Littlewood–Paley theory on $\widetilde{X}$, which in turn is a consequence of a corresponding theory on each factor space.

We make no additional assumptions on the quasi-metrics or the doubling measures, and thus we extend to the full generality of product spaces of homogeneous type the aspects of both one-parameter and multiparameter theory involving the Littlewood–Paley theory and function spaces. Moreover, we expect our methods to be a powerful tool for developing function spaces and the boundedness of singular integrals on spaces of homogeneous type. See also the related talk by Lesley Ward in this session.

This is joint work with Yongsheng Han and Lesley Ward. (Received February 09, 2014)

1099-42-240 **Gyorgy Gat*** (gatgy@nyf.hu), P.O.Box 166., Nyiregyhaza, H-4400, Hungary. *Almost everywhere summability of Walsh-Fourier series.*

Let x be an element of the unit interval $I:=[0,1)$. The $\mathbb{N}\ni n$th Walsh function is

$$\omega_n(x):=(-1)^{\sum_{k=0}^\infty n_kx_k}\quad (n=\sum_{k=0}^\infty k_i2^i,\ x=\sum_{k=0}^\infty \frac{x_i}{2^{i+1}}).$$

The Walsh-Fourier coefficients, the n-th partial sum of the Fourier series, the n-th $(C,1)$ mean of $f\in L^1(I)$:

$$\hat f(n):=\int_I f(x)\omega_n(x)dx,\quad S_nf:=\sum_{k=0}^{n-1}\hat f(k)\omega_k,\quad \sigma_nf:=\frac{1}{n}\sum_{k=0}^{n-1}S_kf.$$

It is of main interest that how to reconstruct a function from the partial sums of its Walsh-Fourier series. In 1955 Fine proved that for each integrable function we have the almost everywhere convergence of Fejér means $\sigma_nf\to f$. In the talk we give a brief résumé of the recent results with respect to summability of Walsh-Fourier series of one and two dimensional functions. Among others, we talk about the convergence properties of Marczinkiewicz means and its generalizations. The Marcinkiewicz means are defined as

$$t_nf(x):=\frac{1}{n}\sum_{k=0}^{n-1}S_{k,k}f(x).$$

(Received February 10, 2014)

1099-42-243 **Rodolfo Toledo*** (toledo@nyf.hu), P.O.Box 166., Nyiregyhaza, Hungary. *Boundedness in L^p-norm of operators based on representative product systems.*

A modern point of view in Fourier analysis is to consider orthonormal systems defined on locally compact groups. Therefore, the study of Walsh series should be performed by representing the Walsh functions as the characters of the dyadic group, i.e., the complete product of the discrete cyclic group of order 2 with the product of topologies and measures. Vilenkin in 1947 generalized this structure studying the complete product of arbitrary cyclic groups.

Toledo and Gát generalized the Vilenkin systems studying the complete direct product of arbitrary finite groups, even though they are non-abelian groups. Product systems formed by normalized coordinate functions of continuous irreducible unitary representations of finite groups are called representative product systems. In Fourier analysis several properties and results differ considerably if they are defined on non-abelian groups.

The aim of my talk is to summarize some results with respect to the boundedness of partial sums of Fourier series and Cesàro means in L^p-norm based on different representative product systems. (Received February 10, 2014)

1099-42-254 **Anna Kairema*** (anna.kairema@helsinki.fi), University of Helsinki, Finland. *Weighted norm inequalities for fractional integrals in a space of homogeneous type: the construction of counter examples to show the sharpness of the result.*

The sharp relationship between the operator norms of fractional integral operators, acting on weighted Lebesgue spaces, and the constant of the weights, was obtained by Lacey, Moen, Pérez & Torres (2010). In the Euclidean space, to show the sharpness of the estimate, one constructs counter examples using suitable power functions.

In this talk, we discuss the generalization of this result into a space of homogeneous type. While the broad outlines of the proof follow the Euclidean case, the rather straightforward example in the Euclidean case, involving functions of the form $|x|^\alpha$, is not available per se. We show, however, that any space of homogeneous type with infinitely many points supports functions which, at least locally, behave sufficiently similarly to the basic power functions $|x|^{-\alpha}$ on the Euclidean space. We believe that such functions may provide counter examples in other situations, too. (Received February 10, 2014)

1099-42-262 **Joshua Isralowitz*** (jisralowitz@albany.edu), **Hyun Kyoung Kwon** (hkwon5@as.ua.edu) and **Sandra Pott** (sandra@maths.lth.se). *Matrix weighted norm inequalities for matrix kernelled CZOs and related operators.*

Given a matrix A_p weight W for $1 < p < \infty$, we will provide very natural characterizations of the boundedness of matrix symbolled dyadic paraproducts and Haar multipliers on $L^p(W)$ in terms of their symbols. Furthermore, we will briefly discuss the $L^p(W)$ boundedness of matrix kernelled Calderón-Zygmund operators. (Received February 10, 2014)

1099-42-276 **Michael W Frazier*** (frazier@math.utk.edu), 227 Ayres Hall, 1403 Circle Drive, Knoxville, TN 379961320, and **Svetlana Roudenko**. *Traces of Weighted Sobolev and Potential Spaces.* Preliminary report.

Let u be an A_p weight on $\mathbb{R}^{n+1}$ and v a doubling weight on $\mathbb{R}^n$. Define the trace operator $Trf(x') = f(x', 0)$, where $x' \in \mathbb{R}^n$ and f is a function on $\mathbb{R}^{n+1}$. If $\alpha > \frac{1}{p} + n\left(\frac{1}{p} - 1\right)_+ + \frac{\beta - n}{p}$, where β is the doubling exponent of v, then the trace operator is bounded from the weighted Bessel potential space $W^{\alpha,p}(u)$ (which coincides with the weighted Sobolev space $W^{k,p}(u)$ if $\alpha = k \in \mathbb{N}$) into the weighted Besov space $B_p^{\alpha-1/p,\, p}(v)$ if and only if there exists $C > 0$ such that

$$\frac{1}{|I|}\int_I v\, dx' \le C \frac{1}{|Q(I)|}\int_{Q(I)} v(x)\, dx$$

for all dyadic cubes $I \subseteq \mathbb{R}^n$ with side length $\ell(I) \le 1$, where $Q(I) = I \times [0, \ell(I)]$. If u and v satisfy the converse inequality, then there exists a continuous linear map $Ext : B_p^{\alpha-1/p,\, p}(v) \to W^{\alpha,p}(u)$. If both inequalities hold, $Tr \circ Ext$ is the identity on $B_p^{\alpha-1/p,\, p}(u)$. More generally, the results hold with $W^{\alpha,p}(u)$ replaced by the Triebel-Lizorkin space $F_p^{\alpha,\, q}(u)$ for any $0 < q \le \infty$. (Received February 10, 2014)

1099-42-281 **Betsy Stovall*** (stovall@math.wisc.edu). *Uniform estimates for Fourier restriction to polynomial curves.*

We will outline a proof of optimal, uniform estimates for the restriction of the Fourier transform to polynomial curves equipped with affine arclength measure. We will also discuss a little of the history of the problem and explain how estimates with affine arclength measure can be used to recover the optimal estimates with Euclidean arclength or other natural measures. (Received February 10, 2014)

1099-42-292 **Arpad Benyi**, **Wendolin Damian**, **Kabe Moen** and **Rodolfo H. Torres*** (torres@math.ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045. *COMPACT BILINEAR COMMUTATORS: THE WEIGHTED CASE.*

We will review several facts about bilinear commutators and present some new compactness results in the context of weighted Lebesgue spaces. (Received February 10, 2014)

1099-42-297 **Nicholas Boros*** (nboros@olivet.edu), Olivet Nazarene University, Department of Mathematics, One University Ave., Bourbonnais, IL 60914. *Matrix Weights, Littlewood Paley Inequalities and the Riesz Transform.*

We will discuss weighted estimates for the squares of the Riesz transforms $R_1^2, \ldots, R_m^2$ on $L^2(W)$ where $W \in \mathbb{C}^{d\times d}$ is an A_2 weight. We will show that if the "Heat A_2 characteristic" of W is sufficiently close to 1 then there is a dimensional constant $c > 0$ such that

$$\|R_i^2\|_{2,W} \leq 1 + c\sqrt{[W]_{A_2^h} - 1},$$

for all $i = 1, \ldots, m$. This is accomplished by proving a Littlewood–Paley estimate with the use of the Bellman function technique. This is a joint result with Nikolaos Pattakos. (Received February 11, 2014)

1099-42-308 **Benjamin David Robinson*** (jamin.robinson@gmail.com), 815 N 52nd St, Apt 1015, Phoenix, AZ 85008, **William Moran** (wmoran@unimelb.edu.au), Level 4, 204 Lygon Street, Carlton, VIC 3053, Australia, and **Douglas Cochran** (cochran@asu.edu), Electrical Engineering Dept, P.O. Box 875706, Tempe, AZ 85287. *Some new g-frames arising from the quasi-regular representation.* Preliminary report.

In Duffin and Schaeffer's original paper on frames, the authors determined multiple sets of conditions on sequences of characters $\ldots, \chi_{-1}, \chi_0, \chi_1, \chi_2, \ldots$ on $\mathbb{R}$ such that $\left\{\chi_j|_{[-1/2,1/2)}\right\}$ form a frame for $H = L^2[-1/2, 1/2)$. For one, if the character χ_j is identified with $\omega_j \in \mathbb{R}$, $\left\{\chi_j|_{[-1/2,1/2)}\right\}$ forms a frame for H if all the differences $|\omega_j - j|$ are less than M, for some appropriately chosen small number $M > 0$, a result which is virtually identical for $\mathbb{R}^n$. In this talk we discuss the analogous result for each of one or two other connected, locally compact Lie groups G (which will involve the so-called quasi-regular representation of G). That is, we give a condition on representations $\pi_1, \pi_2, \ldots$ on G such that $\{\pi_j\}$, suitably interpreted, forms a *g-frame* for a nontrivial Hilbert subspace H of $L^2(G)$. In particular this implies a condition on $\pi_1, \pi_2, \ldots$ such that $f \in H$ is uniquely determined by $\pi_1(f), \pi_2(f), \ldots$ (where $\pi(f)$ for $f \in H$ is defined to be the operator $\int_G f(x)\pi(x)\,dx$), which condition we believe to be new. (Received February 10, 2014)

1099-42-310 **Timur Akhunov*** (takhunov@z.rochester.edu), 820 Hylan Bldg, University of Rochester, Rochester, NY 14607, and **Cristian Rios**. *Hypoellipticity for a new class of infinitely degenerate elliptic operators.* Preliminary report.

Elliptic differential equations are a natural generalization of the Laplace equation and are among the most studied differential equations. From an analytical perspective one of the key properties for these equations is the regularity of their solutions. A classical result from the PDE theory is that for uniformly elliptic operators of second order (which at every fixed point resemble a laplacian in a uniform way), solutions are 2 derivatives smoother than data in most Hölder and Sobolev spaces.

The weakest form of this property, called *hypoellipticity*, when a smooth data leads to smooth solutions. For second order operators, the amount of gain may be less than 2 and in very degenerate cases the local form of this property fails. In a landmark 1964 paper Lars Hörmander established a bracket criterion for degenerate elliptic operators that gain a positive number of derivatives. In this talk, I will discuss a new class of examples of degenerate elliptic operators that gain no derivatives. This work generalizes previous work of Fedii, Morimoto and J.J. Kohn. (Received February 10, 2014)

1099-42-328 **Der-Chen Chang** and **Galia Dafni*** (galia.dafni@concordia.ca), Department of Mathematics and Statistics, 1455 de Maisonneuve Blvd. West, Montreal, Quebec H3G1M8, Canada, and **Hong Yue**. *Nonhomogeneous weighted div-curl lemmas.* Preliminary report.

We prove extensions of the div-curl lemma of Coifman, Lions, Meyer and Semmes to weighted Hardy spaces. This is a continuation of our previous work, as well as of joint work of the first two authors with C. Sadosky, in the context of local Hardy spaces and Hardy spaces on domains. (Received February 10, 2014)

1099-42-352 **Oleksandra V Beznosova*** (alexbeznosova@yahoo.com), 62 Cottonwood st apt 6, Waco, TX 76706, and **Paul A Hagelstein**. *Continuity of halo functions associated to homothecy invariant density bases.* Preliminary report.

We will present our recent result on the continuity of the halo function. In particular, we show that the halo function associated to any homothecy invariant density basis is a continuous function on $(1, \infty)$ and give an example of a homothecy invariant density basis such that the associated halo function is not continuous at 1. (Received February 11, 2014)

1099-42-370 **Shahaf Nitzan*** (shahaf.n.h@gmail.com) and **Gady Kozma**. *Combining Riesz bases in $\mathbb{R}^d$.*

In a previous work, Joint with Gady Kozma, we established that every finite union of intervals in $\mathbb{R}$ admits a Riesz basis of exponentials. In this talk we will discuss an extension of this result to higher dimensions: In $\mathbb{R}^d$ every finite union of rectangles, with edges parallel to the exes, admits a Riesz basis of exponentials. (Received February 11, 2014)

1099-42-375 **Leonid Slavin*** (leonid.slavin@uc.edu). *Best constants for a family of Carleson sequences.*

For a non-negative function Φ on $[1, \infty)$, a dyadic A_2-weight w, and each dyadic interval J let

$$c_J^\Phi := |J|\, \Phi\Big(\langle w\rangle_J \langle w^{-1}\rangle_J\Big) \left[\frac{(\Delta_J w)^2}{\langle w\rangle_J^2} + \frac{(\Delta_J w^{-1})^2}{\langle w^{-1}\rangle_J^2}\right]$$

where $\langle\cdot\rangle_J$ is the average over J; $\Delta_J(\cdot) = \langle\cdot\rangle_{J^-} - \langle\cdot\rangle_{J^+}$, and $J^\pm$ are the two halves of J.

Under mild monotonicity assumptions on Φ and Φ' we find the sharp functions k_Φ and K_Φ in the inequality

$$k_\Phi\big([w]_{A_2}\big) \le \sup_{I\in D} \frac{1}{|I|} \sum_{J\in D(I)} c_J^\Phi \le K_\Phi\big([w]_{A_2}\big).$$

The upper estimate quantifies the Carleson embedding properties of the sequence $\{c_J^\Phi\}$, while the two estimates combined give a range of equivalent definitions of A_2. The proof uses Bellman functions of various structure – some are solutions of PDE, some are nowhere differentiable – and presents optimizing sequences of weights. The results obtained make precise and significantly generalize earlier estimates by Beznosova, Wittwer, and others. (Received February 11, 2014)

1099-42-382 **Dmitriy Bilyk*** (dbilyk@math.umn.edu). *Simultaneous Diophantine approximations and lacunary Fourier series.*

We consider the following one-dimensional problem: given a set Ω on the real line, find a point α such that all the differences $\alpha - \theta$, $\theta \in \Omega$, are badly approximable by rationals. How do the arising Diophantine estimates depend on the geometry of the set Ω? We provide several measure-theoretic approaches to this question which yield different results depending on the entropy properties of Ω. Besides our original motivation for this question, which comes from geometric discrepancy theory, the problem, as well as methods, exhibit connections to some questions in Fourier analysis and combinatorics, e.g. chromatic numbers and the behavior of lacunary Fourier series. This is joint work with X. Ma, J. Pipher, C. Spencer. (Received February 11, 2014)

1099-42-386 **Eric T. Sawyer** (sawyer@mcmaster.ca), Department of Mathematics and Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, **Chun-Yen Shen** (chunyshen@gmail.com), Department of Mathematics, National Central University, Chungli, Taiwan, and **Ignacio Uriarte-Tuero*** (ignacio@math.msu.edu), Department of Mathematics, Michigan State University, 619 Red Cedar Rd., Wells Hall, East Lansing, MI 48824. *Two weight norm inequalities for singular and fractional integral operators in R^n.* Preliminary report.

I will report on recent advances on the topic, related to proofs of T1 type theorems with side conditions and related counterexamples. Joint work with Eric Sawyer and Chun-Yen Shen. This talk is very related to Eric Sawyer's talk on the same topic. (Received February 11, 2014)

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1099-43-35 **Theresa C. Anderson*** (theresa_anderson@brown.edu) and **Wendolin Damian**. *Sharp mixed bounds of many flavors: new techniques and extensions.*

The recent proof of the A_2 theorem (sharp weighted bound for Calderón-Zygmund operators) has led to much investigation in sharp mixed bounds for operators and commutators, that is, a sharp weighted bound that is a product of at least two different A_p weight constants. The reason why these are sought after is that the product will be strictly smaller than the original one-constant bound. In this talk, we will highlight some of these recent results, proved using the new techniques of Lerner, in spaces of homogeneous type. We have sharp results for both operators and commutators in a variety of contexts. This is joint work with Wendolín Damián (Received January 09, 2014)

1099-43-58 **Jens Gerlach Christensen*** (jchristensen@colgate.edu), **Karlheinz Gröchenig** (karlheinz.groechenig@univie.ac.at) and **Gestur Ólafsson** (olafsson@math.lsu.edu). *Representation theoretic approach to atomic decompositions of Bergman spaces on the unit ball.* Preliminary report.

We will present a representation theoretic approach to atomic decompositions of Bergman spaces on the unit ball. The representations in question are the discrete series representations of $SU(n,1)$, and sampling results on reproducing kernel Banach function spaces on this group provide atomic decompositions. This is joint work with Karlheinz Gröchenig and Gestur Ólafsson. (Received January 21, 2014)

1099-43-61 **Bertram M. Schreiber*** (bert@math.wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202. *Algebras of Multilinear Forms on Hypergroups.*

For locally compact hypergroups H_i, $i = 1, 2, \cdots, n$, let $CB(H_1, \cdots, H_n)$ denote the Banach space of completely bounded multilinear forms on $C_0(H_1) \times \cdots \times C_0(H_n)$, in the completely bounded norm. $CB(H_1, \cdots, H_n)$ can be given the structure of a Banach $*$-algebra under a multiplication and adjoint operation which agree with the convolution structure on the measure algebra $M(H_1 \times \cdots \times H_n)$. If the H_i are all abelian, $CB(H_1, \cdots, H_n)$ carries a naturally defined Fourier transform as functions on the space of semicharacters which generalizes the Fourier transform on hpergroup measure algebras. The construction of these Banach algebras will be outlined, and various other aspects of $CB(G_1, \cdots, G_n)$ will be described as time permits. This is joint work with Rupert Lasser. (Received January 23, 2014)

1099-43-266 **O Beznosova**, Baylor University, Department of Mathematics, One Bear Place #97328, Waco, TX 76798-7328, **J C Moraes***, Universidade Federal do Rio Grande do Sul, Instituto de Matemática, Av. Bento Gonçalves 9500 Prédio 43111, Porto Alegre, 91509-900, Brazil, and **M C Pereyra**, University of New Mexico, Department of Mathematics and Statistics, 1 University of New Mexico, Albuquerque, NM 87131-0001. *Sharp bounds for t-Haar multipliers on L^2.*

We show that if a weight $w \in C^d_{2t}$ and there is $q > 1$ such that $w^{2t} \in A^d_q$, then the L^2-norm of the t-Haar multiplier of complexity (m,n) associated to w depends on the square root of the C^d_{2t}-characteristic of w times the square root A^d_q-characteristic of w^{2t} times a constant that depends polynomially on the complexity. In particular, if $w \in C^d_{2t} \cap A^d_\infty$ then $w^{2t} \in A^d_q$ for some $q > 1$. (Received February 10, 2014)

1099-43-270 **Magali Folch-Gabayet***, folchgab@matem.unam.mx. *Weak bounds for oscillatory singular integrals.*

We consider singular integral operators on R given by convolution with a principal value distribution defined by integrating against oscillating kernels of the form eiR(x)/x where R(x) = P(x)/Q(x) is a general rational function with real coefficients. We establish weak-type (1, 1) bounds for such operators which are uniform in the coefficients, depending only on the degrees of P and Q.This is joint work with James Wright. (Received February 10, 2014)

1099-43-371 **Marius Junge*** (mjunge@illinois.edu), Department of Mathematocs, 1409 West Green Street, Urbana, IL 61801, and **Javier Parcet** and **Mei Tao**. *Riesz transforms-old and new.* Preliminary report.

In this joint work with Parcet and Mei, we will discuss Riesz transforms on discrete groups. Although the core of the method is based on Pisier's method, it is surprising that the theory of coycles on groups provides new insides on classical Fourier multipliers and new results for Schur-Fourier multipliers. In fact almost optimal Besov conditions for Fourier multipliers can be obtained as a combination of algebraic tools, Khintchine inequalities and the classical Hilbert transform via the Coifmann-Weiss transference method. (Received February 11, 2014)

44 ► Integral transforms, operational calculus

1099-44-80 **Ibrahim A. Salehbhai*** (ibrahimmaths@gmail.com), Department of Mathematics, V.N. South Gujarat University, Udhana Magdala Road, SURAT, GUJARAT 395007, India, and **M. G. TIMOL**. *On the solution of Nonlinear Fractional Differential equation.*

There has been a great deal of interest in fractional differential equations. These equations arise in mathematical physics and engineering sciences. The main objective of the present talk is to discuss the solution of the nonlinear fractional differential Equation using the method of Mellin transforms. Some special cases with graphs have been discussed. (Received January 28, 2014)

1099-44-129 **Jarod Hart*** (jarod.hart@wayne.edu), **Lucas Chaffee** (lucas.chaffee@gmail.com) and **Lucas Oliveira** (oliveiral1985@gmail.com). *Weight Extrapolation for Square Functions with Rough Kernels.*

In this joint work with Lucas Chaffee and Lucas Oliveira, we use the weight extrapolation theory developed by Rubio de Francia, Grafakos and Martell, and Duoandikoetxea to prove Lebesgue space bounds for multilinear square functions with rough kernels. Classically Lebesgue space bounds for square functions are proved by first obtaining an L^2 estimate and using vector-valued Calderón-Zygmund theory to extend to L^p estimates for $p \neq 2$; although this approach requires certain regularity estimates for the kernels. We remove these kernel regularity assumptions and prove Muckenhoupt weighted Lebesgue space estimates for the associated square function operators. In particular, this approach yields multilinear square function bounds on Lebesgue spaces with indices smaller than 1. We also introduce a strong Carleson condition for the square function operators that is sufficient for weighted Lebesgue space bounds. Furthermore, we show that when a square function is of convolution type, this strong Carleson condition is necessary and sufficient for Lebesgue space bounds. (Received February 04, 2014)

46 ► Functional analysis

1099-46-32 **Youssef N Raffoul*** (yraffoul1@udayton.edu), University of Dayton, Dayton, OH 45469-2316. *Boundedness And Exponential Stability In Highly Nonlinear Stochastic Differential Equations.*

Let $B(t) = (B_1(t), B_2(t), \ldots, B_m(t))^T$ be a m-dimensional standard Brownian motion defined on a complete probability space $(\Omega, \mathfrak{F}, \mathrm{P})$. Consider n-dimensional stochastic systems

$$dx(t) = f(x(t), t)dt + g(x(t), t)dB(t),\ t \geq 0, \tag{1}$$

with initial condition $x(t_0) = x_0 \in \mathbb{R}^n$, where $t_0 \geq 0$,
$x(t) = (x_1(t), x_2(t), \ldots, x_n(t))^T \in \mathbb{R}^n$, and $f : \mathbb{R}^n \times \mathbb{R}^+ \to \mathbb{R}^n$ and $g : \mathbb{R}^n \times \mathbb{R}^+ \to \mathbb{R}^{n \times m}$ are given nonlinear continuous functions.

It is known that if the functions f and g satisfy a general Lipschitz condition and linear growth condition, then all solutions of system (1) exist stochastically.

In this research, we use the method of Lyapunov functions to obtain sufficient conditions for stochastic boundedness and exponential asymptotic stability of system (1) without the above requirement on the functions f and g.

Our theorems will make significant contribution to the theory of stochastic differential equations differential equations when dealing with equations that might contain unbounded terms.

(Received December 29, 2013)

1099-46-49 **Ayse Guven*** (a.guven@qmul.ac.uk), Mile End Road, LONDON, E1 4NS. *an upper bound for the Hausdorff distance of the spectra of two trace class operators.*

In 1985, Elsner proved Hausdorff distance between the spectra of two $n \times n$ matrices A and B. We use a different approach to obtain an upper bound for the Hausdorff distance of the spectra of two $n \times n$ matrices A and B using computationally accessible expressions. We then extend it to the infinite dimensional setting such as Hausdorff distance of the spectra of two trace class operators. (Received January 17, 2014)

1099-46-128 **Henri Martikainen*** (henri.martikainen@helsinki.fi), Department of Mathematics and Statistics, University of Helsinki, P.O.B. 68, 00014 Helsinki, Uusimaa, Finland. *Local L^p testing conditions and general measures.*

Local Tb theorems with L^p type testing conditions have been studied widely in the case of the Lebesgue measure. Until very recently, local Tb theorems in the non-homogeneous case had only been proved assuming scale invariant

(L^∞ or BMO) testing conditions. In a joint work with M. Lacey we proved a non-homogeneous local Tb theorem with L^2 type testing conditions. The combination of non-scale-invariant testing conditions and general measures is a delicate issue. Our theorems are for square functions (vertical/conical) and for all Calderón–Zygmund operators. We shall discuss these results and, time permitting, extensions to L^p testing conditions (joint with M. Mourgoglou). (Received February 04, 2014)

1099-46-133 **Waleed K. Al-Rawashdeh*** (walrawashdeh@mtech.edu), Montana Tech, Department of Mathematical Sciences, 1300 West Park Street, Butte, MT 59701. *Composition Operators on Generalized Weighted Nevanlinna Class.*

Let φ be an analytic self-map of open unit disk $\mathbb{D}$. The operator given by $(C_\varphi f)(z) = f(\varphi(z))$, for $z \in \mathbb{D}$ and f analytic on $\mathbb{D}$ is called a composition operator. Let ω be a weight function such that $\omega \in L^1(\mathbb{D}, dA)$, where dA denotes the normalized area measure on $\mathbb{D}$. The generalized weighted Nevanlinna class $\mathcal{N}_\omega$ consists of all analytic functions f on $\mathbb{D}$ such that $\|f\|_\omega = \int_{\mathbb{D}} \log^+(|f(z)|)\omega(z)dA(z)$ is finite; that is, $\mathcal{N}_\omega$ is the space of all analytic functions belong to $L_{\log^+}(\mathbb{D}, \omega dA)$. In this talk we investigate the boundedness and compactness of these composition operators on the space $\mathcal{N}_\omega$. (Received February 04, 2014)

1099-46-165 **Gulnara Abduvalieva**, Department of Mathematics, Drexel University, 3141 Chestnut St., Philadelphia, PA 19104, and **Dmitry S. Kaliuzhnyi-Verbovetskyi*** (dmitryk@math.drexel.edu), Department of Mathematics, Drexel University, 3141 Chestnut St., Philadelphia, PA 19104. *Fixed-point and implicit/inverse function theorems for noncommutative functions.* Preliminary report.

Noncommutative functions are mappings of matrices over a module to matrices over another module (in particular analysis problems, these modules can be topological vector spaces) that (1) respect matrix sizes, (2) respect direct sums of matrices, (3) respect similarities of matrices. In various analytic settings, just a local boundedness assumption already guarantees the analyticity of a noncommutative function. We show that the theorems of classical analysis highlighted in the title have a stronger form when applied to a noncommutative function. (Received February 06, 2014)

1099-46-196 **Zhe Liu*** (zhe.liu@ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Commutators of operators affiliated with von Neumann algebras and derivations of Murray-von Neumann algebras.*

We discuss results about commutators of operators affiliated with von Neumann algebras. In particular, we examine the case of the family of operators affiliated with finite von Neumann algebras, the Murray-von Neumann algebras. We examine derivations of such algebras and their relations to commutators in those algebras. (Received February 08, 2014)

1099-46-200 **Victor Kaftal*** (kaftalv@gmail.com), Department of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221, and **P. W. Ng** and **Shuang Zhang**. *Positive linear combinations of projections.*

I will discuss the following questions about C*-algebras:

- Which elements are linear combination of projections?
- Which positive elements are linear combinations of projections with positive coefficients (positive linear combinations)?
- Which positive elements are (finite) sums of projections? Which are infinite sums converging in the strict topology (in multiplier algebras)?

After the easier cases of simple purely infinite real rank zero C*-algebras and their multiplier algebras, I will focus on a class of simple finite real rank zero C*-algebras and will consider also their multiplier algebras. (Received February 08, 2014)

1099-46-215 **Yoann N. Dabrowski*** (dabrowski@math.univ-lyon1.fr), 69005 Lyon, France. *Higher order regularity of conjugate variables along free brownian motions.* Preliminary report.

Voiculescu's non-microstates free entropy is based on the computation of conjugate variables ξ_t (the free analogue of score function) along a free brownian motion starting at a rather general vector of self-adjoint non-commutative random variables. Voiculescu proved the first regularity property, namely $\xi_t, t > 0$ is in $L^\infty(M, \tau)$. The author proved last year using time reversals of free diffusions that ξ_t is in the domain of the free difference quotient ∂ as an operator in L^2 for almost every t.

After reviewing this background, we will explain how the use of continuous time martingale techniques coming from [Junge,Perrin] (arXiv:1301.2071) enables to prove $\partial\xi_t$ are in various L^p-modules. Using also Haagerup tensor product techniques, one can get regularity of higher order free difference quotients of ξ_t.

This search for more regularity is motivated by obtaining a strong solution for the time reversal of free brownian motion where ξ_t appears as a drift. This strong solution property is true in the classical case by Veretennikov's result improved recently by Krylov, Priola etc and is important for free entropy applications. (Received February 09, 2014)

1099-46-241 **Alan D Wiggins*** (adwiggin@umich.edu), Department of Mathematics & Statistics, 2014 CASL Building, 4901 Evergreen Road, Dearborn, MI 48128. *Perturbation Problems for II_1 Factors.* Preliminary report.

We review progress on perturbations of II_1 factors and their associated invariants. This is joint work with Jan Cameron, Erik Christensen, Allan Sinclair, Roger Smith, and Stuart White. (Received February 10, 2014)

1099-46-242 **Jacob Fillman*** (jdf3@rice.edu), Department of Mathematics, MS-136, 6100 Main Street, Houston, TX 77251. *Discrete Schrödinger Operators with a Thue-Morse Potential.*

We will discuss the spectral theory of Schrödinger operators whose potentials are described by the Thue-Morse substitution. In particular, we will discuss bounds on the Hausdorff dimension of the spectrum and Hölder continuity of the integrated density of states. This is joint work with Paul Munger (Rice University). (Received February 10, 2014)

1099-46-279 **Raquel Cabral*** (toraquelmc@gmail.com), 1455 de Maisonneuve Blvd. West, Montreal, Quebec H3G 1M8, Canada. *A counterexample in the theory of strong differentiation of the integral.*

We build a function in the product Hardy space $H^1(\mathbf{R}\times\mathbf{R})$ and the Orlicz space $L(\log L)^\epsilon(\mathbf{R}^2)$ for all $0<\epsilon<1$, whose integral is not strongly differentiable almost everywhere on a set of positive measure. Our construction is inspired by an example of J. M. Marstrand and another of A. Stokolos. The inclusion in the product Hardy space $H^1(\mathbf{R}\times\mathbf{R})$ follows from the atomic decomposition, while the inclusion in $L(\log L)^\epsilon(\mathbf{R}^2)$ relies on a method to estimate of the Orlicz norm of series of functions. The failure of the strong differentiation of the integral is a consequence of a result concerning "approximate independence of sets" which illustrates how geometric properties can yield consequences of a probabilistic nature. It consists of a generalization Marstrand's claim about hyperbolic-cross shaped sets and applies to any sets of sufficiently low complexity in any Euclidean space. (Received February 10, 2014)

1099-46-307 **Guillermo Rey*** (reyguill@math.msu.edu) and **Alexander Reznikov**. *Extremizers and sharp weak-type estimates for positive dyadic shifts.*

We find the exact Bellman function for the weak L^1 norm of local positive dyadic shifts. We also describe a sequence of functions, self-similar in nature, which in the limit extremize the local weak-type (1,1) inequality. (Received February 10, 2014)

1099-46-336 **Stephen Avsec*** (savsec@math.tamu.edu). *Recent results on exchangeable noncommutative brownian motions.*

We shall begin with the recent definition due to B. Collins and M. Junge of noncommutative brownian motion. We shall then discuss recent progress towards characterizing these noncommutative brownian motions in the exchangeable case using operator-valued random variables. This includes joint work with Benoit Collins and Marius Junge. (Received February 11, 2014)

1099-46-372 **Marius Junge*** (mjunge@illinois.edu), Department of Mathematics, Urbana, IL 61801, and **Mathilde Perrin**. *Noncommutative stochastic analysis.* Preliminary report.

We will report on noncommutative Hardy spaces for continuous filtrations in von Neumann algebras. This theory developed with Mathilde Perrin is the stepping stone to define stochastic integrals for semi-martingales. We will discuss some technical issues such as 'what means continuous path?', 'is there a way to formulate cadlag?'. We will also indicate applications and problems for conditionally free dilations. (Received February 11, 2014)

1099-46-383 **Stephen Avsec*** (savsec@math.tamu.edu). *Noncommutative gaussian functors.*

The classical gaussian functor affiliates a family of centered gaussian variables $g(\xi)$ to each element ξ in a real Hilbert space H. From this affiliation, for any contraction $u: H\to K$ for Hilbert spaces H and K, we can define a positive map from $\Gamma(u): L^\infty(\Omega(H),d\mu)\to L^\infty(\Omega(K),d\nu)$ where $L^\infty(\Omega(H),d\mu)$ is generated by the (spectral projections) of the variables $g(\xi)$. We define analogous functors from the category of real Hilbert spaces with contractions to von Neumann algebras with completely positive maps. We will then discuss recent applications of this definition. This includes joint work with Marius Junge and Benoit Collins. (Received February 11, 2014)

47 ► Operator theory

1099-47-4 **Adrian Ioana*** (aioana@ucsd.edu), La Jolla, CA 92093. *Rigidity for von Neumann algebras and ergodic group actions.*

I will survey some recent progress in the study of von Neumann algebras and orbit equivalence relations arising from measure preserving actions of non-amenable groups on probability spaces. (Received February 05, 2014)

1099-47-8 **Zhongwei Shen*** (zzs0004@auburn.edu), Auburn University, 221 Parker Hall, Auburn, AL 36849. *Completeness for Sparse Potential Scattering.*

In this talk, we present some recent results about the scattering theory of a class of continuum Schrödinger operators with deterministic sparse potentials. We first establish the limiting absorption principle for both modified free resolvents and modified perturbed resolvents. This actually is a weak form of the classical limiting absorption principle. We then prove the existence and completeness of wave operators by means of Kato's smooth method. For more general models, we obtain the existence and completeness of local wave operators. (Received October 03, 2013)

1099-47-9 **Alain Bourget*** (abourget@fullerton.edu), Department of Mathematics, California State University, Fullerton, Fulleton, CA 92834. *Szegö's Limit Theorem for Band Dominated Operators.* Preliminary report.

Szegö's first limit theorem is a remarkable result concerning the asymptotic eigenvalues distribution of large Toeplitz matrices. In this paper, we extend Szegö's results to a subclass of band dominated operators, namely to bounded operators in the closure of the algebra of infinite band matrices whose diagonal sequences satisfy a vanishing mean variation condition. (Received October 14, 2013)

1099-47-75 **Oscar Blasco** and **Salvador Pérez-Esteva*** (spesteva@im.unam.mx), Instituto de Matemáticas Unidad Cuernavaca, Universidad Nacional Autónoma de México, Av. Universidad s/n Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico. *Averaging operators in the hyperbolic unit disk and atomic decomposition in weighted Bergman spaces.* Preliminary report.

We study weights $0 < W < \infty$ in the disk for which the averaging operators

$$A_r^W(\phi)(z) = \frac{1}{W(D(z,2r))}\int_{D(z,r)} \phi(w)W(w)dA(w),$$

are bounded in $L^p(W)$, where $D(z,r)$ is the hyperbolic neighborhood of z of radius r. These weights are related to the weights characterized by Bekolle for which the Bergman-type projections

$$P_\alpha f(z) = \int_{\mathbb{D}} \frac{f(w)}{(1-z\overline{w})^{\alpha+2}}(1-|w|)^\alpha dxdy.$$

are bounded. We use these concepts to show that atomic decompostions are posible in weighted Bergman spaces for a large class of weights. (Received January 27, 2014)

1099-47-120 **Ping Wong Ng*** (png@louisiana.edu), Mathematics Department, University of Louisiana at Lafayette, 217 Maxim Doucet Hall, P. O. Box 41010, Lafayette, LA 70504-1010. *Commutators in $C_r^*(\mathbb{F}_\infty)$.*

Let $C_r^*(\mathbb{F}_\infty)$ be the reduced C*-algebra of the free group on infinitely many generators, and let τ be the unique tracial state on $C_r^*(\mathbb{F}_\infty)$. For all $x \in C_r^*(\mathbb{F}_\infty)$, x is the sum of three commutators if and only if $\tau(x) = 0$. (Received February 03, 2014)

1099-47-122 **Injo Hur*** (ihur@math.ou.edu), Department of mathematics, University of Oklahoma, Norman, OK 73019, **Matt McBride**, Department of Mathematics, University of Oklahoma, Norman, OK 73019, and **Christian Remling**, Department of Mathematics, University of Oklahoma, Norman, OK 73019. *The Marchenko representation of reflectionless Jacobi and Schrödinger operators.*

We consider Jacobi matrices and Schrödinger operators that are reflectionless on an interval. We give a systematic development of a certain parametrization of this class, in terms of suitable spectral data, that is due to Marchenko. Then some applications of these ideas are discussed. (Received February 07, 2014)

1099-47-137 **Darren C. Ong*** (darren.ong@rice.edu), Math Department MS-136, Rice University, 6100 Main St, Houston, TX 77005. *Purely singular continuous spectrum for CMV operators generated by the period doubling subshift.*

The period doubling word is a substitution sequence generated by the substitution on $\{a,b\}$ given by $S(a) = ab, S(b) = aa$, so that the word begins with $abaaabab\ldots$. There is a significant body of literature on studying discrete Schrödinger operators whose potential corresponds to the dynamical subshift generated by this word. We adapt one of the results to the CMV operator context, that is, we prove absence of point spectrum for all CMV operators generated by this period doubling subshift. (Received February 04, 2014)

1099-47-155 **Brian Simanek*** (brian.z.simanek@vanderbilt.edu), 1326 Stevenson Center, Vanderbilt Math Department, Nashville, TN 37240. *Orthogonal Polynomials and the Bergman Shift Operator.*

Given a finite measure μ with compact and infinite support in the complex plane, the Bergman Shift operator is multiplication by the variable z in the space $L^2(\mu)$. When restricted to the closure of the space of polynomials, the matrix form of this operator is a Hessenberg matrix with respect to the basis given by the orthonormal polynomials for the measure μ. We will discuss the use of orthogonal polynomials to study the relationship between μ and the matrix form of the Bergman Shift. In particular, we will determine when the Bergman Shift is asymptotically Toeplitz; i.e., asymptotically constant along its diagonals, and when "most" of the measures μ is concentrated near a level set of a polynomial. (Received February 06, 2014)

1099-47-169 **Joseph A. Ball** and **Dmitry S. Kaliuzhnyi-Verbovetskyi*** (dmitryk@math.drexel.edu), Department of Mathematics, Drexel University, 3141 Chestnut St., Philadelphia, PA 19104, and **Cora Sadosky** and **Victor Vinnikov**. *Scattering systems with several evolutions and formal reproducing kernel Hilbert spaces.* Preliminary report.

A Schur-class function in d variables is defined to be an analytic contractive-operator valued function on the unit polydisk. Such a function is said to be in the Schur–Agler class if it is contractive when evaluated on any commutative d-tuple of strict contractions on a Hilbert space. It is known that the Schur–Agler class is a strictly proper subclass of the Schur class if the number of variables d is more than two. The Schur–Agler class is also characterized as those functions arising as the transfer function of a certain type (Givone–Roesser) of conservative multidimensional linear system. Previous work of the authors identified the Schur–Agler class as those Schur-class functions which arise as the scattering matrix for a certain type of (not necessarily minimal) Lax–Phillips multievolution scattering system having some additional geometric structure. The present paper links this additional geometric scattering structure directly with a known reproducing-kernel characterization of the Schur–Agler class. We use extensively the technique of formal reproducing kernel Hilbert spaces. (Received February 06, 2014)

1099-47-172 **Daniel Beltita**, **Sasmita Patnaik*** (sasmita@iitk.ac.in) and **Gary Weiss**. *CARTAN SUBALGEBRAS OF OPERATOR IDEALS.*

Denote by $\mathcal{U}_{\mathcal{I}}(\mathcal{H})$ the group of all special unitary operators $V \in \mathbf{1}+\mathcal{I}$ where $\mathcal{H}$ is a separable infinite-dimensional complex Hilbert space and $\mathcal{I}$ is an ideal of $B(\mathcal{H})$. An ideal has a natural structure of a Lie algebra where the Lie bracket is defined as the commutator of operators. For every Cartan subalgebra $\mathcal{C}$ of $\mathcal{I}$ (maximal abelian self-adjoint subalgebra of $\mathcal{I}$), its conjugacy class is defined as the set of Cartan subalgebras $\{V\mathcal{C}V^* \mid V \in \mathcal{U}_{\mathcal{I}}(\mathcal{H})\}$. For nonzero proper ideals $\mathcal{I}$ we construct an uncountable family of Cartan subalgebras $\mathcal{C}$ of $\mathcal{I}$ with distinct conjugacy classes under the action of the group $\mathcal{U}_{\mathcal{I}}(\mathcal{H})$. This is in contrast to the by now classical observation of P. de La Harpe who showed that when $\mathcal{I}$ is any of the Schatten ideals, there is precisely one conjugacy class under the action of the full group of unitary operators. (Received February 07, 2014)

1099-47-206 **Wing Suet Li*** (li@math.gatech.edu). *Saturated Horn inequalities for submodules and C_0 operators.*

A partition of integers is a (finite) nonincreasing sequence of integers. A triple of partitions (a,b,c) that satisfies the so-called Horn inequalities, a set of inequalities conjectured by A. Horn in 1960 and later the conjecture was proved by the work of Klyachko and Knutson-Tao, describes the eigenvalues of the sum of n by n Hermitian matricies, i.e., Hermitian matrices A, B, C such that $A+B=C$ with a, b, c as the set of eigenvalues of A, B, C respectively. Such triple also describes the Jordan decompositions of a nilpotent matrix T, T resticted to an invarint subspace M, and T compressed to $M^\perp$. More precisely, T is similar to $J(c) := J_{c_1} \oplus \cdots \oplus J_{c_n}$, and $T|M$ is similar to $J(a)$ and $T_{M^\perp}$ is similar to $J(b)$. (Here J_k denotes the Jordan cell of size k with 0 on the diagonal.) This result for nilpotent matrices also has an analogue for operators in the class of C_0. In this talk I will explain, through the intersection of certain Schubert varieties, why the same combinatorics solves the eigenvalue and the Jordan form problems. I will also describe the additional information that we can obtain whenever a Horn inequality saturates. This talk is based on the joint work with H. Bercovici. (Received February 09, 2014)

1099-47-212 **Ken Dykema*** (kjd@tamu.edu) and **Anna Skripka**. *Perturbation formulas for traces on normed ideals.*

Trace perturbation formulas are expressions for $\tau(f(H_0+V)-f(H_0))$ where τ is a trace, H_0 and V are operators (H_0 is often allowed to be unbounded) and f is a function belonging to a suitable class. The classical case, where τ is the classical trace on $B(\mathcal{H})$ and V is a trace-class operator, was considered by Krein. We prove more general results, for τ a trace on an ideal $\mathcal{I}$ of operators, with $V \in \mathcal{I}$. We will also discuss higher order perturbation formulas. (Received February 09, 2014)

1099-47-227 **Jireh Loreaux** and **Gary Weiss*** (weissg@ucmail.uc.edu), Mathematics Dept ML 25, University of Cincinnati, Cincinnati, OH 45221. *Diagonalability and Idempotents.* Preliminary report.

Diagonability of an operator here means the study of the properties that its diagonal sequences can have.

0-diagonalability (an operator having zero diagonal in some basis) is one such property. In an attempt to begin a classification of diagonals of idempotents, which is equivalent to a problem in frame theory, J. Jasper asked the following questions: (i) If an idempotent operator has an absolutely summable diagonal in some basis, must it be finite rank? And (ii) If an idempotent operator is 0-diagonalizable, must it be finite rank? These questions were spurred by the case when the idempotent is a projection, where the answer to each question is certainly affirmative. In this lecture we give one example and show how the techniques developed by Fan and Fong (related to work of Fan-Fong-Herrero) on 0-diagonability settle Jasper's question for idempotents.

Main Theorem. For D idempotent, B its off diagonal part wrt its standard decomposition 2x2 matrix block I,B,0,0, and R(Tr D) denotes the set of traces in all bases,

TFAE (i) D is not a Hilbert-Schmidt perturbation of a projection. (ii) B is not Hilbert-Schmidt. (iii) R(Tr D) is the plane. (iv) D has a zero diagonal. (v) D has an absolutely summable diagonal. (vi) R(Tr D) is nonempty. (Received February 10, 2014)

1099-47-252 **Roger Nichols*** (roger-nichols@utc.edu), 415 EMCS Bldg., Dept. 6956, 615 McCallie Ave, Chattanooga, TN 37403, and **Jonathan Eckhardt**, **Fritz Gesztesy** and **Gerald Teschl**. *Supersymmetry and Schrödinger-type Operators with Distributional Potentials.*

Building on work on Miura's transformation by Kappeler, Perry, Shubin, and Topalov, we develop a detailed spectral theoretic treatment of Schrödinger operators with matrix-valued potentials, with special emphasis on distributional potential coefficients. Our principal method relies on a supersymmetric (factorization) formalism underlying Miura's transformation, whereby spectral theoretic results for the Schrödinger operator–with distributional potential–may be deduced by relying on the known spectral theory of the corresponding supersymmetric Dirac-type operator. (Received February 10, 2014)

1099-47-264 **Arup Chattopadhyay*** (arup@isibang.ac.in), Indian Statistical Institute, Bangalore, Karnataka 560059, India, and **Bata Krishna Das**, **Jaydeb Sarkar** and **Santanu Sarkar**. *Wandering Subspaces of the Dirichlet Space Over Polydisc.*

In this talk I am going to discuss that doubly commuting invariant subspaces of the Bergman space and the Dirichlet space over polydisc have the generating wandering subspace property. Our result on the Bergman space over polydisc is a generalization of the base case due to Redett and Tung. Our analysis is based on the Wold-type decomposition result of S. Shimorin for operators closed to isometries. This is a joint work with J. Sarkar, B.K. Das and S. Sarkar. (Received February 10, 2014)

1099-47-301 **Konstantin A Makarov*** (makarovk@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, **Stephan Schmitz** (schmist@uni-mainz.de), Institut für Mathematik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany, and **Albrecht Seelmann** (seelmann@mathematik.uni-mainz.de), Institut für Mathematik, Johannes Gutenberg-Universität Mainz, Mainz, D-55099. *Reducing graph subspaces and Riccati equations.* Preliminary report.

The problem of block diagonalization for diagonally dominant symmetric block operator matrices with self-adjoint diagonal entries is considered. We show that a reasonable block diagonalization with respect to a reducing graph subspace requires a related skew-symmetric operator to be a strong solution to the associated Riccati equation. Under mild additional regularity conditions, we also establish that this skew-symmetric operator is a strong solution to the Riccati equation if and only if the graph subspace is reducing for the given operator matrix.

These regularity conditions are shown to be automatically fulfilled whenever the corresponding relative bound of the off-diagonal part is sufficiently small. (Received February 10, 2014)

1099-47-303 **Hao-Wei Huang*** (hwhuang@mast.queensu.ca), Kingston, Ontario K7L 3N6, Canada, and **Ping Zhong** (pzhong@indiana.edu), 831 E. Third St., Bloomington, IN 47405. *Supports of measures in free multiplicative convolution semigroups.*

In free probability, there are many cases that the number of components in a family of probability measures with parameter t is a non-increasing function of t. For instance, in 1997 Biane showed that the free convolution of any Borel probability measure on $\mathbb{R}$ and semicircular distribution with variance t has this property. In fact, the partially defined free additive convolution semigroup generated by any Borel probability measure on $\mathbb{R}$ has this property as well. Moreover, this non-increasing property also holds for the free multiplicative convolution of an arbitrary probability measure on the unit circle with the free multiplicative analogues of the normal distribution on the unit circle. In this talk, we will talk about our results showing that the partially defined free multiplicative convolution semigroups generated by any Borel probability measure on the unit circle and on the positive real line have the same results. This is a joint work with Ping Zhong. (Received February 10, 2014)

1099-47-332 **Stefania A.M. Marcantognini*** (smarcant@ivic.gob.ve), Km. 11 Carretera Panamericana, Altos de Pipe, Caracas, Miranda , Venezuela. *The dilation theorem of uniformly continuous semigroups of bounded operators.* Preliminary report.

The talk concerns joint work with A. Méndez (Universidad Central de Venezuela).

We give a new proof of Davis Dilation Theorem: Given a uniformly continuous one-parameter semigroup $\{T(s)\}$ on a Hilbert space $\mathfrak{H}$, there exist a Krein space $\mathfrak{K}$ containing $\mathfrak{H}$ as regular subspace and a strongly continuous one-parameter group $\{U(s)\}$ of unitary operators on $\mathfrak{K}$ such that $T(s) = P_{\mathfrak{H}}U(s)|_{\mathfrak{H}}$ for all $s \geq 0$ and $\mathfrak{K} = \vee\{U(s)\mathfrak{H} \ : \ s \in \mathbb{R}\}$. (C. Davies, Rev. Roum. Math. Pures et Appl., 1970.)

The arguments in the proof can be easily extended to the case of strongly continuous one-parameter semigroups with sectorial infinitesimal generators, as considered in (B. McEnnis, J. Operator Theory, 1990.) (Received February 11, 2014)

1099-47-381 **Ali S Kavruk*** (kavruk@illinois.edu). *On a non-commutative analogue of a classical result of Namioka and Phelps.* Preliminary report.

In this talk we will focus on nuclearity aspects in the category of function systems and operator algebras. A classical result of Namioka and Phelps states that the square is a test object for the verification of nuclearity in the tensor theory of convex compact sets. If we introduce the Kadison space $\mathcal{R}_n = \{(a_i) : a_1 + a_2 = a_3 + a_4 = \cdots = a_{2n-1} + a_{2n}\} \subset \ell^{2n}_\infty$ then their result, from a predual perspective, is equivalent to $\mathcal{R}_2$ being a test object to verify nuclearity in the category of Kadison spaces. We establish a non-commutative analogue of this as follows: a unital C*-algebra is nuclear (in the sense of Lance) if and only if its minimal and maximal tensor products with $\mathcal{R}_3$ coincide. The proof we suggest covers the nuclearity characterization via non-commutative tetrahedron outlined by Effros. We also show that the Namioka-Phelps test space $\mathcal{R}_2$ is C*-nuclear, and therefore far from being a test object in the non-commutative case. Time permitting we will also discuss a partition of unity property for C*-algebras which distinguishes nuclear C*-algebras among the others. (Received February 11, 2014)

49 ► *Calculus of variations and optimal control; optimization*

1099-49-33 **Rustum Choksi**, **Ihsan Topaloglu*** (ihsan.topaloglu@math.mcgill.ca) and **Gantumur Tsogtgerel**. *Pattern Formation on Surfaces: A Nonlocal Isoperimetric Problem on the Two-Sphere.*

From biology to physics and materials science energy-driven pattern formation on curved surfaces has been the focus of many research groups lately. In this talk we will consider an isoperimetric problem on the two dimensional sphere perturbed by a long-range interaction term. The functional we consider here arises as the sharp interface limit of the Ohta–Kawasaki sequence of functionals which model the microphase separation of diblock copolymers at the diffuse level and can be considered as a simple model of energy-driven pattern formation. Looking at the axisymmetric patterns on the sphere we will show that depending on the strength of the parameter controlling the nonlocal term such patterns are local minimizers not only in this restricted class but also in the broader sense (i.e., with respect to *all* perturbations). We then explore the rigidity, due to curvature effects, in the criticality condition via several quantitative results regarding these axisymmetric critical points. (Received February 03, 2014)

1099-49-79 **Andres A Contreras*** (contrera@math.mcmaster.ca), **Stanley Alama**, **Lia Bronsard** and **Dmitri Pelinovsky**. *Domain walls in coupled NLS systems.*

Through a variational approach, we study domain walls that arise in many relevant physical systems. Our study considers questions of stability and persistence under a small localized potential. This is joint work with Alama, Bronsard and Pelinovsky. (Received January 28, 2014)

1099-49-162 **Tiziana Giorgi*** (tgiorgi@nmsu.edu), New Mexico State University, Department of Mathematical Sciences, P.O. Box 30001, Department 3MB, Las Cruces, NM. *On a bent-core molecule liquid crystal model.*

We will present some results on existence and the limiting behavior of solutions of a de Gennes-Landau energy functional for bent-core molecule liquid crystals. (Received February 06, 2014)

1099-49-189 **Juan Dong*** (j.claire.dong@gmail.com), 2 Edgewood Rise, NW, Calgary, Alberta T3A 2T7, Canada, and **Deniz Sezer**. *Non-diversifiable Risk and Corporate Bonds Pricing.*

We have devised a methodology for pricing corporate bonds in an incomplete market, based on a notion called "non-diversifiable risk premium" and the concept of an optimal replicating portfolio. The difference between the value of the optimal portfolio and the contingent claim is interpreted as non-diversifiable risk. We model the price of the claim by incorporating the price of the optimal replicating portfolio and a certain reduction due to the lack of complete diversification. The optimality criterion is the expected squared error, and the minimization problem can be formulated as a stochastic optimal control problem, which can be solved by dynamic programming. (Received February 08, 2014)

51 ► Geometry

1099-51-98 **JOSE FERRAN VALDEZ*** (ferran@matmor.unam.mx), Centro de Ciencias Matemáticas, UNAM Campus Morelia, 58089 Morelia, Michoacan, Mexico, and **JESUS HERNANDEZ HERNANDEZ**, 3, place Victor Hugo, 13331 MARSEILLE, PROVENCE, France. *Actions of mapping class groups on curve complexes of surfaces of infinite type.* Preliminary report.

Let S be any orientable surface of infinite genus with a finite number of boundary components. In this work we consider the curve complex C(S), the nonseparating curve complex N(S) and the Schmutz graph G(S). When all the topological ends of S carry genus, we show that all elements in the automorphism groups Aut(C(S)), Aut(N(S)) and Aut(G(S)) are geometric, that is, these groups are naturally isomorphic to the extended mapping class group of the infinite surface S. (Received January 30, 2014)

1099-51-193 **Matthieu Gendulphe** and **Christopher Judge*** (cjudge@indiana.edu), 831 East Third, Bloomington, IN 47405. *Well-rounded translation surfaces.* Preliminary report.

We show that each stratum of translation surfaces (abelian differentials) deformation retracts onto those translation surfaces whose relative homology is generated by short saddle connections. We make some observations about the geometry of the retration. (Received February 08, 2014)

1099-51-221 **Igor N Szczyrba*** (igor.szczyrba@unco.edu), University of Northern Colorado, School of Mathematical Sciences, Greeley, CO 80639. *On dilations, centers of mass, and golden ratio.* Preliminary report.

We investigate properties of regions in the n-dimensional Euclidean spaces E^n that are obtained by 'subtracting' from a connected set in E^n its images under λ-dilations about a homothetic center S. We derive, in particular, the relations between the center of mass G of the set, the center of mass G' of the region, and the homothetic center S. If n=2, we show that the distances d(G,G') and d(G,S) are equal if λ coincides with the golden ratio. (Received February 11, 2014)

1099-51-251 **William G. Hager*** (whager@tlu.edu). *The Minimum Distance Energy Function and Knots with Dihedral Symmetry.* Preliminary report.

There are a number of programs written that can relax polygonal knots and approximate local minima of the minimum distance energy function. Despite this, the exact minima or even critical knots of this energy function are largely unknown. I will describe current progress towards locating the minima of this energy function before presenting some results of my own. For example, the special case of six-segment knots with dihedral symmetry is interesting, in that there is a critical knot in the approximate location of an estimated minimum of the minimum distance energy. (Received February 10, 2014)

1099-51-312 **Fabrice Baudoin** and **Jing Wang*** (wang321@purdue.edu), 150 N. University St., West Lafayette, IN 47907-2067. *The subelliptic heat kernel on sub Riemannian model spaces.*

We work on model spaces of sub Riemannian manifolds: the Cauchy-Riemann sphere $\mathbb{S}^{2n+1}$, the CR complex hyperbolic space $\mathbb{H}^{2n+1}$ and the Quaternionic sphere $\mathbb{S}^{4n+3}$. On each space there is a canonical diffusion operator L: The sub-Laplacian, which is not elliptic but only subelliptic.

The symmetries of these model spaces enable us to obtain an explicit and geometrically meaningful formula for each associated heat kernel. From them we can deduce the small-time behaviors of the heat kernels on the diagonal, on the vertical cut-locus, and outside of the cut-locus.

The key point is to work in cylindrical coordinates that reflect the symmetries coming from the Hopf fibration of these model spaces. (Received February 10, 2014)

1099-51-326 **Jerzy Kocik*** (jkocik@siu.edu), Department of Mathematics, SIU, Carbondale, IL 62901. *Apollonian spin networks.*

Apollonian disk packings involve a surprisingly rich combination of formalisms native to mathematical physics: from relativity and Minkowski space to quantum mechanics. In this presentation we show how an integral Apollonian gasket may be viewed as a spin network. This will also be an occasion to reconsider the underlying relation of spin networks to tensor calculus in general. (Received February 10, 2014)

53 ► Differential geometry

1099-53-40 **Robet B. Kusner*** (profkusner@gmail.com), Mathematics & G.A.N.G. (Center for Geometry, Analysis, Numerics & Graphics), University of Massachusetts, Amherst, MA 01003. *Chirality for knots and fields.* Preliminary report.

How might one measure the chirality of a space curve? Elementary physics offers some guidance. Imagine the curve as a thin wire drifting in a rarified fluid. The resulting torque on the wire leads to a trace-free matrix whose eigenvalues detect the chirality for the curve along the eigendirections. Analogous matrix chirality measures for vector fields are also considered. [Part of continuing collaborations with G. Dietler, W. B. Kusner, H. K. Moffatt, E. Rawdon, P. Szymczak....] (Received January 11, 2014)

1099-53-47 **Valentino Tosatti** and **Ben Weinkove***, 2033 Sheridan Road, Evanston, IL 60208. *Metrics on complex manifolds, Monge-Ampere equations and (n-1, n-1) forms.*

A C^2 function on $\mathbb{C}^n$ is called $(n-1)$-plurisubharmonic in the sense of Harvey-Lawson if the sum of every $n-1$ eigenvalues of its complex Hessian is nonnegative. We show existence of smooth solutions to the associated Monge-Ampere equation on compact Hermitian manifolds. As a consequence we obtain Calabi-Yau theorems for special metrics on complex manifolds. (Received January 15, 2014)

1099-53-48 **Christina Wiis Tonnesen-Friedman*** (tonnesec@union.edu), Department of Mathematics, Union College, Schenectady, NY 12308. *Sasaki join, admissible constructions and constant scalar curvature Sasaki metrics.* Preliminary report.

My talk is based on joint work in progress with Charles Boyer. Combining the Sasaki join construction for quasi-regular contact structures with the transverse admissible Kähler constructions (established by the joint work with Vestislav Apostolov, David Calderbank, and Paul Gauduchon) we have obtained irregular as well as quasi-regular constant scalar curvature (CSC) Sasaki metrics on a large family of manifolds in all dimensions. More specifically, we will show that for the join of a weighted 3-sphere with a regular CSC Sasaki manifold there exists a Reeb vector field in the Sasaki cone such that (up to isotopy) the corresponding ray of Sasakian structures has CSC. We will also consider some special examples, where more information can be obtained on the homotopy, homeomorphism, and diffeomorphism types. (Received January 16, 2014)

1099-53-92 **David E. Blair*** (blair@math.msu.edu). *Conformally Flat Contact Metric Manifolds.*

We will begin with a review of the basic ideas of contact manifolds and associated metrics. Our first topic will then be to discuss the question of constant curvature for contact metric manifolds, a question which has a very short answer. The main topic of the lecture is whether or not there exist conformally flat, contact metric manifolds which are not of constant curvature. In dimensions ≥ 5 this is open, but in dimension 3, these exist. We will also relate the 3-dimensional examples constructed to a problem in astrophysics. We will close by briefly discussing a possible approach in the compact case in general dimension. (Received January 29, 2014)

1099-53-116 **Weiyong He*** (whe@uoregon.edu), Department of Math, University of Oregon, Eugene, OR 97403. *Kahler-Ricci soliton and H-functional.*

We consider Kahler-Ricci solitons on a Fano manifold M. We introduce an H-functional on M; we show that its critical point has to a Kahler-Ricci soliton and the Kahler-Ricci flow can be viewed as its reduced gradient ow. We then obtain a natural lower bound of H-functional in terms of an invariant of holomorphic vector elds on M. As an application, we prove that a Kahler-Ricci soliton, if exists, maximizes Perelman's μ-functional. Second we consider a conjecture proposed by S.K. Donaldson regarding the existence of Kahler metrics with constant scalar curvature in terms of K-energy; a simple observation is that on Fano manifolds, one can consider Donaldson's conjecture in terms of Ding's F-functional. We then state geodesic stability conjecture on Fano manifolds in terms of F-functional. Similar pictures can be naturally extended to Kahler-Ricci soliton and modi ed F-functional. (Received February 03, 2014)

1099-53-178 **Ruth Gornet*** (rgornet@uta.edu), Campus Box 19408, Arlington, TX 76019-0408. *Recent developments in isospectrality.* Preliminary report.

We discuss recent results in isospectrality, particularly related to nilmanifolds. (Received February 07, 2014)

1099-53-179 **G Grantcharov*** (grantchg@fiu.edu), **M Lejmi** and **M Verbitsky**. *Hypercomplex manifolds of dimension eight.* Preliminary report.

We present a quaternionic analog of the well-known fact that a compact complex surface is Kaehler if and only if its first Betti number is even. More precisely we prove that 8-dimensional compact $SL(n, H)$ manifold admits HKT (hyperkaehler with torsion) metric if and only if its Hodge number $h^{0,1}$ is even. (Received February 07, 2014)

1099-53-192 **Christopher S Inbody*** (csinbody@unm.edu), 6301 Lamy St NW, Albuquerque, NM 87120. *Positive Sasakian Structures on Links of Weighted Complete Intersection Singularities.*

Links of isolated singularities defined by weighted homogeneous polynomials have a natural Sasakian structure. Since it is known that Sasaki-Einstein metrics have positive Ricci curvature, and since positive Sasakian structures give rise to Sasakian metrics with positive Ricci curvature, it is useful to determine which links have a positive Sasakian structure. This corresponds to the Fano index of the associated weighted projective variety being positive. Links of dimension $2n-1$ are $(n-2)$-connected. In dimension 5, there is a complete classification of simply connected spin manifolds due to Smale. Hypersurface singularities yielding links of dimension 5 have been treated by Boyer, Galicki, Kollár, Nakamaye, and others. This paper investigates isolated singularities of codimension 2 complete intersections with 5 dimensional links of positive index and provides a complete list up to degree 600, hence a complete (up to degree 600) list of types of links having positive Sasakian structures. (Received February 08, 2014)

1099-53-198 **Owen Dearricott*** (owen.dearricott@gmail.com), 18 Castles Crescent, Kyneton, Victoria, 3444, Australia. *Quaternion-Sasakian manifolds and reduction.*

An n-Sasakian manifold is a Riemannian manifold foliated by equidistant n-dimensional leaves such that the Riemann tensor is that of a curvature one space form on any triple of vector fields the include a field every tangent to the leaves of the foliation. Such manifolds are intimately connected to the parallel even Clifford orbifolds of Moroianu and Semmelmann.

We discuss an analogue of 3-Sasakian reduction in this setting. It turns out in this general setting actions amenable to reduction are somewhat sparse. However the Quaternion-Sasakian case (n=3) have a rich supply that include inhomogeneous examples, reduction in this case closely ties back in with the 3-Sasakian reduction of Boyer, Galicki and Mann. We also touch on some examples of 7-Sasakian circle reduction. (Received February 08, 2014)

1099-53-204 **Daniele Grandini***, grandini@unm.edu. *Generalized almost contact structures and their geometric type.*

The talk is based on a joint work with Marco Aldi, VCU. Generalized contact geometry is the odd dimensional analogue of generalized complex geometry. The object of study of generalized contact geometry are the so-called "generalized almost contact structures " (GACS), which generalize and unify two important structures in odd-dimensional geometry: almost contact structures and almost cosymplectic structures. In particular, the so-called normal GACS generalize both normal almost contact structures and cosymplectic structures. We introduce an important invariant of GACS, called the "geometric type", which is the odd-dimensional analogue of the type of a generalized almost complex structure. Several examples will be given, including examples of GACS whose geometric type is not constant. (Received February 09, 2014)

1099-53-207 **Fabrice Baudoin** and **Bumsik Kim***, Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47906-2067. *Obata's theorem for sub-Riemannian manifolds with transverse symmetries.*

We discuss the Lichnerowicz type theorem and the Obata's sphere theorem on a large class of compact sub-Riemannian manifolds satisfying $CD(\rho_1, \rho_2, \kappa, d)$ - the generalized curvature dimension inequality introduced by F.Baudoin and N.Garofalo. Moreover, applying Escobales' work for Riemannian submersions, we conclude that the manifold must be either 1- or 3-Sasakian sphere when an extremal eigenfunction exists for our Lichnerowicz type estimate. This is a joint work with F.Baudoin. (Received February 09, 2014)

1099-53-265 **Jason Cantarella*** (jason.cantarella@gmail.com) and **Clayton Shonkwiler**. *The Symplectic Geometry of Random Polygonal Knots.*

In this talk, we are interested in the problem of understanding the distribution of topology and geometry in random curves. We apply the Millson/Kapovich symplectic structure on the space of polygons (in 3-space) with fixed edgelengths to the theory of closed random walks. Using the symplectic structure allows us to reduce natural probabilistic questions about the geometry of a closed random walk to corresponding questions on convex polytopes. In this setting, they can be handled by appealing to the theory of the distribution of mass in high-dimensional convex bodies. We will present new results and new numerical methods obtained from this point of view. (Received February 10, 2014)

1099-53-284 **Robert K Hladky*** (robert.hladky@ndsu.edu), NDSU Mathematics Dept #2750, Attn: Melanie, PO Box 6050, Fargo, ND 581086050. *Integrable sub-Riemannian manifolds.*

Looking at sub-Riemannian manifolds of step 2, we shall discuss constructions intrinsic to the sub-Riemannian geometry and define the notion of integrability. This includes several extensively studied special examples, such as strictly pseudoconvex CR manifolds, step 2 Carnot groups and quaternionic contact manifolds, and provides a way of defining special holonomic structures on sub-Riemannian manifolds. We shall consider the existence problem for a structure of a given type and look at some properties of integrable geometries. (Received February 10, 2014)

1099-53-315 **Marco Aldi*** (maldi2@vcu.edu). *Mixed pairs, generalized almost contact structures and T-duality.*

This talk is based on joint work with Daniele Grandini, UNM. Generalized complex structures can be conveniently encoded in the language of pure spinors. In this talk we show how generalized almost contact structures on odd dimensional manifold can be described by suitable pairs of pure spinor. This approach leads to a natural notion of integrability of generalized almost contact structures. The language of spinors also allows for a transform description of T-dual generalized almost contact structures. (Received February 10, 2014)

1099-53-335 **Ralph R Gomez*** (rgomez1@swarthmore.edu), Swarthmore, PA 19081. *On Certain Examples of 2-connected Quasiregular Sasaki-Einstein Manifolds in Dimension Seven.* Preliminary report.

In this talk, we discuss new examples of 2-connected seven dimensional Sasaki-Einstein manifolds realized as links of isolated hypersurface singularities for which some homology information can be obtained. This is done by using a valid case of Orlik's conjecture regarding homology groups of links. These examples pull from the extensive list due to J.Johnson and J.Kollár of Fano Kähler-Einstein orbifolds in weighted projective 4-space. (Received February 11, 2014)

1099-53-342 **Qi S. Zhang*** (qizhang@math.ucr.edu), Riverside, CA 92521. *On volume and diameter bounds under Ricci flows.*

Let (M, g(t)) be a Ricci flow on compact Riemannian manifolds. We will describe why the volume of geodesic balls and diameters are bounded in finite time, provided that the scalar curvature is bounded in certain sense. The result is a synthesis of the work by a few people, including the author. (Received February 11, 2014)

1099-53-345 **Igor Zelenko*** (zelenko@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M Unkiversity, College Station, TX 77843. *Rauch and Bonnet-Myers type comparison theorems in sub-Riemannian geometry.*

We will give estimates for the number of conjugate points along extremals of a general sub-Riemannian metric in terms of curvature-type invariants of this metric. These estimates generalize the classical Rauch and Bonnet-Myers comparison theorems in Riemannian Geometry and they are based on the differential geometry of curves in Lagrangian Grassmannians developed in my previous works with Chengbo Li. The special emphasis will be given to the case of sub-Riemannian metrics on distributions of rank 2 where the formulation of the comparison theorems is especially simple. (Received February 11, 2014)

1099-53-367 **Matthew Gill*** (mfgill@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, 970 Evans Hall #3840, Berkeley, CA 94720-3840, and **Daniel Smith**, Department of Mathematics, Furman University, 3300 Poinsett Highway, Greenville, SC 29613. *Characterizing finite-time singularities of the Chern-Ricci flow.*

I will discuss some joint work with Daniel Smith on finite-time singularity development of the Chern-Ricci flow. In particular, we will show that finite-time singularities of the Chern-Ricci flow are characterized by the blow-up of the scalar curvature. (Received February 11, 2014)

1099-53-376 **Jie Qing*** (qing@ucsc.edu), **Changping Wang** (cpwang@fjnu.edu.cn) and **Jingyang Zhong** (jzhong2@ucsc.edu). *Conformal geometry of surfaces in 3-sphere via Minkowski spacetime.* 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. (Received February 11, 2014)

1099-53-379 **Tristan C. Collins*** (tcollins@math.columbia.edu) and **Gabor Szekelyhidi**. *K-Semistability for Sasakian manifolds.*

We will discuss an algebraic notion of stability related to existence of constant scalar curvature Sasakian metrics, which extends the notion of K-stability introduced by Donaldson for projective varieties. Time permitting we will give some examples of Sasakian manifolds not admitting Sasaki-Einstein metrics by exhibiting concrete algebraic obstructions. (Received February 11, 2014)

1099-53-399 **Oguz C. Durumeric*** (oguz-durumeric@uiowa.edu) and **Gary Christensen**. *Distance Functions and Cut-locus: From Riemannian Geometry to Thickness and Shape Collapsing in Image Deformations.* Preliminary report.

In this talk, we will discuss some applications of the distance function methods from Riemannian Geometry in other areas. Uniform thickness was defined as the normal injectivity radius of a smooth curve in the Euclidean space, and the non-uniform thickness was studied with weighted distance functions from a submanifold. A phenomenon called shape collapse occurs in image deformation when greedy algorithms (both small and large deformation) are used, this can be detected a priori, and collapsing shape can be predicted by studying the skeleton (a generalization of cut-locus) and the distance function from the boundary of a binary image. (Received February 11, 2014)

55 ► Algebraic topology

1099-55-232 **Seung Yeop Yang*** (syyang@gwmail.gwu.edu) and **Jozef Przytycki** (przytyck@gwu.edu). *Knot spinning and (co)cycle invariants.*

We discuss relations between knot spinning and (co)cycle invariants. The idea is to relate spinning – a geometric operation with homological operations on homology of racks and quandles. This is a joint work with Jozef Przytycki. (Received February 10, 2014)

1099-55-392 **Rob Scharein*** (rob@knotplot.com), 2116 West 6 Avenue, #211, Vancouver, BC V6K 1V6, Canada. *New possibilities for computational experiments with physical knots.*

After more than twenty years of experimenting with physical knots on a computer, there still remain many unsolved problems and the field is wide open for new kinds of investigations. We will look at several approaches to setting up such experiments, for example, colliding knots with various obstacles, simulating knots in arbitrary cavities and also playing in the still exciting arena of random knotting.

In addition to performing experiments, it is equally important to be able to analyze the results. Perhaps the greatest task that confronts the experimenter could be called *The Black Art of Knot Identification*. We will focus on some of the difficulties inherent in that endeavour. In addition, some new visualization techniques will be showcased. (Received February 11, 2014)

57 ► Manifolds and cell complexes

1099-57-37 **Erica Flapan*** (eflapan@pomona.edu), 640 N College Ave., Department of Mathematics, Pomona College, Claremont, CA 91711, **Will Fletcher** (willrowanfletcher@gmail.com), Biophysics Program, Stanford University, Stanford, CA 94305, and **Ryo Nikkuni** (nick@lab.twcu.ac.jp), Department of Mathematics, Tokyo Women's Christian University, 2-6-1 Zempukiji, Suginami-ku, Tokyo, 167-8585, Japan. *Reduced Wu and generalized Simon invariants for spatial graphs.* Preliminary report.

We introduce invariants of graphs embedded in S^3 which are related to the Wu invariant and the Simon invariant. Then we use our invariants to prove that certain graphs are intrinsically chiral, and to obtain lower bounds for the minimal crossing number of particular embeddings of graphs in S^3. (Received January 09, 2014)

1099-57-39 **Stu Whittington*** (swhittin@chem.utoronto.ca), University of Toronto, Toronto, Ontario M5S 3H6, Canada. *Entanglement complexity of closed 2-manifolds in tubes in Z^3 and Z^4.* Preliminary report.

Consider a random embedding of a closed 2-manifold in a three or four dimensional lattice. For the complete lattice there are many open questions about how bad this embedding will typically be. By restricting attention to embeddings in tubes in Z^3 or Z^4 we can use transfer matrix techniques to answer some of these questions. This is joint work with Mahshid Atapour, Chris Soteros and De Witt Sumners. (Received January 10, 2014)

1099-57-110 **Louis H. Kauffman*** (kauffman@uic.edu), Math UIC, 851 South Morgan Street, Chicago, IL 60607-7045. *Minimal Flat Folded Knotted Ribbons.* Preliminary report.

This talk will survey problems about the minimal length to diameter ratio of flat folded knotted ribbons. (Received February 03, 2014)

1099-57-126 **Eric J Rawdon***, University of St. Thomas, Dept of Math, OSS 201, 2115 Summit Ave, Saint Paul, MN 55105. *Subknotting in closed chains.* Preliminary report.

For a fixed knot configuration, the subknots are the knot types seen in the open subchains. For nice knot configurations (like energy-minimized ones), 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 February 04, 2014)

1099-57-139 **Dorothy Buck***, Dept of Maths & Centre for Integrative, Systems Biology & BioInformatics, Imperial College London, London, sw7 2az, United Kingdom. *Knotted DNA: Mathematical Models and Biological Consequences.*

Abstract: Motivated both by drug development (chemotherapeutics and antibiotics) and synthetic biology (including GMOs), we'll discuss recent work on knotted and linked DNA molecules. Using several case studies as examples, we'll consider the topological techniques used to model the fundamental cellular processes that knot and link DNA. We'll explore the biological ramifications of DNA knotting and linking, and how the results of these topological models can inform experimentalists, aid drug development and further synthetic biology. (Received February 05, 2014)

1099-57-160 **Claus Ernst***, Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101. *Generating Stiff Random Walks and Polygons in Spherical Confinement.*

There are several methods to generate confined equilateral random walks or polygons in spherical confinement. One such method uses probability density functions to generated a random walks or polygon one step at a time. In this talk a stiffness parameter is introduced in the generation process by modifying the probability density functions. (Received February 06, 2014)

1099-57-321 **JING WANG*** (jxfzwangjing@gmail.com) and **Jozef H Przytycki**. *Hochschild homology and Khovanov type homology of noncommutative algebras.*

We apply Turner and Wagner's multipath method to relate Hochschild homology and Khovanov type homology of noncommutative algebras. In particular, we use the language of homology of a small category with functor coefficients. (Received February 10, 2014)

1099-57-323 **Susan C. Brooks**, **Oguz Durumeric** and **Jonathan K. Simon*** (jonathan-simon@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Knots connected by wide ribbons.* Preliminary report.

Thin ribbons in $\mathbb{R}^3$ are well understood: the two boundary curves are the same knot type, and there is the important "link=twist+writhe" theorem. What happens if we let the ribbons get wide?

In this talk, we consider how the knot types of the ribbon edges might be related. Think in terms of one "core" curve K and the ribbon being generated by a vector field of length r defined along K. When the width r gets larger than the injectivity radius of K, the knot type of the outer boundary curve can change. Does the knot type eventually stabilize? to what?? How many knot types might occur? (Received February 10, 2014)

1099-57-330 **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20052, and **Krzysztof K. Putyra**, Columbia University. *Degenerate homology in frail simplicial modules.*

We discuss the degenerate part of homology of simplicial (or weak simplicial, or very weak simplicial (frail) modules. We start from recalling the classical normalization result of Eilenberg and Mac Lane, 1950, that the degenerate part of the homology of a simplicial module (which Eilenberg and Zilber introduced in 1950 under the name "complete semi-simplicial complex") is trivial. We describe our recent result that the degenerate part of the rack homology of a quandle or a spindle (RDIS) is determined by the normalized part of the rack homology (we deal here only with a weak simplicial module). Finally, we analyze the case of the very weak (frail) simplicial module (here $t_i = d_i s_i - d_{i+1} s_i$ is not necessarily equal to zero) and discuss the generalized degeneracy of rack chain complexes of racks and shelves (RDS). (Received February 11, 2014)

1099-57-393 **Gregory Buck*** (gbuck@anselm.edu). *The Role of Curvature in Entanglement, or, What Jon Simon Taught Me.*

What is the role of curvature in entanglement? Does more curvature mean more entanglement? What would Jon Simon say? (Received February 11, 2014)

1099-57-398 **Mieczyslaw K. Dabkowski*** (mdab@utdallas.edu) and **Changsong Li**. *Catalan and Kauffman States of Lattice Crossing.* Preliminary report.

For lattice crossing $L(m, n)$ we show which Catalan connections between $2(m + n)$ points on the boundary of $m{\times}n$ rectangle P can be realized as Kauffman states and we give an explicit formula for the number of such connections. In some special cases of Catalan connection, we also give a formula for their coefficients in the Relative Kauffman Bracket Skein Module of $P{\times}I$. (Received February 11, 2014)

58 ► Global analysis, analysis on manifolds

1099-58-29 **Floyd L. Williams*** (williams@math.umass.edu), 17 Moss Lane, Amherst, MA 01002. *Magnetic resolvent trace formula for 2d black hole vacua.*

We compute the Hadamard regularized trace of the automorphic resolvent kernel of a Schrodinger operator H(B) with a uniform magnetic field of strength B on the upper half plane for a 2d black hole vacuum. H(B) is essentially a Maass Laplacian of weight B,in terms of which its point spectrum is expressed.In the absence of a magnetic field (the special case with B=0),our result reduces to a known result due,for example,to D.Borthwick,C.Judge,and P.Perry. (Received December 20, 2013)

1099-58-41 **Michel L Lapidus*** (lapidus@math.ucr.edu), Department of Mathematics, University of California, Riverside, CA 92521-0135, and **Jonathan Sarhad**, Department of Biology, University of California, Riverside, CA 92521. *Dirac Operators on Fractal Manifolds, Noncommutative Geometry and Intrinsic Geodesic Metrics.*

This is joint work with Jonathan Sarhad, which will appear in the "Journal of Noncommutative Geometry". We construct Dirac operators and spectral triples for certain, not necessarily self-similar fractal sets built on countably many curves. Connes' distance formula in noncommutative geometry provides a natural intrinsic metric on the fractal. As an important motivating example, we consider the harmonic Sierpinski gasket, which represents the ordinary (Euclidean) gasket from the analytical point of view. We prove that the noncommutative metric coincides with the natural geodesic metric on the harmonic gasket (recently studied by J. Kigami). The present work extends to the non-Euclidean (and analytically relevant) setting some of the main results of the paper by E. Christensen, C. Ivan and M.L. Lapidus (Adv. in Math. No. 1, 217 (2008, pp.42-78). Our current, broader framework allows for several further potential applications to geometric analysis on fractal manifolds. If time permits, several open problems will be discussed, including the recovery of the intrinsic Hausdorff metric, via a Dixmier trace-type formula. (Received January 12, 2014)

1099-58-76 **Thomas Krainer*** (tuk14@psu.edu), Penn State Altoona, 3000 Ivyside Park, Altoona, PA 16601, and **Gerardo A. Mendoza**, Temple University, Department of Mathematics, 1801 N. Broad Street, Philadelphia, PA 19122. *Boundary Value Problems for Elliptic Wedge Operators of First Order.*

Spaces with singularities of edge type are modeled by a smooth compact manifold with boundary, where the boundary is the total space of a locally trivial fibration. The relation with the singular space is given by collapsing the fibers to points. On such manifolds there is a natural class of incomplete Riemannian metrics (wedge metrics, a.k.a. incomplete-edge metrics) that reflect the conic degeneration of the fibers at the boundary. Geometric operators associated with such metrics are examples for the broader class of wedge differential operators. In the case of the trivial boundary fibration (fiber is a point), wedge metrics are precisely the smooth metrics up to the boundary, and the class of wedge differential operators includes all regular differential operators with smooth coefficients up to the boundary.

In this talk, I plan to report about joint work with G. Mendoza addressing the problem of well-posedness of elliptic equations for wedge operators of first order. Central to the investigation is the development of an appropriate notion of boundary condition associated with the singular locus (i.e. the edge). In the case of the trivial boundary fibration, our theory includes the classical theory of elliptic boundary problems (for first-order operators) as a special case. (Received January 27, 2014)

1099-58-81 **Gerardo A Mendoza*** (gmendoza@temple.edu), Philadelphia, PA 19122. *Spectral instability of selfadjoint extensions.*

Let M be a smooth compact manifold with boundary, boundary defining function x, and smooth b-density $\mathfrak{m}_b$. Further let $E, F \to M$ Hermitian vector bundles and $A : C_c^\infty(\mathring{M}; E) \subset x^{-\nu/2}L^2_b(M;E) \to x^{-\nu/2}L^2_b(M;F)$ a symmetric elliptic cone operator which is bounded from below and admits more than one selfadjoint extension. The family, $\mathfrak{SA}$, of domains of such extensions has the structure of a smooth compact real-analytic manifold. The spectrum of A with any domain $D \in \mathfrak{SA}$ is bounded below, but there exist domains D_0 which admit a neighborhood $U \subset \mathfrak{SA}$ in which the property $\forall \zeta \in \mathbb{R}\ \exists D \in U$ s.t. $\zeta > \inf \operatorname{spec}(A_D)$ holds. I will give a characterization of these spectrally unstable domains. (Received January 28, 2014)

1099-58-84 **Guglielmo Fucci*** (fuccig@ecu.edu), Department of Mathematics, East Carolina University, 331 Austin Building, East Fifth Street, Greenville, NC 27858-4353. *Spectral Functions for Regular Sturm-Liouville Problems.*

Spectral functions represent an invaluable mathematical tool used in several areas of both mathematics and physics. For this reason, developing accurate methods for their detailed analysis is of fundamental importance. In this talk we present a powerful technique for the study of the analytic continuation of the spectral zeta function associated with one-dimensional regular Sturm-Liouville problems endowed with self-adjoint separated and coupled boundary conditions. The analytically continued expression for the spectral zeta function is then utilized for the evaluation of the functional determinant of the Sturm-Liouville operator and the computation of the coefficients of the asymptotic expansion of the trace of the associated heat kernel. (Received January 28, 2014)

1099-58-166 **Fabrice Baudoin***, Purdue University. *Weitzenböck formulas and Riesz transforms on sub-Riemannian manifolds with transverse symmetries.*

In this talk we prove a Weitzenböck type formula on sub-Riemannian manifolds with transverse symmetries. As an application we derive several gradient bounds for heat equation solutions and dimension independent bounds for the Riesz transform. The results are new even in the Heisenberg group which is the simplest example of a sub-Riemannian manifold with transverse symmetries. (Received February 06, 2014)

1099-58-167 **Nikhil A Savale*** (nsavale@nd.edu). *Asymptotics of the Eta Invariant.*

We prove an asymptotic bound on the eta invariant of a family of coupled Dirac operators on an odd dimensional manifold. In the case when the manifold is the unit circle bundle of a positive line bundle over a complex manifold, we obtain precise formulas for the eta invariant. (Received February 06, 2014)

1099-58-214 **Christopher D Sogge*** (sogge@jhu.edu), Department of Mathematics, Johns Hopkins University, Baltimore, MD 21218. *Focal points and sup-norms of eigenfunctions.*

If (M, g) is a compact real analytic Riemannian manifold, we give a necessary and sufficient condition for there to be a sequence of quasimodes saturating sup-norm estimates. The condition is that there exists a self-focal point

$x_0 \in M$ for the geodesic flow at which the associated Perron-Frobenius operator $U : L^2(S^*_{x_0}M) \to L^2(S^*_{x_0}M)$ has a nontrivial invariant function. The proof is based on von Neumann's ergodic theorem and stationary phase. This is joint work with Steve Zelditch. (Received February 09, 2014)

1099-58-222 **Lance D. Drager**, **Jeffrey M Lee**, **Efton Park** and **Ken Richardson*** (k.richardson@tcu.edu). *Smooth and cosmooth general distributions.*

Smooth and cosmooth general distributions are subbundles of the tangent bundle of a manifold that do not have constant rank yet share many of the features of smooth distributions of constant rank. I will discuss joint work with my coauthors in proving that all such distributions are finitely generated, meaning that a finite set of vector fields (or one-forms in the case of cosmooth distributions) suffices to be a pointwise spanning set of the distribution. At the same time, we demonstrate that the corresponding spaces of sections of these distributions are not finitely generated as modules over the smooth functions. I will also discuss some open problems in analysis and spectral theory for these distributions. (Received February 09, 2014)

1099-58-338 **Wei Yuan*** (wyuan2@ucsc.edu). *On the Geometry of Static Spaces.*

In 1975, A.Fischer and J.Marsden proposed a conjecture about the classification of the static spaces. It has been solved under the assumption of locally conformal flatness back in 1980's. But the generic case is still open. In this talk, we will give an improvement providing only Bach flatness and an even weaker one for dimension 3. Also using the same idea, we will give a confirmed answer to one of Bess's conjecture assuming Bach flatness. Inspired by the solution of Min-Oo's conjecture, we will investigate the scalar rigidity phenomenons in static spaces for the second part of the talk. We will give a sharp conformal rigidity result for static spaces with positive scalar curvature. As for generic static spaces, we will also discuss the corresponding rigidity phenomenons. In the end, with a careful analysis, we will give an improvement of some recent results concerning the rigidity of geodesic balls in upper hemisphere, which in some sense is almost optimal. This is a joint work with Professor Jie Qing in University of California, Santa Cruz. (Received February 11, 2014)

1099-58-346 **Juan B Gil*** (jgil@psu.edu). *Trace asymptotics of elliptic cone operators.*

I will give an account of joint work with T. Krainer and G. Mendoza regarding the asymptotic expansion of the resolvent trace for the closed extensions of an elliptic cone operator. The results involve only minimal conditions on the symbols of the operator, and combine previous investigations on the subject with an analysis of the asymptotics of a family of projections related to the domain. (Received February 11, 2014)

60 ► Probability theory and stochastic processes

1099-60-11 **Robert G Smits*** (rsmits@nmsu.edu), Department of Mathematical Sciences, P.O. Box 30001, Department 3MB, Las Cruces, NM 88003. *A Cox-Ingersoll-Ross type Model with Subexponential Return Times.*

I present a model for short term interest rates which has many of the features of the CIR model but with the advantage of having return times which are not heavy tailed. The model is analyzed by a change of measure where the associated large deviation problem can be solved by solving a singular problem in the calculus of variations. (Received November 03, 2013)

1099-60-14 **Rabi N Bhattacharya*** (rabi@math.arizona.edu), The University of Arizona, Department of Mathematics, Tucson, AZ 85721, **Mukul K Majumdar** (mkm5@cornell.edu), Cornell University, Department of Economics, Uris Hall, Ithaca, NY 14853, and **Lizhen Lin** (lizhen@stat.duke.edu), Duke University, Statistical Science, Durham, NC 27708. *Two problems of ruin and survival in economics: applications of limit theorems in probability.*

We compare the probabilities of bank default when the same total amount of loan is distributed among a small number of borrowers versus when it is distributed to a large group of borrowers, with all borrowers having the same probability of default. The computations by different probabilistic tools, such as large deviations and their refinements and the central limit theorem, are assessed for their accuracy. Although this is of direct relevance for Grameen banks in developing countries, the model can be extended to include partial payments with collaterals and correlated defaults. A second problem looks at the so-called Lindley-Spitzer process in the context of management of a renewable resource, and explores its mathematical equivalence to another widely studied theme of much importance, namely, the ruin problem in insurance. A third problem, technically equivalent to the two cited above, concerns queuing, which will also be touched upon. (Received November 06, 2013)

1099-60-17 **Sylvain Corlay*** (scorlay@bloomberg.net). *Quantization techniques for pricing and calibration in stochastic volatility models.*

We describe numerical techniques for option pricing and calibration in stochastic volatility models. We first present the recently developed theory of functional quantization and we show that we can obtain efficient cubature formulas for a large class of models including some otherwise numerically intractable cases such as multifractional stochastic volatility models. Then, we present Markov projection techniques with B-splines to calibrate the local volatility component of SLV models. (Received November 17, 2013)

1099-60-21 **Andrey Sarantsev*** (ansa1989@math.washington.edu), Department of Mathematics, Box 354350, University of Washington, Seattle, WA 98195. *Infinite Systems of Competing Brownian Particles with Asymmetric Collisions.* Preliminary report.

Consider countably infinite (one-sided or two-sided) systems of Brownian particles on the real line. Each particle moves as a Brownian motion with drift and diffusion coefficients depending on its current rank. When two particles collide, they are pushed away from each other, and the push may be distributed not evenly between these two particles. Similar systems with finitely many particles were considered by Karatzas, Pal and Shkolnikov (2012). We prove existence and uniqueness theorems for such systems. We find product of exponentials stationary distributions for gaps between adjacent particles. For example, the well-known fact that the Poisson point process with constant intensity on the real line is invariant when points move as independent Brownian motions turns out to be also true for some analogous systems with asymmetric collisions. (Received November 23, 2013)

1099-60-28 **Michael Carlisle** (michael.carlisle@baruch.cuny.edu), **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu) and **Ioannis Stamos** (istamos@hunter.cuny.edu). *Trends and trades.*

We present a trend following algorithm based on the sequential statistical rule known as the cumulative sum (CUSUM). We draw connections between these statistics and the problem of online statistical surveillance and quality control. We build a trading strategy based on the CUSUM stopping rule and apply it to high-frequency tick data from 5-year and 30-year US Treasury notes sold at auction. We analyze the performance of the proposed trend following strategy in detail. In particular, it is seen that the proposed trading rule is most profitable during times of market instability and long trends. We further calculate in closed form the expected value of the gain of the proposed strategy for a class of random walk models. Not surprisingly, it is seen that the suggested strategy is most profitable in biased random walks but is indifferent to the direction of the bias. We also examine the performance of the proposed strategy in simulated data from a variety of random walk models and analyze this behavior in relation to the analytical results and the results of the performance of the strategy on the actual data. We finally discuss other statistics of interest and the way in which they can help us improve the performance of our proposed algorithm. (Received December 19, 2013)

1099-60-31 **Alec N Kercheval*** (kercheva@math.fsu.edu), Department of Mathematics, 1017 Academic Way, rm 208, Florida State University, Tallahassee, FL 32306-4510, and **Pierre Garreau**. *Jump dependence, multidimensional default risk, and a new class of structural default models.* Preliminary report.

We describe a framework for default risk in which the time of default is the first jump of the log-return below a (possibly stochastic) level. This is equivalent to a stochastic intensity default model when the stock price is an exponential Levy process. To understand basket default risk, we therefore need to understand the jump dependence of respective prices processes. We show that two one-dimensional Levy processes form a two-dimensional Levy process if and only if the joint survival times satisfy a two-dimensional memoryless property, and therefore are bivariate exponential and the survival times satisfy a Marshall-Olkin copula. This provides a structure theorem for modeling basket default instruments for multidimensional Levy prices processes. (Received December 28, 2013)

1099-60-45 **Paolo Guasoni**, **Gur Huberman** and **Dan Ren*** (dren01@udayton.edu), Department of Mathematics, University of Dayton, 300 College Park, Dayton, OH 45469. *Optimal consumption and investment for shortfall aversion.*

We solve an optimal consumption and investment problem for a risk-averse investor who is sensitive to declines than to increases of standard living (i.e., the investor is shortfall-averse), and the investment opportunities are constant. We use the tools of stochastic control and duality methods to solve the resulting free-boundary problem in an infinite time horizon. Briefly, the investor consumes constantly when holding a moderate amount of wealth. In bliss time, the investor increases the consumption so that the consumption-wealth ratio reaches some fixed minimum level; in gloom time, the investor decreases the consumption gradually. Moreover, high loss aversion tends to raise the consumption-wealth ratio, but cut the investment-wealth ratio overall. (Received January 15, 2014)

1099-60-77 **Alexander Melnikov*** (melnikov@ualberta.ca), 632 CAB, Edmonton, AB , Canada. *Orthogonal polynomials technique and its applications in mathematical finance and insurance.*

The primary goal of the talk is to present a new approach to financial and actuarial modeling which is based on polynomial extensions of probability distributions for financial assets and insurance claims. Besides improvements in modeling of asset returns and insurance claim sizes a better option pricing as well as risk measures calculations become possible using this approach. Theoretical findings are supported with numerical examples and illustrations exploiting financial and actuarial statistical data. (Received January 27, 2014)

1099-60-85 **Jun Deng*** (jdeng6@ualberta.ca), #1607,9747,104st, Edmonton, Alberta T5K0Y6, Canada, and **Tahir Choulli**, **JunFeng Ma**, **Anna Aksamit** and **Monique Jeanblanc**. *Non-arbitrage under Uncertainty.*

This talk consists of two main themes. In the first theme, I will address the equivalence among non-arbitrage, viability and numéraire portfolio that would be our economic motivation of the further development. While in the second theme, I will talk about how non-arbitrage affected by some extra information that is characterized by a random time τ (or an honest time) that could be the retirement time, death time, or the occurrence of any event that would affect the market and the agents' behaviours. Mathematical speaking, we gave the necessary and sufficient conditions on the random time to preserve the NUPBR condition for any semi-martingale S stopped at the random horizon τ. To guarantee the NUPBR condition after an honest time, we introduced an important assumption that would play a crucial role in characterizing default times. The spirit driving us is the characteristics of semi-martingale and the optional (or compensated) stochastic integral. (Received January 28, 2014)

1099-60-86 **Anatoliy Swishchuk*** (aswish@ucalgary.ca), 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada. *'Covariance and Correlation Swaps for Markov-modulated Volatilities'.*

'In this talk, we price covariance and correlation swaps for financial markets with Markov-modulated volatilities. As an example, we consider stochastic volatility driven by two-state continuous Markov chain. In this case, numerical example is presented for VIX and VXN volatility indices (S&P 500 and NASDAQ-100, respectively, since January 2004 to June 2012). We also use VIX (January 2004 to June 2012) to price variance and volatility swaps for the two-state Markov-modulated volatility and to present a numerical result in this case.' (Received January 28, 2014)

1099-60-117 **Jiaoyang Huang*** (jiaoyang@mit.edu), 3 Ames Street, Building 62, Room W302, Cambridge, MA 02139. *Asymptotic Expansion of Spherical Integral.*

In this paper we consider the expansion of the spherical integral

$$I_N^{(\beta)}(A_N, B_N) = \int \exp\{NTr(A_N U^* B_N U)\} dm_N^{(\beta)}(U), \tag{1}$$

where $m_N^{(\beta)}$ is the Haar measure on orthogonal group $O(N)$ if $\beta = 1$, on unitary group $U(N)$ if $\beta = 2$, and A_N, B_N are deterministic $N \times N$ real symmetric or Hermitian matrices, that we can assume diagonal without loss of generality. We follow the work of Alice Guionnet and Mylène Maïda, investigate the asymptotics of the spherical integrals under the case $A_N = \mathrm{diag}(\theta, 0, 0, 0, 0 \cdots 0)$:

$$I_N^{(\beta)}(A_N, B_N) = I_N^{(\beta)}(\theta, B_N) = \int \exp\{\theta N(e_1^* B_N e_1)\} dm_N^{(\beta)}(U), \tag{2}$$

where e_1 is the first column of U.

In this case the spherical integral provides a finite dimensional analogue of the R-transform in free probability. The main result of the paper is proof of the existence of the full asymptotic expansions of these spherical integrals and derive the first and the second term in the asymptotic expansion. (Received February 03, 2014)

1099-60-125 **Guillaume Cébron*** (guillaume.cebron@upmc.fr). *Matricial model for free multiplicative Lévy processes.*

The free unitary Brownian motion, introduced by Philippe Biane in 1997, is the limit of the Brownian motion on the unitary group in large dimension. In this talk, I shall extend this result to unitary free Lévy processes. More precisely, each unitary noncommutative stochastic process whose multiplicative increments are stationary and freely independent is the limit (in non-commutative distribution) of a classical Lévy process on the unitary group with adapted parameters. The techniques of proof relies on the theory of free log-cumulants, and on the Schur-Weyl duality. (Received February 04, 2014)

1099-60-170 **Yuanan Diao*** (ydiao@uncc.edu), Department of Mathematics and Statistics, University of North Carolina Charlotte, 9201 University City Blvd., Charlotte, NC 28223. *The Linking Problem of Random Polygons.*

In this talk, I will discuss problems associated with the linking probability of random polygons. (Received February 06, 2014)

1099-60-187 **Pradip R Aryal*** (pradip@nmsu.edu), Department of Mathematical Sciences, NMSU, Las Cruces, NM 88003. *A Study of Brownian Motion under Brachistochrone-type metrics.*

I will derive some expressions for the transition density of a Brownian motion in upper-half spaces under Brachistochrone-type metrics. In one regime, 0<alpha< 2, these variable curvature metrics sit between Euclidean Brownian motion and hyperbolic Brownian motion. In this case the process has a killing time which can be expressed in terms of Bessel processes of negative dimension. In the other regime 2<alpha, they behave as more extreme analogs of hyperbolic Brownian motion which never exit the domain. Keywords: Brownian motion, Bessel process and Brachistochrone-type. (Received February 08, 2014)

1099-60-203 **Salah-Eldin A. Mohammed*** (salah@sfde.math.siu.edu), Department of Mathematics, Southern Illinois University-Carbondale, Carbondale, IL 62901, **Torstein Nilssen**, Department of Mathematics, University of Oslo, Oslo, Norway, and **Frank Proske**, Department of Mathematics, University of Oslo, Oslo, Norway. *" Differentiable Flows for Singular SDE's and Applications to the Transport Equation".*

Abstract:

In this talk, we establish the existence of a stochastic flow of Sobolev diffeomorphisms for an SDE driven by a bounded measurable drift and additive Brownian motion. The result is striking, since the dominant 'culture' in stochastic (and deterministic) dynamical systems is that the flow 'inherits' its spatial regularity from the driving vector fields. The spatial regularity of the stochastic flow yields existence and uniqueness of a Sobolev differentiable weak solution of the (Stratonovich) stochastic transport equation. It is well-known that the deterministic transport equation does not in general have a solution. Using stochastic perturbations and our analysis of the above SDE, we establish a deterministic flow of Sobolev diffeomorphisms for classical one-dimensional (deterministic) ODE's driven by discontinuous vector fields. Furthermore, and as a corollary of the latter result, we construct a Sobolev stochastic flow of diffeomorphisms for one-dimensional SDE's driven by discontinuous diffusion coefficients. This is joint work with T. Nilssen and F. Proske. (Received February 08, 2014)

1099-60-228 **Victor Perez-Abreu*** (pabreu@cimat.mx), CIMAT, Apdo Postal 402, 36000 Guanajuato, Mexico. *Matrix Ensembles for Free Lévy Processes.*

It is known that the so-called Bercovici-Pata bijection can be explained in terms of certain Hermitian random matrix ensembles which asymptotic spectral distributions are free infinitely divisible. We present results on Hermitian Lévy processes with jumps of rank one associated to these random matrix ensembles and the corresponding free Lévy processes. (Received February 09, 2014)

1099-60-233 **Giovanni Peccati*** (giovanni.peccati@gmail.com), Université du Luxembourg., Mathematics Research Unit, L1359 Luxembourg, Luxembourg, and **Solesne Bourguin**, Carnegie Mellon University., Department of Mathematical Sciences.. *Limit and transfer on free chaoses.*

I will describe some recent progress concerning limit theorems for non-commutative random variables living in a free chaos, like for instance the Wigner chaos or the free Poisson chaos. In particular, I will discuss a remarkable 'transfer principle' between classical and free probability spaces, and show that such a principle might fail when one considers random variables arising in the classical theory of random geometric graphs. (Received February 10, 2014)

1099-60-246 **Davar Khoshnevisan*** (davar@math.utah.edu), Department of Mathematics, University of Utah, Salt Lake City, UT 84112, and **Mohammud Foondun** and **Pejman Mahboubi**. *Analysis of the gradient of the solution to a stochastic heat equation via fractional Brownian motion.* Preliminary report.

We present an analysis of approximate gradients of solutions to various nonlinear stochastic heat equations. Included are a few applications to the local behavior of the solutions to the parabolic Anderson model and the KPZ equation.

This is joint work with M. Foondun and P. Mahboubi. (Received February 10, 2014)

1099-60-273 **Chia Ying Lee*** (lchiaying@math.ubc.ca) and **Leila Setayeshgar**. *The large deviation principle for a stochastic Korteweg-de Vries equation with additive noise.*

We prove the large deviation principle for the law of the solutions to a stochastic Korteweg-de Vries (KdV) equation driven by a small additive noise. We appeal to the recent result of Budhiraja, Dupuis, and Maroulas, which uses the weak convergence approach to provide sufficient conditions for a uniform Laplace principle to hold in general infinite dimensional systems, and use it to show that the large deviation principle holds for the stochastic KdV equation in the space $C(0,T;H^\sigma(\mathbb{R}))$ for $3/4<\sigma<1$. The beauty of this approach is that it allows us to directly adapt the techniques used in the existence proofs, based on fixed point arguments and energy estimates, to deduce the large deviation principle in a concise and elegant manner. (Received February 10, 2014)

1099-60-277 **Natasha Blitvić*** (nblitvic@indiana.edu) and **Todd Kemp** (tkemp@math.ucsd.edu). *The Segal–Bargmann Transform for (q,t)-Gaussian Spaces.*

Classically, the Segal-Bargmann transform is a unitary isomorphism between the L^2 space of the Gaussian measure on $\mathbb{R}^d$ and the space of holomorphic functions on $\mathbb{C}^d$ that are square-integrable with respect to the complex Gaussian measure. An analogous construction is available in free probability, where, for $d=1$, the L^2 space of the standard semicircle measure is seen to correspond to the Hardy space of the unit disk. The general free Segal-Bargmann transform (over any separable Hilbert space) was constructed by Biane and extended to the q-Gaussian algebras for $-1\le q<1$ by Kemp. The q-deformed case was also studied in the one-dimensional setting by Maassen and van Leeuwen. In this talk, I will discuss the Segal-Bargmann transform for (q,t)-Gaussian non-commutative probability spaces, which are a combinatorially natural, but non-tracial, generalization of the q-Gaussian spaces. The proofs will draw on explicit combinatorial constructions and a revised two-parameter quantum calculus (compared to physics literature). (Received February 10, 2014)

1099-60-298 **Ionel Popescu*** (ipopescu@math.gatech.edu), 686 Cherry Street, Atlanta, GA 30332. *Refinements of the Free Poincare Inequality.*

The classical Poincare inequality for the normal distribution is exactly the spectral gap of the Ornstein-Uhlembeck operator. Two extensions are due to Houdre-Kagan for the normal distribution and to Brascamp-Lieb for more general log-concave distributions on the other.

In this talk I will show how one can view both of these from the same perspective and extend a similar treatment to the free Poincare inequality in one dimension and some versions in several dimensions.

From the process point one way of treating the inequalities is via the semigroup theory of the free Ornstein-Uhlembeck operator.

Part of this work is together with Christian Houdre. (Received February 10, 2014)

1099-60-302 **Octavio Arizmendi*** (octavius@cimat.mx), Centro de Investigación en Matemáticas, Jalisco S/N, Col. Valenciana., 36240 Guanajuato, Gto., Mexico, and **Takahiro Hasebe** and **Noriyoshi Sakuma**. *On the Law of Free Subordinators.*

We study the freely infinitely divisible distributions that appear as the laws of free subordinators. This is the free analog of classically infinitely divisible distributions supported on $[0,\infty)$, called the free regular measures. We prove that the class of free regular measures is closed under the free multiplicative convolution, t-th boolean power for $0\le t\le 1$, t-th free multiplicative power for $t\ge 1$ and weak convergence. In addition, we show that a symmetric distribution is freely infinitely divisible if and only if its square can be represented as the free multiplicative convolution of a free Poisson and a free regular measure. This gives two explicit examples of distributions which are infinitely divisible with respect to both classical and free convolutions: χ^2 and $F(1,1)$. Another consequence is that the free commutator operation preserves free infinite divisibility. (Received February 10, 2014)

1099-60-322 **Bruce K Driver**, **Nathaniel Eldredge** and **Tai Melcher*** (melcher@virginia.edu). *An example of hypoellipticity in infinite dimensions.*

A collection of vector fields on a manifold satisfies Hörmander's condition if any two points are connected by a path whose tangent vectors only lie in the given directions. It is well-known that a diffusion which is allowed to travel only in these directions is smooth, in the sense that its transition probability measure is absolutely continuous with respect to the volume measure and has a strictly positive smooth density.

Smoothness results of this kind in infinite dimensions are typically not known, the first obstruction being the lack of an infinite-dimensional volume measure. We will discuss recent results on a particular class of infinite-dimensional spaces, where we have shown that vector fields satisfying Hörmander's condition generate a diffusion which has a strictly positive smooth density with respect to an appropriate reference measure. (Received February 10, 2014)

1099-60-349 **Katie Newhall*** (newhall@cims.nyu.edu) and **Eric Vanden-Eijnden**. *Transitions and Recurrence in a Nonlinear Wave Equation and Their Application to Magnetization Reversals.*

A large variety of observable phenomena are mathematically described as transitions between metastable states in a system with many degrees of freedom, such as magnetization reversals. As a toy system for a nanomagnet, we investigate a nonlinear wave equation. Metastability in such an infinite dimensional Hamiltonian system results from the phase-space containing a small bottle-neck separating two states. We discuss the existence of an invariant measure for the stochastic in space but deterministic in time flow, and build on finite dimensional results to compute the average time for transitions across a dividing boundary in phase-space. (Received February 11, 2014)

1099-60-363 **Igor Cialenco** (igor@math.iit.edu) and **Liaosha Xu*** (lxu29@hawk.iit.edu), 2800 S Lowe Ave, Side 2R, Chicago, IL 60616. *Hypothesis Testing for Stochastic PDEs Driven by Additive Noise.*

In this talk, we discuss the simple hypothesis testing problem for the drift/viscosity coefficient for stochastic fractional heat equation driven by additive space-time white noise colored in space. We assume that the first N Fourier modes of the solution are observed continuously over time interval $[0, T]$. We introduce the notion of asymptotically the most powerful test, and find explicit forms of such test in two asymptotic regimes: large time asymptotics $T \to \infty$, and increasing number of Fourier modes $N \to \infty$. The proposed statistics are derived based on Maximum Likelihood Ratio. Over the course of proving the main results, we obtain a series of technical results that are also of independent interest. In particular, we find the cumulant generating function of the log-likelihood ratio, we obtain some sharp large deviation type results for both $T \to \infty$ and $N \to \infty$, and find some useful asymptotics for the power of the likelihood ratio type tests. Besides the theoretical work, we also present some simulation results to illustrate that the idea is sensible and practical. Finally, we show some prospective results for discrete sampling. (Received February 11, 2014)

1099-60-368 **Chad T. Olinger*** (colinger@lanl.gov), MS H434, PO Box 1663, Los Alamos, NM 87545. *Solar Wind Implant Simulations for Improved Understanding of Genesis Solar Wind Collector Results.* Preliminary report.

Simulations of solar wind ions implanted in ultra-pure Genesis Collector materials are improving measurement results by correcting for ions lost due to back-scatter and providing a way to extrapolate measured implant profiles into contaminated regions. Solar wind is modeled for four different solar wind regimes: Bulk, Coronal Hole, Interstream and Coronal Mass Ejection. Input files for the ion simulation code Stopping and Range of Ions in Matter (SRIM) are generated for each regime and isotope of each element studied. Results and impact on the Genesis mission science will be discussed. (Received February 11, 2014)

1099-60-378 **Juan M Restrepo*** (restrepo@math.arizona.edu), Mathematics Department, University of Arizona, Tucson, AZ 85721, and **Shankar Venkataramani**, **Darin Comeau** and **Hermann Flaschka**. *How can you tell whether Earth is warming Up?*

How does one determine whether the high summer temperatures in Moscow of a few years ago was an extreme climatic fluctuation or the result of a systematic global warming trend? How does one perform an analysis of the causes of this summer's high temperatures in the US, if climate variability is poorly constrained? It is only under exceptional circumstances that one can determine whether a climate signal belongs to a particular statistical distribution. In fact, climate signals are rarely "statistical." It is thus often the case that one relies on statistical assumptions in order to compute a trend. There are other challenges in obtaining a trend: inherent multi-scale manifestations, and nonlinearities/non-Gaussianity, incomplete knowledge of climate variability. We propose a non-parametric notion of a trend, we call the tendency, that can handle multi-scale time series and that does not rely on statistical assumptions. Its primary utility lies in the analysis of time series with the aim of discerning structure from processes that could be modeled as noise. (Received February 11, 2014)

1099-60-397 **Jonathan C Mattingly*** (jonm@math.duke.edu), Department of Math, physics building, science drive, Duke University, Durham, NC 27701. *Stabilization by noise.*

I will present some examples of unstable ODES which are stabilized by the addition of noise. The examples will show how a small amount of noise can cause a global change in the behavior of the system. (Received February 11, 2014)

62 ► Statistics

1099-62-238 **Indika P Wickramasinghe*** (indika.wickramasinghe@enmu.edu), Department of Mathematical Sciences, ENMU Station 18, 1500 S Ave K, Portales, NM 88130. *A comparison of the distributions of the estimators of MA (1) parameter for the case of Exponential Power Distributions.* Preliminary report.

In this work, the aim is to make a comparison of distributions of the estimators of moving average order 1(MA(1) parameter). The MA(1) parameter is estimated using three estimators, namely Conditional Least Squared Estimator (CLSE), Methods of Moments (MOME) and Maximum Likelihood Estimator (MLE) under the assumption that the MA(1) model follows an Exponential Power (EP) distribution. Estimation is carried out based on some selected values of the shape parameter ($\beta = 0.5$, 1 and 2) of the EP model, and a comparison among these three estimators is made. According to the obtained results, it is evident that the both MOME and MLE of the MA(1) parameter give better estimation than the CLSE. (Received February 10, 2014)

65 ► Numerical analysis

1099-65-18 **Dr. Kanadpriya Basu*** (kbasu@utep.edu), 500 W. University Ave., El Paso, TX 79968, and **Dr. Maria C. Mariani** (mcmariani@utep.edu), 500 W. University Ave., El Paso, TX 79968. *Local regression type models applied to Geophysics and high frequency market data.* Preliminary report.

In this work we applied locally weighted scatterplot smoothing techniques(Lowess/Loess) to Geophysical and high frequency financial data. We first analyze and applied this technique to the California earthquake geological data. A spatial analysis was performed to show that the prediction of the earthquake magnitude at a fixed location is very accurate up to the relative error of 0.01%. We also applied the same method to the high frequency data set arising in the financial sector and obtained similar satisfactory results. The application of this approach to the two different data sets demonstrate that the overall method is accurate and efficient, and the Lowess approach is much more desirable than the Loess method. Comparing with previous modeling implementations, this model serve completely different information out of the geophysics data: Instead of doing time series analysis, our local regression model perform a spatial analysis. For high frequency data, our model predicts the curve of best fit where data are dependent on time. (Received November 21, 2013)

1099-65-27 **Treena S. Basu*** (treena.basu@gmail.com), 2000 North Parkway, Department of Mathematics and Computer Scienc, Rhodes College, Memphis, TN 38112. *Fast Solution Methods for the Fractional Diffusion Equation and Its Application in Mathematical Finance.* Preliminary report.

Fractional diffusion equations model phenomena exhibiting anomalous diffusion that can not be modeled accurately by the second order diffusion equations. Because of the non-local property of fractional differential operators, the numerical methods have full coefficient matrices which require storage of $O(N^2)$ and computational cost of $O(N^3)$, where N is the number of grid points.

Together we develop a fast finite difference method for the one-dimensional space and time fractional diffusion equation, which only requires storage of $O(N)$ and computational cost of $O(N \log N)$, while retaining the same accuracy and approximation property as the regular finite difference method. Numerical experiments are presented to show the utility of the method.

For example, with 1024 computational nodes, the new scheme developed for the one-dimensional problem has about 40 times of CPU reduction than the standard scheme.

This work introduces a new financial risk assessment model based on Lévy statistics and considers a financial forecasting system that uses a solution to a non-stationary fractional diffusion equation characterized by the Lévy index. (Received December 17, 2013)

1099-65-280 **Daniel Appelo***, The University of New Mexico, Albuquerque, NM 87131, and **Thomas Hagstrom**. *Discontinuous Galerkin methods for Nonlinear Variational Wave Equations.* Preliminary report.

We present new discontinuous Galerkin formulations for second order non-linear variational wave equations. Various choices for the numerical flux and its impact on conservation and rate of convergence will be discussed. Numerical experiments will be presented. (Received February 10, 2014)

1099-65-304 **Rachel Ward*** (rward314@gmail.com), 2515 Speedway, Austin, TX 78712, and **Holger Rauhut**. *Interpolation via l1 minimization.*

Functions of interest are often smooth and sparse in some sense, and both priors should be taken into account when interpolating sampled data. Classical linear interpolation methods are effective under strong regularity assumptions, but cannot incorporate nonlinear sparsity structure. At the same time, nonlinear methods such as l1 minimization can recon- struct sparse functions from very few samples, but do not necessarily encourage smoothness. Here we show that weighted l1 minimization effectively merges the two approaches, promoting both sparsity and smoothness in reconstruction. More precisely, we provide specific choices of weights in the l1 objective to achieve rates for functions with coefficient sequences in weighted lp spaces, p<=1. We consider the implications of these results for spherical harmonic and polynomial in- terpolation, in the univariate and multivariate setting. Along the way, we extend concepts from compressive sensing such as the restricted isometry property and null space property to accommodate weighted sparse expansions; these developments should be of independent interest in the study of structured sparse approximations and continuous-time compressive sensing problems. (Received February 10, 2014)

68 ► Computer science

1099-68-255 **Michael I. Ham*** (mikeh@lanl.gov). *An Exploration of Sampling Methods for Dictionary Learning With a Focus on Object Detection In Imagery.*

Dictionary learning methods have proven extremely robust for algorithms designed to detect objects within imagery and have greatly advanced the state of the art in computer vision. However, human level detection accuracy is still lacking in a broad range of object categories despite the large amount of research, computational power and training sets that have been dedicated to this issue. A potential hypothesis to explain this disparity in accuracy is that modern methods simply do not generate enough unique dictionary elements for classifiers to use when attempting to distinguish and classify objects. To explore this hypothesis, methods for learning a larger number of relevant dictionary elements are presented, and the potential applications of this work are discussed.

LA-UR-14-20769 (Received February 10, 2014)

1099-68-405 **Markus Schläpfer*** (schlmark@mit.edu), MIT, Cambridge, MA 02139. *Quantifying the dynamics of cities with human activity patterns.*

The recent availability of many new and large-scale data of human activities opens up unprecedented possibilities to quantify the social dynamics and organization of cities. Here we show that analyzing society-wide communication networks inferred from mobile phone data allows us *i*) to derive a natural definition of cities, *ii*) to reveal the organization of cities in terms of interacting subcenters, and *iii*) to assess the impact of cities on the network of human interactions. (Received February 12, 2014)

74 ► Mechanics of deformable solids

1099-74-63 **Jong Uhn Kim*** (kim@math.vt.edu), Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123. *Stochastic variational inequality associated with elasto-plastic torsion.*

In this talk, we will discuss an initial value problem for a stochastic variational inequality associated with elasto-plastic torsion. The goal is to establish the existence and uniqueness of a solution. The stochastic problem is reduced to essentially a deterministic problem, which is not covered by existing results on evolution variational inequalities. We propose a definition of a solution in the same spirit as for weak solutions of partial differential equations, and derive some basic consequences of our definition. Based on these results, we can prove the existence and uniqueness of a solution to the stochastic problem. (Received January 23, 2014)

76 ► Fluid mechanics

1099-76-69 **Ivan C. Christov*** (christov@alum.mit.edu), CNLS, MS B258, Los Alamos National Laboratory, Los Alamos, NM 87545. *On eigenfunction expansion solutions for the start-up of fluid flow.*

Most mathematics and engineering textbooks describe the process of "subtracting off" the steady state of a linear parabolic partial differential equation as a technique for obtaining a boundary-value problem with homogeneous boundary conditions that can be solved by separation of variables (i.e., eigenfunction expansions). While this method produces the correct solution for the start-up of the flow of, e.g., a Newtonian fluid between parallel plates, it can lead to erroneous solutions to the corresponding problem for a class of non-Newtonian fluids. We show that the reason for this is the non-rigorous enforcement of the start-up condition in the textbook approach, which leads to a violation of the principle of causality. Nevertheless, these boundary-value problems can be solved correctly using eigenfunction expansions, and we present the formulation that makes this possible (in essence, an application of Duhamel's principle). The solutions obtained by this new approach are shown to agree identically with those obtained by using the Laplace transform in time only, a technique that enforces the proper start-up condition implicitly (hence, the same error cannot be committed). (Received January 25, 2014)

1099-76-119 **Yuri V Lvov*** (lvov@rpi.edu), Department of Mathematical Sciences, Rensselaer Polytechnic Institute, 110 8th street, Troy, NY 12180. *Inverse Cascade in Capillary Waves Turbulence.*

We present an experimental study of surface capillary wave turbulence. In our experiment energy flows not only to small, but also to large scales, thus creating large scale, large amplitude waves. These large scale waves can be seen as a capillary analogue of rogue waves that are sometimes observed in the ocean.

Such energy flux is at odds with previous experiments and with current theoretical picture of capillary wave turbulence.

I will present numerical simulations and theoretical arguments explaining this new and unusual behavior of capillary wave turbulence. (Received February 03, 2014)

1099-76-135 **De Witt L Sumners*** (sumners@math.fsu.edu), Department of Mathematics, 1017 Academic Way, Tallahassee, FL 32306. *Conservation of Writhe and Helicity Under Reconnection.*

Reconnection is a fundamental event in many areas of science, including interaction of fluid vortices and flux tubes in fluid mechanics and magnetohydronamics, and site-specific recombination in DNA. The helicity of a flux tube is a measure of knotting and linking of field lines in the tube, and the absolute value of the helicity is a lower bound for the energy. A theorem of Moffatt and Ricca computes the helicity (a lower bound for energy) of a flux tube in terms of the writhe of the tube centerline and the twist of a ribbon determined by the centerline and one of the other field lines in the tube. We show that the writhe is conserved in a reconnection event. Hence, for a pair of interacting tubes of equal flux, if the twist of the reconnected tube is the sum of twists of the individual tubes, then helicity is conserved in a reconnection event. So, any deviation from helicity conservation is entirely due to twist inserted or deleted at the reconnection site. This result has important implications for helicity and energy considerations in various physical contexts.

This work is joint with Christian Laing and Renzo Ricca. (Received February 04, 2014)

1099-76-278 **C. D. Tomkins*** (ctomkins@lanl.gov), **B. J. Balakumar**, **G. Orlicz**, **K. P. Prestridge** and **J. R. Ristorcelli**. *Evolution of the density self-correlation in developing Richtmyer-Meshkov Turbulence.*

Turbulent mixing in a Richtmyer-Meshkov unstable light-heavy-light (air-SF_6-air) fluid layer subjected to a shock (Mach 1.20) and a reshock (Mach 1.14) is investigated using ensemble statistics obtained from simultaneous velocity-density measurements. The mixing is driven by an unstable array of initially symmetric vortices that induce rapid material mixing and create smaller scale vortices. The density self-correlation $b = -\langle \rho v \rangle$ (where ρ and v are the fluctuating density and specific volume, respectively) and terms in its evolution equation are directly measured experimentally for the first time. Amongst other things, it is found that production terms in the b equation are balanced by the dissipation terms, suggesting a form of equilibrium in b. A lengthscale analysis suggests that an inertial range is beginning to form, consistent with the onset of a mixing transition. Second-order two-point structure functions of the density field exhibit a power-law behavior with a steeper exponent than the standard 2/3 power found in canonical turbulence. The absence of a significant 2/3 region is observed to be consistent with the state of the flow, and the emergence of the steeper power-law region is discussed. (Received February 10, 2014)

1099-76-285 **Benno Rumpf*** (brumpf@mail.smu.edu), Southern Methodist University, Department of Mathematics, Dallas, TX 75275-0156. *An instability of wave turbulence causing the formation of radiating pulses.*

Wave turbulence can be unstable under long modulations via a mechanism that is reminiscent of a negative Landau-damping process. This can lead to a a new mechanism for turbulent transport in systems which support radiating solitary wave packets. The direct energy cascade is provided by evolving pulses, whose widths and carrier wavelengths decrease. The inverse cascade is due to the excitation of radiation. I show how the stability of wave turbulence can be analyzed by deriving a Vlasov-type of envelope equation. I examine these mechanisms for the Majda-McLaughlin-Tabak model. (Received February 10, 2014)

1099-76-291 **Pavel M Lushnikov***, MSC01 1115, 1 University of New Mexico, Albuquerque, NM 87131-0001. *Branch Cut Singularity of Stokes Wave.*

Stokes wave is the fully nonlinear gravity wave propagating with the constant velocity. We consider Stokes wave in the conformal variables which maps the domain occupied by fluid into the lower complex half-plane. Then Stokes wave can be described through the position and the type of complex singularities in the upper complex half-plane.We identified that this singularity is the square-root branch point. We reformulated Stokes wave equation through the integral over jump at the branch cut which provides the efficient way for finding of the explicit form of Stokes wave. (Received February 10, 2014)

1099-76-339 **Alexander O Korotkevich*** (alexkor@math.unm.edu), Department of Mathematics and Statistics, MSC01 1115, 1 University of New Mexico, Albuquerque, NM 87131-0001, and **Vladimir E Zakharov** (zakharov@math.arizona.edu), Department of Mathematics, 617 N. Santa Rita Ave., University of Arizona, Tucson, AZ 85721. *Direct measurement of a spectral line for Phillips spectrum.*

We measure directly from the simulations in the framework of primordial dynamical equations the spectral line for different levels of nonlinearity in the system, corresponding to weakly turbulent Kolmogorov-Zakharov spectrum, intermediate case, and Phillips spectrum. The original motivation of the work was to check one of the assumptions under which kinetic equation for water waves was derived in order to understand whether it can be applied to the Phillips spectrum. It is shown that even in the case of relatively high average steepness, when Phillips spectrum is present in the system, the spectral lines are still very narrow, at least in the region of direct cascade spectrum. It allows us to state that even in the case of Phillips spectrum the kinetic equation can be applied to the description of the ensembles of ocean waves. (Received February 11, 2014)

1099-76-343 **Robert M Owczarek*** (rowczare@unm.edu), 59 Coryphodon Ln, Jemez Springs, NM 87025. *Fluid mechanics in Galilean space-time.* Preliminary report.

The concept of Galilean space-time will be discussed, and proper interpretation of fluid mechanics equations will be presented. (Received February 11, 2014)

1099-76-380 **Sergey A. Dyachenko*** (sdyachen@unm.edu), 1855 Girard Blvd NE, apt 16, Albuquerque, NM 87106, and **Pavel M. Lushnikov** and **Alexander O. Korotkevich**. *Finding the Stokes wave: From Low Steepness to Almost Limiting Wave.*

Stokes wave is a fully nonlinear wave propagating on the surface of deep water. We solve free surface hydrodynamic equations in the framework of conformal variables via Generalized Petviashvili and Newton Conjugate Gradient methods and find Stokes waves in high nonlinearity regimes and study their Pade approximants to infer the analytic structure of Stokes waves. (Received February 11, 2014)

1099-76-396 **Roberto Camassa*** (camassa@amath.unc.edu), The Department of Mathematics, Phillips Hall, CB#3250, UNC-CH, Chapel Hill, NC 27599-3250. *Some fundamental issues in internal wave dynamics.*

One of the simplest physical setups supporting internal wave motion is that of a stratified incompressible Euler fluid in a channel. This talk will discuss asymptotic models capable of describing large amplitude wave propagation in this environment, and in particular of predicting the occurrence of self-induced shear instability in the waves' dynamics for continuously stratified fluids. Some curious properties of the Euler setup revealed by the models will be presented. (Received February 11, 2014)

78 ► Optics, electromagnetic theory

1099-78-140 **Curtis R Menyuk*** (menyuk@umbc.edu), CSEE Dept., 1000 Hilltop Circle, Baltimore, MD 21250, and **Shaokang Wang** (swan1@umbc.edu), CSEE Dept., 1000 Hilltop Circle, Baltimore, MD 21250. *Boundary tracking algorithms for determining the stability of modelocked lasers.*

Modelocked laser pulses can be studied as equilibria of a infinite-dimensional nonlinear dynamical system, whose linear stability can be determined by examining the spectrum of the perturbed system. Despite the importance of modelocked lasers, this approach has only be applied in idealized setting in which analytical solutions for the modelocked (equilibrium) solutions are known. Here, we describe boundary-tracking algorithms that allow us to apply this approach to realistic systems. (Received February 05, 2014)

1099-78-257 **Sky K. Sjue***, Los Alamos National Laboratory, P.O. Box 1663, MS H846, Los Alamos, NM 87545. *The point spread function of a charged particle in a magnetic field: limits, interference phenomena and experimental demonstration.* Preliminary report.

The derivation of an analytic point spread function for a charged particle in a magnetic field will be given in a limit where the Larmor radius divided by the distance of the source from the detector vanishes. More general point spread functions will also be presented; interference phenomena arise when this limit does not hold. Methods will be given to estimate the magnitude of these interference phenomena for a given arrangement of source, detector and magnetic field. Data will be presented which exhibit the consequences of these interference phenomena on the point spread function. (Received February 10, 2014)

1099-78-294 **Pavel M Lushnikov***, MSC01 1115, 1 University of New Mexico, Albuquerque, NM 87131-0001. *Collapse and laser beam combining.*

Solution of a nonlinear Schrodinger equation (NLSE) in dimension two results in finite-time singularity (blow up) for a general class of initial conditions if the L2 norm of the initial condition exceed a critical value. Blow up is often accompanied by a dramatic contraction of the spatial extent of solution, which is called by collapse. We consider application of NLSE to the combing of multiple laser beams, generated by a number of fiber lasers, into a single coherent powerful laser beam. That situation is described by the NLSE with the stochastic initial condition such that the total power (square of L2 norm) exceeds the critical value. We analyze the statistics of the background fluctuations of NLSE solution to produce collapse which results in the spontaneous formation of the powerful coherent laser beam. (Received February 10, 2014)

1099-78-341 **Ildar R Gabitov*** (gabitov@math.arizona.edu), Department of Mathematics, University of Arizona, 617 N Santa Rita, Tucson, AZ 85721, **Andrei Maimistov** (maimistov@pico.mephi.ru), Department of Solid State Physics, Moscow Engineering Physics Institute, Kashirskoe sh. 31, Moscow, and **Zaxylyk Kudyshev** (z.kudyshev@gmail.com), Department of Electrical Engineering, State University of New York at Buffalo, Buffalo, NY 14260. *Parametric process in index graded metamaterials.* Preliminary report.

We considered electromagnetic wave interaction with the graded index nonlinear meta-material, when index of refraction changes sign. Incident field generates surface waves propagating along zero-index interface. Propagation directions of these fields are opposite at the different sides of the interface. Electromagnetic field exhibits strong enhancement at the interface which leads to nonlinear interactions even if incident field is of moderate amplitude. We analyzed parametric wave interaction in case of quadratic nonlinearity. (Received February 11, 2014)

1099-78-385 **Ildar Gabitov*** (gabitov@math.arizona.edu), Department of Mathematics, University of Arizona, 617 N Santa Rita, Tucson, AZ 85721, and **Andrei Maimistov** (maimistov@pico.mephi.ru), Department of Solid State Physics, Moscow Engineering Physics Institute, Moscow, 115409, Russia. *Noncollinear phase matched second harmonic generation in metamaterials.*

We investigated three wave parametric interaction with noncollinear phase matching in metamaterials. In particular, second harmonic generation was considered as a special case of backward waves interaction. Frequency conversion efficiency was analyzed as a function of beams crossing angle. (Received February 11, 2014)

81 ► Quantum theory

1099-81-68 **Constanze Liaw***, One Bear Place #97328, Waco, TX 76798. *Cyclic vectors for rank one perturbations and Anderson-type Hamiltonians.*

We develop a rather explicit approach concerning the extended states conjecture for the discrete random Schroedinger operator. We provide a formula which 'may' lead the way to a rigorous proof of the conjecture, and an implementation of the proposed approach which yields numerical evidence in favor of the conjecture being true for the discrete random Schroedinger operator in dimension two.

This approach is based on the theory of rank one perturbations. (Received January 24, 2014)

1099-81-101 **David Damanik*** (damanik@rice.edu), Rice University, Houston, TX 77005. *Transport exponents associated with the Fibonacci Hamiltonian.*

We discuss transport exponents associated with the Fibonacci Hamiltonian. (Received January 31, 2014)

1099-81-111 **Louis H. Kauffman*** (kauffman@uic.edu), Math UIC, 851 South Morgan Street, Chicago, IL 60607-7045. *Iterants, Majorana Fermions and the Dirac Equation.* Preliminary report.

Iterants are a generalsation of matrix algebra useful for expressing many of the algebras that occur in mathematical physics (such as the Dirac algebra). We will use iterants to discuss the structure of Majorana Fermions. In particular, we will give a Feynman checkerboard model for a Majorana Fermion in the 1+1 case, and we will discuss the possibility of using Majorana Fermions in topological quantum computing. (Received February 03, 2014)

1099-81-220 **Israel Michael Sigal*** (im.sigal@utoronto.ca). *On the Hartree-Fock-Bogolubov and Bogolubov-de Gennes equations.* Preliminary report.

In this talk I will describe recent results on the mathematical origin and properties of the Hartree-Fock-Bogolubov and Bogolubov-de Gennes equations appearing in the theories of Bose-Einstein condensation and superconductivity. (Received February 09, 2014)

1099-81-293 **Bruno Nachtergaele** (bxn@math.ucdavis.edu), Department of Mathematics, One Shields Ave., Davis, CA 95616, **Robert Sims*** (rsims@math.arizona.edu), Department of Mathematics, 617 N. Santa Rita Avenue, Tucson, AZ 85721, and **Gunter Stolz** (stolz@math.uab.edu), Department of Mathematics, Campbell Hall, 1300 University Blvd., Birmingham, AL 35294. *Localization for Disordered Quantum Harmonic Oscillators.*

We consider quantum harmonic oscillator models with random coefficients. Our goal is to find verifiable signatures of many-body localization in simple systems. Given certain conditions on the effective one-particle Hamiltonian, we prove results on localization of the dynamics and localization in specific states. The result on dynamical localization is expressed in terms of a zero-velocity Lieb-Robinson bound. We also prove exponential decay of correlation functions at both zero and positive temperature, demonstrating a form of localization in the ground state and in thermal states. Finally, we prove an area law for the bipartite entanglement of both the ground state and thermal states, as measured by the logarithmic negativity. The above conditions (on the one-particle Hamiltonian) are satisfied for some standard models that are almost surely gapless in the thermodynamic limit. This is joint work with Bruno Nachtergaele and Gunter Stolz (Received February 10, 2014)

82 ► Statistical mechanics, structure of matter

1099-82-67 **Esaias J Janse van Rensburg*** (rensburg@yorku.ca), Mathematics and Statistics, York University, 4700 Keele street, Toronto, Ontario M3J 1P3, Canada. *Modelling the Entropic Pressure near a Knotted Ring Polymer.*

The entropic pressure in the vicinity of a ring polymer in a good solvent can be modelled by lattice polygons in the cubic lattice. In this talk I will explain the Monte Carlo sampling of knotted lattice polygons. The results of these simulations can be used to make numerical estimates of the entropic pressure close to the polygon. A scaling analysis will be presented for the pressure, and tested against the numerical results. In addition, the effect of the knot type on the entropic pressure will be examined. (Received January 24, 2014)

1099-82-72 **Ibrahim Fatkullin***, 617 N Santa Rita Ave, Tucson, AZ 85721, and **Valeriy Slastikov**.
An aggregation model and discotic liquid crystals.
I will discuss a rather simple aggregation model and describe scalings and phase transitions arising in it. Then I will apply the results of this analysis to Onsager-type models of discotic liquid crystals and columnar phases. (Received January 26, 2014)

1099-82-253 **William Yessen*** (yessen@rice.edu). *On the Ising-OPUC Duality.*
A connection between some one-dimensional quantum spin models (including the Ising model) and Jacobi operators via the Jordan-Wigner transformation (1930's or earlier) and the Lieb-Schultz-Mattis ansatz (1960's) is well known. In particular, such a duality allows one to study the spectrum of the spin model in the thermodynamic limit as the spectrum of the associated Jacobi operator; and, as is well known, the Jacobi operators are intimately related to the orthogonal polynomials on the real line. On the other hand, it has been suggested (since the 1980's or earlier) that to classical (in contrast to the quantum) spin models one should also be able to associate an operator on an infinite-dimensional Hilbert space, such that one of the most important quantities of the model, namely the partition function zeros, could be studied as the spectrum of this associated operator. Until recently, such a connection was not known. To a class of models, namely the nearest-neighbor Ising models, we associate a CMV matrix and show that the partition function zeros in the thermodynamic limit can be studied as the (essential) spectrum of the associated CMV matrix (which is to orthogonal polynomials on the unit circle as the Jacobi matrices are to orthogonal polynomials on the real line). (Received February 10, 2014)

1099-82-259 **Stephen D Levene*** (sdlevene@utdallas.edu), Departments of Bioengineering, Molecular and Cell Biology, and Physics, 800 West Campbell Rd, Richardson, TX 75080.
Knot Your Average Guy: a Tribute to Jon Simon and his Contributions to the Energetics of Physical Knots.
The energy of a knot has been defined mathematically in many ways, often with the objective of characterizing an ideal knotted configuration. In this view the ideal knotted state is one that minimizes the associated knot energy. Simon was one of the first to recognize the importance of defining knot energy in a way that makes contact with the physical behavior of real knots including knotted polymers such as DNA. This talk will review the general concept of knot energy, emphasizing the general problem of evaluating energies for topologically and geometrically constrained polymers. We present a novel method for computing the free energy for semi-flexible polymers subject to constraints, a class of problems that has generally eluded standard computational free-energy methods due to the large fluctuations of these systems on their corresponding length scales. (Received February 10, 2014)

1099-82-268 **Christine Soteros*** (soteros@math.usask.ca), 106 Wiggins Road, Saskatoon, SK S7N 5E6, Canada. *Statistics and physics of knots in lattice tubes.* Preliminary report.
Self-avoiding polygons on the simple cubic lattice are the standard statistical mechanics lattice model for ring polymers in dilute solution. A standard model for studying the effects of geometrical confinement on ring polymers is to constrain the self-avoiding polygons to lie in an infinite rectangular lattice tube. In this talk I will review both theoretical and exact enumeration results regarding the knot complexity of compressed and stretched polygons in a lattice tube. (Received February 10, 2014)

1099-82-329 **Mihai Stoiciu*** (mstoiciu@williams.edu) and **Peter Hislop**. *Spectral Properties of Random Schrödinger Operators with Small Coupling Constants.* Preliminary report.
We consider one-dimensional Schrödinger operators $H = -\Delta + \lambda V$ with random potentials V and coupling constants $\lambda > 0$. We describe the behavior of the density of states and the transition in the microscopic eigenvalue statistics of these operators, as the coupling constant λ approaches 0. (Received February 10, 2014)

1099-82-384 **Nicholas M. Ercolani***, Department of Mathematics, Building # 89, University of Arizona, Tucson, AZ. *Random Partitions in Statistical Mechanics.*
We will introduce and describe a family of distributions on spatial random partitions that serve to connect a variety of statistical mechanical models of interest including the ideal Bose gas, the zero range process, particle clustering and spatial permutations. Our results focus on the distribution of the size of the largest "component" in such models. For this introductory talk we will focus on results, including new results, related to fluctuations around the equilibrium state for the ideal Bose gas. This is joint work with Sabine Jansen and Daniel Ueltschi. (Received February 11, 2014)

85 ► Astronomy and astrophysics

1099-85-181 **Hanna E. Makaruk*** (hanna_m@lanl.gov), LANL, MS D410, P-21, Los Alamos, NM 87545, and **Chad T. Olinger**, LANL, MS D434, P21, Los Alamos, NM 87545. *Chelyabinsk Meteorite: what radiography tells about its structure?* Preliminary report.

Los Alamos National Laboratory examined meteorite fragments originated from the atmospheric explosion over Chelyabinsk, Russia 02/15/2013. Nondestructive tests -proton and neutron radiography of two fragments have been performed in order to examine its structure. The results can provide valuable information about the near-Earth Apollo asteroids group, from which the meteor originated. Classic Inverse Abel Transform method allows for density and shape reconstruction of axially symmetric objects from theirs radiograms. The generalization of Abel transform, proposed by the authors at previous AMS Sessions allows for similar investigation of non-axially symmetric objects. Reconstruction of a 3D object from its 2D radiogram requires an additional assumption to make it unique; in case of missing axial symmetry, other information has to be provided. Sufficient information makes this type of reconstruction unique. In complex cases like the meteor fragments examination, estimated assumptions lead to the results which are also known within an experimental uncertainty. A short summary of the method and its validation on a radiogram of a steel sphere with known dimensions and density is presented. After this, an application of the method to the Chelyabinsk Meteorite images is discussed. (Received February 07, 2014)

90 ► Operations research, mathematical programming

1099-90-30 **Qihang Lin*** (qihang-lin@uiowa.edu), 21 East Market Street, PBB S301, Iowa City, IA 52245, and **Xi Chen** (xichen@cs.cmu.edu). *An approximated dynamic programming approach for optimal trade execution problem with a simplified limit order book model.* Preliminary report.

In the optimal trade execution problem, we consider selling a large risky asset before a deadline with a control to the transaction cost. We characterize the price dynamic and the market impacts of transactions using a simplified model of limit order book. We propose an approximated dynamic programming approach to solve the associated Markov decision problem. The performance of the resulting trading strategy is evaluated based on real limit order book data. (Received December 22, 2013)

1099-90-134 **Xikui Wang*** (xikui.wang@umanitoba.ca), Department of Statistics, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada. *Use of Markov decision processes in some finance problems.*

This talk is focused on the use of Markov decision processes and bandit processes for some finance problems including optimal investment and consumption as well as dynamic pricing. Several different models are discussed. We focus on problems where the return functions involve unknown parameters. The Bayesian parametric approach is applied to deal with the unknown parameters. This is joint work with Yanqing Yi, Yan Wang and You Liang. (Received February 04, 2014)

1099-90-283 **Giovanni Petri**, Torino, Italy, and **Samuel V Scarpino*** (scarpino@santafe.edu), Santa Fe, NM. *Local and nonlocal information in a traffic network: how important is the horizon?*

Recent advances in distributed sensor network technology have changed the landscape of traffic optimization in which small, mobile devices are able to sense local information and communicate in real time with one another. Naive optimization algorithms that operate solely on the local or global level are inherently flawed, as global optimization requires sensors to communicate with a centralized base-station, creating prohibitive bandwidth, robustness, and security concerns, while local optimization methods are limited by a near information horizon. Here we investigate an intermediate approach where individual sensors are able to propagate congestion information over a variable distance. For this study, we considered both stylized, random graphs and empirical road networks. Our intermediate strategy consistently out-performed a naive strategy, where every car follows the shortest network path to its destination, but was outperformed by an optimization algorithm that only incorporated local information. The results suggest that local information may represent an upper-bound on performance in models of cascading information. (Received February 10, 2014)

91 ► Game theory, economics, social and behavioral sciences

1099-91-7 **Irinel C. Dragan*** (dragan@uta.edu), 1412 Hyde Park Lane, Arlington, TX 76015. *On the coalitional rationality of the Shapley Value and other efficient values for cooperative transferable utilities games.*

A cooperative transferable utilities game is a pair (N,v), where N is the set of players and v, called characteristic function, is a function defined on the set of subsets of N, with v=o for the empty set. The main problem is to divide fairly v(N) among the players taking into account the capabilities of the coalitions expressed by their worth given by the function v. In a previous work of the author (1991), it has been introduced and solved the inverse problem for the Shapley Value. In the present paper, we are looking for finding games in the Inverse Set for which the Shapley Value is coalitional rational. The same problem is solved for the Least Square Values due to Luiz et. al. Some examples are illustrating the technique. (Received September 03, 2013)

1099-91-12 **Maria Pia Beccar Varela*** (mpvarela@utep.edu), Department of Mathematical Sciences - UTEP, 500 W. University Ave., El Paso, TX 79968-0514. *Analysis of generic diversity data and financial data by using Levy models.*

In this work we analyze different sets of data: generic diversity estimated from the fossil record, financial data, and high frequency (tick) data. We begin by presenting some theoretical results on convolutions of exponential waiting times, as this simple model offers a straightforward starting point for analyzing origination and extinction data. The resulting distributions will be used for comparison with the data sets. We conclude that the Levy flights are appropriate for modeling the three different set of data. (Received November 04, 2013)

1099-91-13 **Maria C. Mariani***, Department of Mathematical Sciences, UTEP, 500 W. University Ave., El Paso, TX 79968-0514. *Extreme events in Finance: Analysis of the Behavior of Major Indices near a Crash.*

In this work Truncated Levy models, Ising models, DFA and Hurst methods are applied to the analysis of financial data. The existence of intermittence and characteristic scales and the prediction by using scale invariance will be also analyzed. (Received November 05, 2013)

1099-91-16 **Ambar N Sengupta*** (ambarnsg@gmail.com). *Mathematical methods for default events.* Preliminary report.

The valuation and risk assessment of portfolios comprised of assets that are impacted by default events require modeling such default phenomena. We present techniques and discuss models for the behavior of default events and their implications for portfolios of assets dependent on such events. (Received November 10, 2013)

1099-91-55 **Ruihua Liu*** (rliu01@udayton.edu), 300 College Park, Mathematics Department, University of dayton, Dayton, 45469-2316. *Optimal Investment and Consumption with Proportional Transaction Costs in Regime-Switching Model.*

This presentation is concerned with an infinite-horizon problem of optimal investment and consumption with proportional transaction costs in continuous-time regime-switching models. An investor distributes his wealth between a risky asset (a stock) and a risk-less asset (a bond) and consumes at a non-negative rate from the bond account. The market parameters (the interest rate, the appreciation rate and the volatility rate of the stock) are assumed to depend on a continuous-time Markov chain with finite number of states (also known as regimes). The objective of the optimization problem is to maximize the expected discounted total utility of consumption. For this optimal control problem, the Hamilton-Jacobi-Bellman (HJB) equation is given by a system of m_0 coupled variational equalities where m_0 is the total number of regimes. For a class of HARA (hyperbolic absolute risk aversion) type utility functions, we establish some fundamental properties of the value function and show that the value function is a viscosity solution of the HJB equation. We then treat a power utility function and derive qualitative properties of the optimal trading strategy and the value function. (Received January 20, 2014)

1099-91-78 **Maria R. D'Orsogna*** (dorsogna@csun.edu), Department of Mathematics, California State University at Northridge, 18111 Nordhoff Avenue, Los Angeles, CA 91330. *Evolutionary games for crime, recidivism and rehabilitation of criminal offenders.*

We present two evolutionary games to study crime and intervention strategies. In our first adversarial game, players choose whether to actively harm others and whether to cooperate with authorities. Among the four possible strategies that arise is the "informant" who cooperates with authorities while still committing crimes. Our dynamics lead to high or low crime equilibration regimes depending and on the number of informants,

suggesting that the latter may be of crucial importance in helping reduce crime. Our second "carrot and stick" game is motivated by recent efforts to treat and rehabilitate nonviolent offenders rather than focusing solely on their punishment. In our game, individuals commit crimes depending on their history, environment and in the case of recidivists, on any available counseling or training programs. We find that the most successful strategy to decrease recidivism is in carefully balancing punishment and intervention programs. Excessively harsh or lenient punishments are found to be less effective. We present stochastic simulations and ODEs connected to our models and discuss experimental realizations conducted on actual human subjects. (Received January 27, 2014)

1099-91-176 **Martin B Short***, School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332. *Mathematical modeling of crime hotspots.*

Many crime types exhibit strong spatio-temporal clustering; such clusters are often referred to as crime hotspots. The driving forces behind this clustering have been extensively studied by criminologists for many years, but the mathematical nature of these processes has received little attention. In this talk, I will present mathematical models and techniques that I and my colleagues have used to understand the dynamics of hotspot formation, ranging from partial differential equations to statistical density estimation. Throughout, I will discuss the link between the criminological understandings and the mathematics, and also show how the mathematical models allow insight into the process that go beyond what the criminological studies readily allow. (Received February 07, 2014)

1099-91-237 **Simina Branzei*** (simina@cs.au.dk) and **Peter Bro Miltersen**. *A Dictatorship Theorem for Cake Cutting.*

We consider discrete protocols for the classical Steinhaus cake cutting problem. Under mild technical conditions, we show that any deterministic strategy-proof protocol in the standard Robertson-Webb query model is dictatorial, that is, there is a fixed agent to which the protocol allocates the entire cake. In contrast, we exhibit randomized protocols that are truthful in expectation and compute approximately fair allocations. (Received February 10, 2014)

1099-91-247 **Nick Foti** and **Scott D. Pauls*** (scott.pauls@dartmouth.edu), 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03766, and **Daniel Rockmore**. *Systemic Risk: Robustness and Fragility in Trade Networks.*

We explore systemic risk in an organic system which changes and evolves over time, the World Trade Web (WTW). Our goal is to better understand the risk that a country exposes itself to through mere participation in trade. We find situations where participants in the WTW are exposed to risk no matter what choices they make or safeguards they put in place.

We have two main findings. First, the WTW is robust to relatively small shocks but not to larger ones. Second, for small shocks, increasing edge density correlates with increasing robustness while for large shocks, the opposite is true. This supports the view that globalization, as witnessed by growing edge density, increases the ability of a system to absorb shock up until a certain size, whereupon the shock overwhelms the system and sparks a broader contagion. (Received February 10, 2014)

1099-91-263 **Gangaram S. Ladde*** (gladde@usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 East Fowler Avenue, CMC 342, Tampa, FL 33620-5700. *Energy Function Method and Stochastic Mathematical Finance.* Preliminary report.

We present several examples to illustrate the role and scope of the "Energy function Method" in the study of stochastic dynamic processes. Moreover, a special attention is given to problems in stochastic mathematical finance. (Received February 10, 2014)

1099-91-305 **Simon DeDeo*** (sdedeo@indiana.edu), School of Informatics and Computing, 901 E 10th St., Bloomington, IN 47408. *From Wikipedia to the Arab Spring: Game Theory and Collective Cognition.*

In an analysis of range of social systems, from online collaboration in Wikipedia to revolutionary activity in Tahir Square, we find a common structure to social reasoning that crucially involves the formation of long-term memories and dispositions. No individual member serves as the system memory or reasoner; these dispositions are, instead, collective states of the group as a whole. The underlying computational structure appears to make use of at least one (formally) unbounded resource. We provide a game theoretic account of group-level strategies based on a simple belief-formation mechanism, and show the challenges that arise in connecting these group level phenomena to the beliefs and desires of the underlying individuals. (Received February 10, 2014)

92 ► Biology and other natural sciences

1099-92-25 **Ranadhir Roy*** (rroy@utpa.edu), Mathematics Department, University of Texas Pan American, 1201 West University Drive, Edinburg, TX 78539. *Inverse Problem in Optical Tomography.*

Near infrared (NIR) optical imaging is a developing diagnostic tool for cancer screening. A novel image reconstruction (inverse problems) algorithm was developed and was formulated as a nonlinear least-squares-type simple bounds constrained optimization problem. Reconstruction problem is ill-posed. To make the reconstruction problems well-posed, the penalty modify barrier function method (PMBF) is used instead of Tikhonov regularization technique. The accuracy and the rapid convergence of the PMBF method require a good initial guess of the Lagrange multipliers. To obtain the initial guess of the multipliers, we use a least square unconstrained minimization problem. Three dimensional images are reconstructed from contact and noncontact experimentally measured data with good accuracy. (Received December 11, 2013)

1099-92-164 **Rossitza N. Irobalieva** (irobalie@bcm.edu), **Jonathan M. Fogg** (fogg@bcm.edu), **Daniel J. Catanese, Jr.**, **Anna K. Barker** (anna.barker@bcm.edu), **Michael F. Schmid** (mschmid@bcm.edu), **Wah Chiu** (wah@bcm.edu) and **Lynn Zechiedrich*** (elz@bcm.edu), One Baylor Plaza, Mail-stop: BCM-280, Baylor College of Medicine, Houston, TX 77030. *How linking number affects the structure and reactivity of DNA.* Preliminary report.

The negatively charged sugar-phosphate backbone contains no genetic information yet forms the accessible exterior of the DNA double helix. Hydrophobic bases, the readout of the genetic code, are buried within the interior of the helix. We hypothesized that the seemingly contradictory requirements of DNA stability and readout are accomplished via a tightly-regulated switch whereby torsional strain causes localized structural alterations, including base-flipping, denaturation, and other non-B-DNA structures. Molecular dynamic simulations had indicated that our hypothesis was correct (Randall, G.L., Zechiedrich, L., and Pettitt, B.M. (2009) Nucleic Acids Res 37, 5568), but it had never been tested directly. Using tiny, closed circles of DNA, we demonstrate that the structural alterations brought about by torsional stress, base-flipping and denaturation in the underwound, negatively supercoiled direction, and likely inside-out Pauling-like DNA in the overwound, positively supercoiled direction, facilitate access to the genetic code to initiate DNA readout. Funded by NIH T90DK070121 (R.N.I.), NIH P41RR02250 (W.C.), and NIH R01AI054830 and the Human Frontier Science Program (L.Z.). (Received February 06, 2014)

1099-92-177 **Jennifer L Schei*** (jlschei@lanl.gov), **Garrett T Kenyon** and **John S George**. *Deciphering Retinal Encoding in Vision Processing.*

As our eyes scan the surrounding environment, changes in luminosity and color sweep across the retina. Photoreceptors in the retina detect these changes in light and convey signals through the retina to the ganglion cells, which ultimately encode the information about spatial and temporal contrast and transmit it to the visual cortex via the optic nerve. Initial methods for analyzing signals from the retina investigated spike timing from individual retinal ganglion cells; such studies led to the recognition that the rate of neuronal spiking encodes the magnitude of the signal. However, more recent studies measuring the simultaneous activity of many neurons support the hypothesis that spatiotemporal correlations between cells contain more robust information about visual features than single cell spike trains. By analyzing correlations of spike events between neighboring cells, we show that higher spatial frequency features are encoded through spatiotemporal correlations compared to spiking rate, especially for moving stimuli. These results suggest that spatiotemporal correlations may help encode relationships between local features in visual stimuli. (Received February 07, 2014)

1099-92-201 **Isabel K Darcy*** (idarcymath@gmail.com), 14 MLH, Mathematics Department, Iowa City, IA 52242, and **Annette Honken** (annette-honken@uiowa.edu), 14 MLH, Mathematics Department, Iowa City, IA 52242. *Topological Distances on DNA Knots and Links.*

Topoisomerases and recombinases are two classes of proteins which can knot circular DNA. Type II topoisomerases are proteins which cut one double-stranded DNA segment, allowing a second DNA segment to pass through before resealing the break. This is mathematically modeled by changing a crossing. Recombinases break two segments of DNA, exchanging the DNA ends before resealing the breaks. This action can be mathematically modeled by smoothing a crossing. Distances between knots have been defined based upon the minimum number of times these proteins must act to convert one knot into another knot. Methods for calculating these distances will be discussed. Applications and ways to visualize and analyze these distances via graphs and KnotPlot will be discussed. (Received February 08, 2014)

1099-92-250 **Javier Arsuaga*** (jarsuaga@sfsu.edu), Mathematics Department, San Francisco State University, San Francisco, CA 94132. *Topological analysis of chromosome conformation capture data.* Preliminary report.

Chromosome conformation capture data provides an unprecedented opportunity to analyze the three dimensional organization of genomes. The richness of the data, the apparently endless trajectories that explain the data and their accuracy call for new mathematical methods. In this talk I will present topological tools we are developing for analyzing three dimensional reconstructions of the genome. (Received February 10, 2014)

1099-92-287 **Jeffrey C. Nekola*** (jnekola@unm.edu), Biology Department, Castetter Hall, University of New Mexico, Albuquerque, NM 87131. *Universal diversity patterns across complex natural and social systems.*

In 1950 Frank Preston noted that the frequency distribution of species abundances in ecological communities was remarkably similar to the Boltzmann distribution of molecular kinetic energies and the Pareto distribution of personal incomes. He later expanded this list to include marriage ages of Danish, British, and US women, the longevity of restaurant drink tumblers, and the stress required to fracture microscope slides. This correspondence runs deeper and also includes power-law species area/time relationships and the non-linear distance decay of similarity. A striking resemblance even exists between the body-size distribution of beetles in Borneo tree canopies and cars in York and Heathrow Airport parking lots. Social scientists – as well as ecologists – are thus faced with three major tasks: 1) documenting those patterns which reflect general cross-disciplinary expectations; 2) searching for ultimate mechanisms of these patterns; and 3) we must understand which patterns can and can not be altered. I consider these issues via a thorough cross-disciplinary investigation the non-linear distance decay, and will show how variation in its functional form (power-law like vs. exponential) and decay rate provides important insights regarding system dynamics. (Received February 10, 2014)

1099-92-296 **Mariel Vazquez*** (mariel@sfsu.edu), Mathematics Department, San Francisco State U, 1600 Holloway Ave, San Francisco, CA 94132, and **Javier Arsuaga** and **Brian Cruz**. *Knots in bacteriophages.* Preliminary report.

DNA presents high levels of condensation in all organisms. We are interested in the problem of DNA packing inside bacteriophage capsids. Bacteriophages are viruses that infect bacteria, and DNA extracted from bacteriophage P4 capsids is highly knotted. These knots can shed information on the packing reaction and DNA architecture inside the capsid. I here will overview a few research questions stemming from the DNA packing problem. (Received February 10, 2014)

1099-92-357 **Sarah A Harris*** (s.a.harris@leeds.ac.uk), Leeds, LS2 9JT, United Kingdom, **Thana Sutthibuttpong**, Leeds, United Kingdom, **Agnes Noy**, Leeds, United Kingdom, and **Charles Laughton**, , United Kingdom. *Sequence Dependent Denaturation in Small DNA Circles: A Multi-scale Approach.*

The discovery of the structure of duplex DNA revealed how cells store genetic information. Small DNA circles offer a controllable model system for the systematic exploration of the dependence of DNA structure on supercoiling. We use computer simulation to explore the supercoiling-dependent conformation of small DNA circles and how this is affected by supercoiling. However, even given the most powerful supercomputers currently available, we are unable to perform fully atomistic simulations over sufficiently long timescales to gain adequate statistics to quantify patterns of sequence dependent denaturation due to supercoiling. Consequently, in ongoing calculations we are comparing the results of the atomistic models with statistical mechanical methods [1] and coarse-grained simulations [2].

[1] Mitchell J. S., Laughton C. A. & Harris S. A. Atomistic simulations reveal bubbles, kinks and wrinkles in supercoiled DNA. Nucleic Acids Res. 2011. 39: p. 3928-3938. [2] Sulc P., Romano F., Ouldridge T. E, Rovigatti L., Doye J. and Louis A. A. Sequence-dependent thermodynamics of a coarse-grained DNA model. J. Chem. Phys. 2012, 137, 135101. [3] Wang, H.Q. and Benham, C.J, Superhelical Destabilization in Regulatory Regions of Stress Response Genes. PLoS Comp. Biol., 2008, 4, e17. (Received February 11, 2014)

1099-92-360 **Elizabeth A. Hobson*** (emoseman@nmsu.edu), NM , and **Simon Dedeo**. *From aggression to dominance: the logic of missing links closes the gap between behavior and knowledge.* Preliminary report.

Individual actions are fundamentally important in the emergence of group-level social structure. Dominance hierarchies in animals are built from ranking individuals based on patterns of aggression. Hierarchies can also provide knowledge that can facilitate inference of third-party relationships. We analyzed aggression in two groups of captive monk parakeets (*Myiopsitta monachus*) to (1) quantify the behavioral structure that led to the formation of a dominance hierarchy and (2) test whether individuals used third-party information contained in the hierarchy to make strategic decisions about how to behave. Basic models of aggression can reproduce the rank-order hierarchy without attributing great cognitive complexity to individuals. However, these models were unable to account for the complex ways in which actual birds expressed aggression. Instead, behavior was structured well beyond that predicted by simple hierarchy maintenance. Analysis of graph motifs in the aggression network revealed that observed aggression is structured in part by the existence of transitive chains. These transitive chains provided a cognitively-accessible structure that individuals could use infer third-party relationships and avoid unnecessary and potentially costly social interactions. (Received February 11, 2014)

1099-92-403 **Sean T. Hammond*** (seanth@unm.edu), **James H. Brown**, **Astrid Kodric-Brown**, **Joseph R. Burger**, **Trevor S. Fristoe**, **Norman Mercado-Silva**, **Jeffrey C. Nekola**, **Jordan G. Okie** and **Tatiana P. Flanagan**. *Human Macroecology: Food, Storage, Transportation, and Human Civilization.* Preliminary report.

Food is essenital to human survival.

Prior to 11,000 years ago, all evidence implies that human groups were limited to a hunter-gatherer lifestyle where seasonal variations would greatly influence their success. The Malthusian-Darwinian dynamic–where environmental constraints are modified through the use of technological and cultural adaptations–led to millenia during which humans have learned to reshape their environment and themselves, leading to increases in population and economic output.

Starting with the assumptions that 1) thermodynamics results in a zero sum game in human and natural systems, 2) that smaller systems are interconnected with larger ones, and 3) that there are hard global limits on the resources available on the planet, the Malthusian-Darwinian dynamic forces human societies to create complex support systems. From hunter-gather societies and progressing through early agricultural settlements, city states, nations, and empires, basic scaling rules about how human systems are organized emerge. These patterns are of particular interest when considering the vulerability of the global food system in relation to projected decreases in petrolium supply. (Received February 12, 2014)

94 ► Information and communication, circuits

1099-94-316 **Christopher M. Brislawn*** (brislawn@lanl.gov), Los Alamos National Laboratory, Information Sciences Group (CCS–3), Mail Stop B265, Los Alamos, NM 87545-1663.
Groups of Linear Phase Filter Banks.

FIR filter banks are the digital incarnations of compactly supported wavelet transforms. Linear phase filter banks correspond to symmetric or antisymmetric wavelets and are particularly important in applications like digital signal and image coding. Filter banks are represented mathematically by invertible *polyphase transfer matrices* over (Laurent) polynomial rings. *Lifting factorization* is a method for factoring such transfer matrices into elementary matrix decompositions such that each factor matrix has a single off-diagonal lifting filter. Transfer matrix factorizations are useful for both theoretical and practical engineering purposes, and the theory of factoring linear phase transfer matrices into linear phase lifting factors has a particularly rich algebraic structure because of the various symmetries involved. The polyphase matrices for odd-length linear phase filter banks form a nonabelian matrix polynomial group known as the *whole-sample symmetric (WS) group*. Results of the author on uniqueness of linear phase lifting factorizations for WS filter banks are used to characterize the group-theoretic structure of the WS group up to isomorphism. Analogous results are also obtained for even-length (*half-sample symmetric*) filter banks. (Received February 10, 2014)

97 ► Mathematics education

1099-97-290 **Aaron Hill*** (aaron.hill@unt.edu). *Some aspects of designing a course for prospective elementary school teachers.*

In the fall of 2011, as a new postdoc, I was given the opportunity to teach a math course for prospective elementary school teachers. In the fall of 2012 I taught an experimental version of the same course, with major changes to the structure of the course. In this talk I'll describe some specifics of how I approached the design of the course, the eventual structure I decided upon, and key features of the implementation that I think contributed to the success of the course. I'll also describe what I might do differently if I were to teach the same course again. (Received February 10, 2014)

1099-97-347 **Ted Stanford*** (stanford@nmsu.edu). *The Properties of Addition and Multiplication.* Preliminary report.

The Common Core State Standards put a strong emphasis on the properties of operations and their relation to computation and sense-making. However, for many teachers and educations, "properties" are not naturally as central to understanding operations as they are to mathematicias. How to bridge this gap? I will argue two points. First, "properties" should be understood more broadly than just the standard ones with names (commutative, distributive, etc). Second, some properties are more important than others, and deserve more instructional time and attention. I will approach these two points from several directions: theorems, models, computations, applications, and common student misconceptions. (Received February 11, 2014)

1099-97-350 **Kevin McLeod*** (kevinm@uwm.edu), Department of Mathematical Sciences, EMS Building, Room E403, P.O. Box 413, Milwaukee, WI 53201-0413. *How Can Institutes of Higher Education Best Support the Common Core State Standards for Mathematics?*

The Common Core State Standards for Mathematics (CCSSM) were rapidly adopted by 45 states, the District of Columbia, the US Department of Defense, and several US territories. More recently, however, opposition to the Common Core has been building in many states, and it is likely that this opposition will strengthen as results of Common Core-aligned assessments are made public. This presentation will provide some background information on the opposition to the Common Core in Wisconsin, and will suggest ways in which university mathematics departments, and institutes of higher education generally, might consider visibly supporting the CCSSM. While the presentation will focus on the Common Core, the real question is more general: how can we in higher education support our K-12 colleagues as they attempt the hard task of raising student expectations in mathematics? (Received February 11, 2014)

1099-97-351 **Kyle L Swanson*** (kswanson@uwm.edu), Department of Mathematical Sciences, University of Wisconsin-Milwaukee, PO Box 413, Milwaukee, WI 53201. *Mathematics across the high school-college transition: An administrative view of collaboration and transformational change.*

Introduction of standards-based curriculum such as the Common Core raises the important question of 'What math do we teach (and why)?' at the college developmental level. However, the history of math education reform suggests that changing curricular structure in relation to desired learning outcomes is a necessary but not sufficient solution to improving student success in pre- college mathematics. Rather, math practice standards such as those explicit in the common core invite the questions 'How do we teach?' and 'How do we know students have learned the math?' which are directed more at the culture of teaching mathematics. This presentation will describe a transformational change in the developmental mathematics program at a large urban research university that has occurred in response to asking these questions, and how this change has impacted the collaboration dynamic with area secondary schools regarding mathematics content at the 11th and 12th grade levels. (Received February 11, 2014)

1099-97-361 **Theresa A. Jorgensen*** (jorgensen@uta.edu). *Connecting university mathematics faculty to the K-12 classroom via research mathematics integrated in the curriculum.*

Preparing future K-12 mathematics teachers is a key component of most university mathematics departments. University-level mathematicians have expertise in teaching, learning, and researching mathematics at the post-secondary level, but few mathematicians have opportunities to connect their expertise with K-12 education. We provide a model for meaningful interaction between research mathematicians, their graduate students, and K-12 educators. This cooperation results in the creation and implementation of classroom lessons that seamlessly integrate research mathematics into local elementary, middle, and high school mathematics classrooms. This work is supported in part by the NSF GK-12 program. (Received February 11, 2014)

1099-97-369 **Richard S Kitchen*** (richard.kitchen@du.edu), 1999 E. Evans, Denver, CO 80208. *Modeling the CCSS-M Mathematical Practices to Support the Learning of All.* Preliminary report.

Implementation of the Common Core State Standards in Mathematics (CCSS-M) has the potential to move forward key features of standards-based reforms in mathematics that have been promoted in the U.S. for more than two decades (see for example, NCTM, 1989; 2000; NSF, 1996). Prospective and practicing K-12 teachers of mathematics need extensive training and professional development support to both understand the mathematics contained within the CCSS-M and to learn how to effectively teach these standards.

One way that Mathematics faculty can support CCSS-M is by becoming aware of the eight Standards for Mathematical Practice and working to model these practices in their instruction. Modeling such instruction

could be particularly valuable for prospective secondary mathematics teachers who often teach mathematics as they were taught (Kitchen, 2005). In addition, teaching mathematics in ways aligned with the CCSS-M mathematical practices are important to support the learning of all students. In this talk, I will specifically address the potential of Mathematical Practice 1, making sense of problems and persevering in solving them, and Mathematical Practice 4, modeling with mathematics to support the learning of low-income, culturally and linguistically diverse students. (Received February 11, 2014)

1099-97-389 **Rebecca H McGraw*** (rmcgraw@math.arizona.edu), 617 N. Santa Rita Ave., Tucson, AZ 85721. *From K12 to the University and Back Again: Preparing Future Teachers with an Eye to the Common Core.* Preliminary report.

Prominent in the Common Core Standards for Mathematics is a transformational approach to foundational topics in middle and high school geometry. Unfortunately, university students, including those preparing to become teachers, often have minimal previous exposure to transformations, to transformation-based definitions of congruence and similarity, and to proving theorems through transformations. In addition, middle/high school textbooks may not provide beginning teachers with enough guidance and support. It is incumbent upon those of us who teach future teachers to find effective methods for preparing our students.

The author is the instructor of an undergraduate, Euclidean geometry course that is required of future teachers at the author's institution. Through cycles of development and implementation over the past three years, teaching strategies and lesson plans have been developed in an effort to (1) address gaps in the knowledge of incoming students, (2) combine study of transformations with attention to a wider range of topics, and (3) prepare future teachers to go "back again" to the K12 classroom. Foci of lessons include development of definitions, properties of transformations, triangle congruence, and properties of quadrilaterals. (Received February 11, 2014)

1099-97-395 **Guadalupe Lozano*** (guada@math.arizona.edu), 617 N Santa Rita Ave, University of Arizona, Mathematics, Tucson, AZ 85721-0089. *Framing the Transition from High School to College in the Time of the Common Core.* Preliminary report.

In many ways, the CCSSM crystallize a perspective on what it means to know mathematics that has existed in college reform curricula since the early 90s.

But what exactly do I mean by reform mathematics curricula? In what ways has the Common Core philosophy been latent in such curricula and teaching practices? And how may such connections guide or come to bear upon the training of secondary teachers?

In this talk I will outline partial answers to these questions with a focus on college readiness in the time of the Common Core. I will illustrate similarities and differences between college entry courses curricula and practices, and the CCSSM with a primary focus on the function domains.

Recent views of college freshmen and secondary school teachers on streamlining the transition from high school to college will be weaved into the content discussion. (Received February 11, 2014)

1099-97-401 **Emina Alibegovic*** (emina@math.utah.edu), Department of Mathematics, 155 South 1400 East, JWB233, Salt Lake City, UT 84112-0090. *Mathematics teaching major as an interdisciplinary major.*

Mathematics departments tend to have a teaching major as one of the options on the list of majors offered. Teaching major generally has 2-5 required courses which differ from those for math majors of other flavors. These courses are taught by mathematicians who deem the topics therein as appropriate for the teaching profession. We will discuss why this might be an insufficient preparation for the pre-service teachers in their field of study. We will further discuss how we can think of mathematics teaching major as an applied, interdisciplinary major and how to design courses that fit this description. (Received February 11, 2014)

1099-97-404 **Diana White*** (diana.white@ucdenver.edu). *What knowledge do mathematicians need to contribute to K12 education?*

The Common Core State Standards are proving a once in a generation opportunity for those involved with K12 mathematics education. With our deep disciplinary content knowledge and our responsibility for the bulk of the mathematics content that future teachers learn, mathematicians can play a prominent role in this. However, we have only one piece of the puzzle, making partnerships important. In this talk, we investigate some of the other knowledge that mathematicians need to know to contribute effectively to K12 mathematics education, where they might gain such knowledge, and how we might support them in their efforts. (Received February 12, 2014)

1099-97-407 **Kristin Umland*** (umland@math.unm.edu), **Justin Boyle** (boylej@unm.edu) and **Michael Nakamaye** (nakamaye@math.unm.edu). *The Common Core and University Mathematics Instruction.* Preliminary report.

The Common Core State Standards for Mathematics (CCSSM) have been adopted by 45 states, and their wide adoption allows for them to provide a framework to talk about the interplay between K-12 and university mathematics, although these issues transcend the standards themselves. This framework presents at least two opportunities/challenges for university instructors. First, many people have noted that we need to adapt the way teachers are prepared to help them help students meet these new, higher expectations. What should mathematics faculty know and how can they help with this? Second, the standards also expect mathematical work that is in some cases different than traditional entry-level mathematics courses as they call for more reasoning and applications. Are there implications for the mathematics classes we ask first and second year university students to take? This talk will outline the framework embodied by the CCSSM and talk in broad strokes about these opportunities and challenges. (Received February 12, 2014)

00 ▶ General

1100-00-126 **Rebecca R. OWENS***, rebecca.owens@ttu.edu. *Changes in Texas Playas Over The Past Three Decades.*

Playas are ephemeral freshwater wetlands that are important resources for people and wildlife in Texas. Due to intense land conversion, playas have been deliberately or inadvertently modified. Activities such as drainage and infill have caused some playas to be lost altogether. However, it is unknown the quantity of playas that have been lost, particularly given the seasonal and interannual wet/dry periods, and the inherently dynamic nature of playas. This is important information to know in light of projected climate change in this area. In my project, I used satellite imagery to identify playas containing water during wet and dry portions of three decades (1980's, 1990's, 2000's) relative to historic locations of playas based on hydric soils in a 34000 km^2 portion of the Texas panhandle. I then examined the number and size distributions of playas that held water at least once versus those that were either wet or dry the entire time. There were over 8000 playa basins identified in my stud area based on hydric soil. I found that a large number of the playa basins no longer held water even during wet times; in contrast, there were relatively few playas that never went dry. My research provides important foundational information of temporal changes in playa wetlands. (Received February 05, 2014)

03 ▶ Mathematical logic and foundations

1100-03-6 **JASIM MOHAMMED ALI ALTAMEEMI*** (`jasimtimimi@yahoo.com`), , Iraq. *The effect of using a site for a tutorial on the Internet for teaching mathematics.*

ABSTRACT

The research aims to know the use of an educational site on the Internet for teaching mathematics in the university academic achievement. To test the research hypotheses, were provided an educational site on the Internet has been developed and tested Academic achievement was extracted, Indications of sincerity and Reliability coefficient formed the research sample of (60) students, students from the first stage of the students of Yarmouk University - Department of Computer Science was divided into two groups (experimental group and control group). And the application of research procedures and the use of statistical treatments appropriate, the results of research that have been reached the following The existence of statistically significant differences in academic achievement of university mathematics e attributed to the variable method of teaching through educational site on the Internet for the benefit of the experimental group. (Received August 22, 2013)

1100-03-334 **Karl Backs***, University of North Texas, Department of Mathematics, 1155 Union Circle #311430, Denton, TX 76203-5017, and **Steve Jackson** and **R Daniel Mauldin**. *CH, V=L, disintegration of measures and* Π^1_1 *sets.* Preliminary report.

In 1950 Maharam asked whether every disintegration of a σ-finite measure into σ-finite measures is necessarily uniformly σ-finite. Over the years under special conditions on the disintegration, the answer was shown to be yes. However, we show here that the answer may depend on the axioms of set theory in the following sense. If CH, the continuum hypothesis holds, then the answer is no. One proof of this leads to some interesting problems in infinitary combinatorics. If Gödel's axiom of constructibility $\mathbf{V} = \mathbf{L}$ holds, then not only is the answer no, but, of equal interest is the construction of $\mathbf{\Pi}^1_1$ sets with very special properties.

This is joint work with Steve Jackson and R. Daniel Mauldin. (Received February 10, 2014)

05 ▶ Combinatorics

1100-05-49 **George E Andrews*** (`gea1@psu.edu`), Department of Mathematics, 306 McAllister Bldg., University Park, PA 16802. *The seventh order mock theta functions revisited.*

In 1986, Hecke type expansions (involving indefinite quadratic forms) were found for the fifth and seventh order mock theta functions of Ramanujan. The treatment of the fifth order functions relied on the classical q-hypergometric series hierarchy. The treatment of the seventh order functions relied on ad hoc recurrence

arguments. In this talk we discuss a recent, unified approach to these problems which has the advantage of introducing an infinite family of results whose first two instances are instances of the fifth and the seventh order mock theta functions respectively. (Received January 24, 2014)

1100-05-72 **Krishnaswami Alladi*** (alladik@ufl.edu), Department of Mathematics, 358 Little Hall, University of Florida, Gainesville, FL 32611. *Basis partitions and their signature.*

Basis partitions are minimal partitions corresponding to successive rank vectors. We show combinatorially how basis partitions can be generated from primary partitions which are equivalent to the Rogers-Ramanujan partitions. This leads to the definition of a signature of a basis partition that we use to deduce and explain certain parity results involving partial theta series. We then study a special class of basis partitions which we term as complete. Finally we discuss basis partitions and minimal basis partitions among partitions with non-repeating odd parts by representing them using 2-modular graphs, and establish two new parity results involving partial theta series. (Received January 28, 2014)

1100-05-190 **Briana Foster-Greenwood** and **Cathy Kriloff*** (krilcath@isu.edu). *Spectra of Cayley graphs of complex reflection groups.*

We present a result on integrality of eigenvalues of the adjacency, distance, and codimension matrices of the Cayley graphs of finite reflection groups with respect to all reflections. This generalizes a similar result of Renteln for real reflection groups, but requires new techniques because the reflection length function and codimension function can differ for complex reflection groups. This is joint work with Briana Foster-Greenwood. (Received February 07, 2014)

1100-05-357 **Scott Lacy***, scott.lacy@mavs.uta.edu. *Looking Glass Neofields.*

A neofield is a set with two binary operations similar to a field, with the addition not necessarily associative and the multiplication not necessarily commutative. In his 1948 paper L.J. Paige presented all known results with his own contributions in admissible groups and planar neofields. The notion of a property-D neofield was introduced by A.D Keedwell in his 1966 paper in relation to orthogonal latin squares. Property D neofields are known to exist for every order up to 20, except 2 and 6, and are believed to exist for every finite order greater than 20. In this talk we discuss a class of commutative property-D neofields, and in particular examine a family of commutative property-D neofields of order $2^k + 1$ for all $k > 2$. (Received February 10, 2014)

11 ► Number theory

1100-11-19 **Charles L Samuels*** (clsamuels@okcu.edu) and **Tanner J Strunk** (tjstrunk@okcu.edu). *Optimal Factorizations in the Metric Mahler Measures.*

Let $m_t(\alpha)$ denote the t-metric Mahler measure of the algebraic number α. Recent work of the first author established that the infimum in $m_t(\alpha)$ is attained by a single point $\bar{\alpha}$ for all sufficiently large t. Unfortunately, this work does not suggest an efficient method for locating $\bar{\alpha}$. We define a new tree data structure, called a factorization tree, which enables us to find $\bar{\alpha}$ when $\alpha \in \mathbb{Q}$. We establish several basic properties of factorization trees, and use these properties to locate $\bar{\alpha}$ in previously unknown cases. (Received January 09, 2014)

1100-11-27 **Ivan Horozov*** (horozov@math.wustl.edu), Washington University in t. Louis, Department of Mathematics, One Brookings Dr, Campus Box 1146, Saint Louis, MO 63130. *Cohomology of $GL(4, Z)$ with non-trivial coefficients.*

I compute the cohomology groups of $GL(4, Z)$ with coefficients in symmetric powers of the standard representation twisted by the determinant. This problem arises in Goncharov's approach to the study of motivic multiple zeta values of depth 4. I use Borel-Serre compactification, a result of Harder on Eisenstein cohomology and a computationally effective version for the homological Euler characteristic of arithmetic groups from my thesis. (Received January 14, 2014)

1100-11-50 **George E Andrews*** (gea1@psu.edu), Department of Mathematics, 306 McAllister Bldg., University Park, PA 16802, and **James A Sellers**. *Congruences for Fishburn Numbers.*

The Fishburn numbers, $\xi(n)$, are defined to be the number of upper triangular matrices with nonnegative integer entries, without zero row or column sums such that the sum of the entries is n. The Fishburn numbers grow superexponentially so that their generating function only converges at zero. We prove that if p is prime and a quadratic nonresidue modulo 23, then there is a nonempty set, T(p), of integers in [0,p-1] such that if j is in T(p), then $\xi(pn + j)$ is congruent to 0 modulo p for all nonnegative integers n. (Received January 24, 2014)

1100-11-65 **Jesse Thorner*** (jthorn5@emory.edu). *Bounded Gaps Between Primes in Chebotarev Sets.*

A new and exciting breakthrough due to Maynard and Tao establishes that there exist infinitely many pairs of primes p_1, p_2 with $|p_1 - p_2| \leq 600$ as a consequence of the Bombieri-Vinogradov Theorem. In this paper, we apply their general method to the setting of Chebotarev sets of primes. We study applications of these bounded gaps with an emphasis on ranks of prime quadratic twists of elliptic curves over $\mathbb{Q}$. (Received January 27, 2014)

1100-11-70 **Michael J Griffin*** (mjgrif3@emory.edu), Department of Mathematics & Computer Science, Emory University, Atlanta, GA 30322, and **Ken Ono** and **Ole Warnaar**. *A framework of Rogers-Ramanujan identities and their arithmetic properties.*

The two Rogers–Ramanujan q-series

$$\sum_{n=0}^{\infty} \frac{q^{n(n+\sigma)}}{(1-q)\cdots(1-q^n)},$$

where $\sigma = 0, 1$, play many roles in mathematics and physics. By the Rogers–Ramanujan identities, they are essentially modular functions. Their quotient, the Rogers–Ramanujan continued fraction, has the special property that its *singular values* are algebraic integral units. We find a framework which extends the Rogers–Ramanujan identities to doubly-infinite families of q-series identities. If $a \in \{1, 2\}$ and $m, n \geq 1$, then we have

$$\sum_{\substack{\lambda \\ \lambda_1 \leq m}} q^{a|\lambda|} P_{2\lambda}(1, q, q^2, \ldots; q^n) = \text{“Infinite product modular function”}.$$

The $P_\lambda(x_1, x_2, \ldots; q)$ are “extended” *Hall–Littlewood polynomials*. We identify our q-series as specialized characters of affine Kac–Moody algebras, and show that their singular values are algebraic. Generalizing the Rogers–Ramanujan continued fraction, we prove in the case of $A_{2n}^{(2)}$ that the relevant q-series quotients are again algebraic integral units. (Received January 27, 2014)

1100-11-74 **Arunabha Biswas*** (arunabha.biswas@ttu.edu), Broadway & Boston, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, and **Chris Monico** (chris.monico@ttu.edu), Broadway & Boston, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Limiting value of higher Mahler measure.*

We consider the k-higher Mahler measure $m_k(P)$ of a Laurent polynomial P as the integral of $\log^k |P|$ over the complex unit circle. In this talk I shall present an explicit formula for the value of $|m_k(P)|/k!$ as $k \to \infty$. (Received January 28, 2014)

1100-11-98 **Alejandra Alvarado** and **Edray Herber Goins*** (egoins@math.purdue.edu), Mathematical Sciences Building, 150 North University Street, West Lafayette, IN 47907-2067. *Arithmetic Progressions on Curves.*

The set $\{1, 25, 49\}$ is a 3-term collection of integers which forms an arithmetic progression; the common difference is 24. Hence the set $\{(1,1), (5,25), (7,49)\}$ is a 3-term collection of rational points on the parabola $y = x^2$ whose y-coordinates form an arithmetic progression. Similarly, the set $\{6, 12, 18\}$ is a 3-term collection of integers which also forms an arithmetic progression; the common difference is 6. Hence the set $\{(6,3), (12,39), (18,75)\}$ is a 3-term collection of rational points on the elliptic curve $y^2 = x^3 - 207$ whose x-coordinates form an arithmetic progression. Are there other examples such as these? What is the longest progression of rational points on either a quadratic or cubic curve such that either the x- or y-coordinates form an arithmetic progression? In this talk, we give a survey on what's known about arithmetic progressions on algebraic curves. We introduce elliptic curves as a means to show the non-existence of certain arithmetic progressions. We also introduce bielliptic curves in order to settle conjectures of Saraju P. Mohanty. This project is joint work with Alejandra Alvarado. (Received February 01, 2014)

1100-11-105 **Ameya Pitale*** (apitale@ou.edu). *CAP representations for GL(2,D).*

The Saito-Kurokawa liftings are examples of Siegel modular forms obtained from elliptic modular forms and constitute the first counter-examples to the generalized Ramanujan conjecture. In representation theoretic terms, they give rise to CAP representations for GSp(4). We present an analogous lifting from Maass forms to automorphic forms on 5 dimensional hyperbolic space. These give rise to cuspidal representations of GL(2,D,) where D is a definite quaternion algebra, that are CAP representations and violate the generalized Ramanujan conjecture. This is joint work with Masanori Muto and Hiro-aki Narita. (Received February 03, 2014)

1100-11-106 **Paul Jenkins*** (jenkins@math.byu.edu) and **David J. Thornton**. *Congruences for Coefficients of Modular Functions.*

We examine canonical bases for spaces of modular functions of small level with poles only at the cusp at ∞, and show that many of the Fourier coefficients of elements of these bases are divisible by high powers of the primes dividing the level. This extends results of the first author and Andersen. (Received February 03, 2014)

1100-11-109 **Igor E Pritsker*** (igor@math.okstate.edu), Department of Mathematics, 401 MSCS, Oklahoma State University, Stillwater, OK 74078. *Asymptotic distribution and symmetric means of algebraic numbers.*

Schur introduced the problem on the smallest limit point for the arithmetic means of totally positive conjugate algebraic integers. This area was developed further by Siegel, Smyth and others. We consider several generalizations of the problem that include questions on the smallest limit points of symmetric means. The key tool used in the study is the asymptotic distribution of algebraic numbers understood via the weak* limits of their counting measures. We establish interesting properties of the limiting measures, and find the smallest limit points of symmetric means for totally positive algebraic numbers of small height. (Received February 03, 2014)

1100-11-113 **Armin Straub*** (astraub@illinois.edu), 1409 W. Green St., Mathematics Department, University of Illinois at Urbana-Champaign, Urbana, IL 61801. *Multivariate Apéry numbers and supercongruences of rational functions.*

The Apéry numbers $A(n)$ are the famous sequence which underlies Apéry's proof of the irrationality of $\zeta(3)$. Together with their siblings, known as Apéry-like, they enjoy remarkable properties, including connections with modular forms, and have appeared in various contexts. One of their (still partially conjectural) properties is that these sequences satisfy supercongruences, a term coined by Beukers to indicate that the congruences are modulo exceptionally high powers of primes. For instance,

$$A(p^r m) \equiv A(p^{r-1} m) \pmod{p^{3r}}$$

for primes $p \geq 5$. In this talk, we realize the Apéry numbers as the diagonal coefficients of a simple rational function in four variables and demonstrate that supercongruences hold for all Taylor coefficients of this rational function. We then indicate that this fresh perspective on supercongruences extends to other Apéry-like numbers. (Received February 04, 2014)

1100-11-132 **Adele Lopez*** (adele.lopez@emory.edu). *Kummer congruences arising from the mirror symmetry of an elliptic curve.*

In the genus 1 case, mirror symmetry reduces to the statement that a certain family of generating functions, relating to an elliptic curve, are quasimodular. In their proof of this fact, Kaneko and Zagier used a related family of generating functions $A_n(\tau)$, which they show to be quasimodular. We show that these A_n's also satisfy Kummer-type congruences. Additionally, we show that for a prime p, the pth power coefficients of A_n p-adically converge to zero, for specific values of n. (Received February 05, 2014)

1100-11-149 **Detchat Samart*** (detchats@math.tamu.edu). *The elliptic trilogarithm and Mahler measures of $K3$ surfaces.*

The Mahler measure of an n-variable Laurent polynomial P is defined to be the arithmetic mean of $\log(|P|)$ over the n-dimensional torus. We derive explicitly a connection between the Zagier elliptic trilogarithm and Mahler measures of certain families of three-variable polynomials. These results exhibit new relationships between families of $K3$ surfaces and the families of elliptic curves which give rise to Shioda-Inose structures of the surfaces. We will also briefly explain how these results imply some identities relating the elliptic trilogarithm to special values of L-functions. (Received February 06, 2014)

1100-11-162 **Bruce C. Berndt*** (berndt@illinois.edu), Dept. of Mathematics, University of Illinois, 1409 W. Green St., Urbana, IL 61801. *Partition Identities Inspired by Ramanujan.*

Our study has its origin in the work of H. M. Farkas and I. Kra, who observed that certain theta function identities can be transformed into remarkable identities for partition functions. The present author then observed that many of these theta function identities can be recast in the language of Ramanujan's modular equations. The author and his co-author, Roberta Rui Zhou, continue this study. First, we examine Ramanujan's formulas for multipliers from his second notebook, and find that each implies a beautiful partition identity. Second, inspired by the work of Ole Warnaar and Sun Kim on bijective proofs of partition identities arising from modular equations, in a recent systematic study, Colin Sandon and Fabrizio Zanello offered 30 conjectured partition identities. The author and Zhou have now proved all of these identities, but we emphasize that bijective proofs have yet to be found. We discuss both of these two facets of our work on partitions in this lecture. (Received February 06, 2014)

1100-11-184 **Kimball Martin*** (kmartin@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 17055. *Explicit non-vanishing of quadratic twist L-functions.* Preliminary report.

We are interested in the following question: let f be a modular form which is a cuspidal eigenform. Let $K = \mathbb{Q}(\sqrt{D})$ be the quadratic field of discriminant D, and χ_D the associated Dirichlet character. When can one say the central L-value $L(1/2, f, \chi_D)$ is nonzero? Many results along the lines of "given f, infinitely many quadratic twists are nonzero" are well known. We'll examine the question of specifically determining which twists are nonzero. This is joint work with Phillipe Michel and Dinakar Ramakrishnan. (Received February 07, 2014)

1100-11-194 **Sarah Trebat-Leder*** (strebat@emory.edu), **Ken Ono** and **Larry Rolen**. *Connecting Classical and Umbral Moonshine Through Borcherds Products.*

The classical theory of monstrous moonshine describes the unexpected connection between the representation theory of the monster group M, the largest of the simple sporadic groups, and certain modular functions, called Hauptmodln. In particular, the Fourier coefficients of Hauptmoduln are graded traces T_g of $g \in M$ acting on V, a special infinite dimensional representation of M. Similar phenomena have been shown to hold for the Matthieu group M_{24}, but instead of modular functions, mock-modular forms must be used. This has been conjecturally generalized even further, to umbral moonshine, which associates to each of 23 Niemeier lattices a finite group, infinite dimensional representation, and mock-modular form. We use generalized Borcherds products to relate monstrous moonshine and umbral moonshine. Namely, we use mock-modular forms from umbral moonshine to construct via generalized Borcherds products rational functions of the Hauptmoduln T_g from monstrous moonshine. This allows us to associate to each pure A-type Niemeier lattice a conjugacy class g of the monster group, and gives rise to identities relating dimensions of representations from umbral moonshine to values of T_g. (Received February 08, 2014)

1100-11-198 **Thomas Garrity*** (tgarrity@williams.edu), Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. *On Some Functional Analysis Behind Multidimensional Continued Fractions.* Preliminary report.

At the heart of the proof behind the Gauss-Kuzmin statistics for traditional continued fractions is the transfer operator. The functional analysis behind this operator has been extensively studied for many years, and has some links with special functions. We will look at analogous results for a certain multidimensional continued fraction algorithm. We will show that this algorithm's transfer operator has leading eigenvalue one for a particular Banach space and is nuclear of trace class zero for a particular Hilbert space.

We will review the continued fraction case, explain the triangle multidimensional continued fraction algorithm, explicitly find its transfer operator and then explore its spectral properties. It is in the last part that special functions will (briefly) appear. (Received February 08, 2014)

1100-11-204 **Frank Garvan*** (fgarvan@ufl.edu), Department of Mathematics, University of Florida, PO BOX 118105, Gainesville, FL 32611-8105. *Universal mock theta functions and two-variable Hecke-Rogers identities.*

We obtain two-variable Hecke-Rogers identities for three universal mock theta functions. This implies that many of Ramanujan's mock theta functions, including all the third order functions, have a Hecke-Rogers-type double sum representation. We find new generating function identities for the Dyson rank function, the overpartition rank function, the $M2$-rank function and related spt-crank functions. Results are proved using the theory of basic hypergeometric functions. (Received February 08, 2014)

1100-11-212 **Ameya Pitale**, **Abhishek Saha** and **Ralf Schmidt*** (rschmidt@math.ou.edu). *Local and global Maass relations.*

The first counterexamples to the naive formulation of the Ramanujan conjecture for Siegel modular forms of degree 2 were the Saito-Kurokawa liftings, discovered in the 1970s. These liftings are characterized by relations among their Fourier coefficients known as the Maass relations. In this talk we present a p-adic version of the Maass relations. This local version characterizes certain spherical representations of the group GSp(4,F), where F is a p-adic field, in terms of relations satisfied by their spherical vector in a special Bessel model. We show that the classical Maass relations are a consequence of the local relations. (Received February 08, 2014)

1100-11-213 **Bruce C. Berndt*** (berndt@illinois.edu), Dept. of Mathematics, University of Illinois, 1409 W. Green St., Urbana, IL 61801. *A Riesz Sum Analogue of an Identity in Ramanujan's Lost Notebook.*

In his lost notebook, Ramanujan states without proofs two remarkable identities that are connected with the famous unsolved circle and divisor problems. The identities involve double series of Bessel functions. In the study of the average order of arithmetical functions, say $a(n)$, an identity for $\sum_{n\leq x} a(n)$ may not exist, but an identity for the Riesz sum $\sum_{n\leq x} a(n)(x-n)^{\alpha}$ may exist for sufficiently large α. For Ramanujan's identity associated with the divisor problem, we establish a Riesz sum identity involving double series of Bessel functions that generalizes Ramanujan's result. This continues the work of the author and his coauthors, Sun Kim and Alexandru Zaharescu, connected with the aforementioned two identities of Ramanujan. (Received February 08, 2014)

1100-11-214 **Tim Huber*** (hubertj@utpa.edu), **Danny Lara** and **Esteban Melendez**. *Symmetric generators for graded rings of modular forms.*

A number of theta function representations for modular forms due to Klein and Ramanujan have apparent symmetric form. These are shown to be special cases of more general symmetric constructions on graded rings of modular forms for congruence subgroups of prime level $N \geq 5$. The symmetry reflects a permutative action of $\Gamma_0(N)$ on certain weight one generators for the rings. For low levels, the symmetry is linked to the action of classical Kleinian automorphism groups on vectors of theta constants. The theta quotients generating each ring have interesting formulations in terms of twisted Eisenstein series and satisfy similarly symmetric coupled systems of differential equations. (Received February 08, 2014)

1100-11-231 **Alexander Berkovich*** (alexb@ufl.edu). *On partition inequalities.*

I describe an injection technique to prove a new class of partition inequalities involving certain q -products with two finitization parameters. New theorems represent a substantial generalization of work by Andrews and of previous work by Berkovich and Grizzell. (Received February 09, 2014)

1100-11-272 **Dylan Airey** and **Bill Mance***, mance@unt.edu. *Some fractals associated with unexpected distribution phenomenon resulting from Cantor series expansions.*

We will compute the Hausdorff dimension of a large class of fractals that arise naturally from Cantor series expansions. As a result, we will generalize many preexisting results including H. G. Eggleston's theorem on the Hausdorff dimension of sets of nonnormal numbers. (Received February 09, 2014)

1100-11-281 **Taylor Dupuy*** (dupuy@math.ucla.edu) and **Alexandru Buium**. *Arithmetic Picard-Vessiot Theory.*

We present definitions and basic constructions in an arithmetic analog of differential Galois theory. (Received February 09, 2014)

1100-11-298 **Jenny G. Fuselier*** (jfuselie@highpoint.edu). *Traces of Hecke operators in level 1 and Gaussian hypergeometric functions.*

In this talk, we explore some extensions of formulas relating traces of p^{th} Hecke operators in level 1, traces of Frobenius of families of elliptic curves, and values of finite field hypergeometric functions. Initial results carried the restriction $p \equiv 1 \pmod{12}$. In 2011, Lennon removed this restriction to prove a formula relating values of a ${}_2F_1$ function over $\mathbb{F}_q$ to traces of Frobenius of families of elliptic curves over $\mathbb{F}_q$, where $q = p^e$ and $q \equiv 1 \pmod{12}$. In this talk, we provide a general formula for the traces of p^{th} Hecke operators in level 1 (for all $p > 3$) in terms of the trace of Frobenius of a family of elliptic curves over $\mathbb{F}_p$. Then, we combine this result with Lennon's work to produce formulas for traces of p^{th} Hecke operators in level 1 in terms of hypergeometric functions over $\mathbb{F}_{p^2}$. (Received February 10, 2014)

1100-11-304 **Yasuyuki Kachi*** (kachi@math.ku.edu), Snow Hall 405, 1460 Jayhawk Boulevard, Lawrence, KS 66045-7523, and **Pavlos Tzermias** (tzermias@neptune.math.upatras.gr), 26500 Rion, Patras. *Generalization of Bernoulli polynomials and analytic continuation of Riemann-Hurwitz zeta function.* Preliminary report.

We all know that $f_n(k) = 1^n + 2^n + 3^n + \cdots + k^n$; $n = 1, 2, ..$ are polynomials in k. In part because $f_n(k) = \zeta(1, -n) - \zeta(k+1, -n)$ where $\zeta(s, x) := \sum_{j=0}^{\infty}(s+j)^{-x}$ is Riemann-Hurwitz zeta function, $f_n(s)$, or $B_n(s) := (\partial/\partial s)\, f_n(s-1)$ (Bernoulli polynomials), had been under intense scrutiny. Dozen generalizations were crafted. Among all, Akiyama-Tanigawa's Pascal-like triangle (ATT) is striking. While $B_n(s)$ reflect much of the trait of $\zeta(s, x)$, they alone do not have a capacity to recover $\zeta(s, x)$. We (1) define a double-sequence $\{m_{i,j}(t, s)\}$ of polynomials using $Ler(z, s, x) := \sum_{j=0}^{\infty} z^j (s+j)^{-x}$. (2) For each $n = 1, 2, ..$ write $\zeta(s, x)$ as a series involving

$m_{i,j}(t,s)$ over $\{x;\, \mathrm{Re}\, x > -n\}$. This differs from the classical Euler sum and a recent work by Rubinstein. (3) $\{(\partial^2/\partial t \partial s) m_{i,j}(t,s)|_{s=t=1}\}$ is ATT. Thus $\zeta(1,x)$ is written as a sum involving numbers in ATT. (4) Analyze automorphisms on the algebraic curves $C_{i,j} := \{m_{i,j}(t,s) = 0\}$ in conjunction with the functional identity for $Ler(z,s,x)$ by Apostol and Berndt. (Received February 10, 2014)

1100-11-311 **AE JA YEE*** (yee@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *The truncated Jacobi triple product theorem.*

Recently, G. E. Andrews and M. Merca considered the truncated version of Euler's pentagonal number theorem and obtained a non-negativity result. They asked the same question on the truncated Jacobi triple product identity. In this talk, we will discuss the question. (Received February 10, 2014)

1100-11-325 **W. Cheng**, **S. Chaubey** and **Amita Malik*** (amalik10@illinois.edu), 1409 W Green Street, Urbana, IL 61801, and **A. Zaharescu**. *On the parity of broken k-diamnond partitions.*

We discuss several new parity results for broken k-diamond partitions on certain types of arithmetic progressions. We also obtain bounds for the parity of broken k-diamond partitions and more general colored partitions. (Received February 10, 2014)

1100-11-329 **Katherine Thompson*** (kthompson0721@gmail.com). *Positive Definite Quaternary Quadratic Forms Over* $\mathbb{Q}(\sqrt{5})$.

In this talk, we will describe how to use the theory of local densities (developed by Siegel) and Hilbert modular forms to provide proofs of universality and almost-universality of quaternary positive definite quadratic forms over $\mathbb{Q}(\sqrt{5})$. (Received February 10, 2014)

1100-11-343 **Ramin Takloo-Bighash*** (rtakloo@math.uic.edu), Department of Math, Stat, and Comp Sci, University of Illinois at Chicago, 851 S Morgan St (M/C 249), Chicago, IL 60202. *Certain Siegel modular forms of genus 2.* Preliminary report.

In this talk I will discuss certain (non-cuspidal) Siegel modular form that show up in connection with certain Abelian surfaces. This is work in progress with Kumar Murty. (Received February 10, 2014)

1100-11-352 **Bruce C. Berndt**, **Atul Dixit** and **Arindam Roy***, Department of mathematics, 1409 West green street, Urbana, IL 61801, and **Alexandru Zaharescu**. *Generalization of Ramanujan's double Bessel function series identities.*

On page 335 in his Lost Notebook, S. Ramanujan claimed two identities involving finite trigonometric sums and doubly infinite series of Bessel functions. These two identities are closely connected with the classical divisor and circle problems. It was only recently that these identities were proved. In this talk, we present a generalization of these identities. One of these new identities is connected to the generalized divisor problem.

This talk is a continuation of the talk by A. Dixit in the 'Special Session on Complex Function Theory and Special Functions'. This is joint work with B.C. Berndt, A. Dixit and A. Zaharescu. (Received February 10, 2014)

12 ► Field theory and polynomials

1100-12-57 **Wei Li*** (liwei@mmrc.iss.ac.cn), Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No.55 Zhongguancun East Road, Beijing, 100190, Peoples Rep of China. *Sparse Difference Resultant and Difference Chow Form.*

In this talk, we first define the sparse difference resultant for a Laurent transformally essential system and then discuss its basic properties by comparing with its differential counterpart. We also propose an algorithm to compute the sparse difference resultant. The algorithm is single exponential in terms of the Jacobi number, the number of variables, and the size of the Laurent system.

Besides, we present an intersection theory for generic difference polynomials. We show that the intersection of an irreducible difference variety of dimension $d > 0$ and order h with a generic difference hypersurface of order s is an irreducible difference variety of dimension $d - 1$ and order $h + s$. Based on the intersection theory, we define the difference Chow form for an irreducible difference variety and give its basic properties.

This talk is based in part on joint work with X.S. Gao and C.M. Yuan. (Received January 26, 2014)

1100-12-138 **Andy R Magid*** (amagid@ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73072. *Differential étale extensions.* Preliminary report.

The étale property for commutative algebra asserts that ring homomorphisms to square–zero extensions lift. We show that a similar result obtains for certain simple differential rings, although the requirement is more stringent than differentially simple, and we show by example that not all Picard–Vessiot rings have this "'differential étale" property. The requirement is met, however, for Picard–Vessiot rings of Picard–Vessiot closures. (Received February 05, 2014)

1100-12-242 **Michael Wibmer***, Lehrstuhl für Mathematik (Algebra), RWTH Aachen, 52056 Aachen, Germany. *Finiteness properties of difference algebraic groups.* Preliminary report.

We will present some basic finiteness results for affine difference algebraic groups, i.e., groups defined by algebraic difference equations. Like affine algebraic groups correspond to Hopf algebras which are finitely generated as algebras, affine difference algebraic groups correspond to difference Hopf algebras which are finitely generated as difference algebras. In the language of Hopf algebras, one of our finiteness results may be stated as follows:

Let R be a difference Hopf algebra which is finitely generated as a difference algebra. Then every difference Hopf ideal of R is finitely generated as a difference ideal.

This is a surprising fact as the basis theorem in difference algebra only yields that perfect difference ideals are finitely generated as perfect difference ideals. (Received February 09, 2014)

1100-12-328 **Arne Ledet*** (arne.ledet@ttu.edu). *Generic polynomials for quaternion groups.* Preliminary report.

The known construction of a generic polynomial for the quaternion group Q_8 over $\mathbb{Q}$ is generalised to produce generic polynomials for larger quaternion groups over fields containing appropriate 'cosines', such as $\mathbb{R}$. Since Q_{16} is known to *not* have a generic polynomial over $\mathbb{Q}$, these 'cosines' are necessary. In the case of Q_{16}, we get a generic polynomial over $\mathbb{Q}(\sqrt{2})$. (Received February 10, 2014)

1100-12-387 **Thomas Warren Scanlon*** (scanlon@math.berkeley.edu), Department of Mathematics, Evans Hall, Berkeley, CA 94720-3840. *Algebraic differential equations associated to Shimura varieties.* Preliminary report.

It is well-known that the analytic j-function, $j : \mathfrak{h} \to \mathbb{C}$ with $j(\tau) = \exp(-2\pi i\tau) + 744 + 196884\exp(2\pi i\tau) + 21493760\exp(4\pi i\tau) + \cdots$ satisfies a nonlinear algebraic differential equation of order three. Buium showed that, in fact, there is a differential rational function χ on $\mathbb{A}^1$ regarded as the moduli space of elliptic curves having the properties that (1) the fibres of χ are finite dimensional and (2) if a and b are the moduli points of isogenous elliptic curves, then $\chi(a) = \chi(b)$.

Using a remarkable strengthening of Chow's Theorem due to Peterzil and Starchenko to the effect that an o-miniminally definable meromorphic function on a (not necessarily projective) algebraic variety must be rational, we show that all Shimura varieites possess corresponding algebraic differential operators. (Received February 11, 2014)

13 ► Commutative rings and algebras

1100-13-14 **Kai Fong Ernest Chong*** (kc343@cornell.edu), Department of Mathematics, 310 Malott Hall, Cornell University, Ithaca, NY 14853. *An application of liaison theory to the Eisenbud-Green-Harris conjecture.*

In this talk, we discuss how liaison theory can be used to prove the Eisenbud-Green-Harris conjecture for a certain subclass of homogeneous ideals in the linkage class of a complete intersection ideal. Our emphasis will be on explaining the underlying motivation for identifying this particular subclass of ideals. In the case of three variables, we show that the conjecture is true for Gorenstein ideals. (Received December 12, 2013)

1100-13-61 **Hannah L Altmann*** (hannah.altmann@ndsu.edu). *Semidualizing complexes over tensor products.* Preliminary report.

Let R be a commutative, noetherian ring with identity. An R-complex C is *semidualizing* if C is homologically finite and the homothety map $\chi^R_C : R \to R\operatorname{Hom}_R(C, C)$ is an isomorphism in D(R). We will discuss the existence of nontrivial semidualizing complexes over tensor products of algebras over a field. (Received January 26, 2014)

1100-13-79 **Hans Schoutens*** (hschoutens@citytech.cuny.edu), 365 Fifth Avenue, NY, NY 10016.
Higher canonical modules and balanced depth.

Over a complete CM ring, Grothendieck duality enables us to study the local cohomology of a module. Moreover, the "dualizing" module is canonically defined, whence its eponymous name. Whereas duality fails over non CM rings, there is still a canonically defined module: the Matlis dual of the top local cohomology of the ring. However, the lower local cohomology does no longer vanish, so we should also study their Matlis duals. These are what I term the "i-th higher canonical modules".

Any CM ring is unmixed, which implies the following "balanced" behavior: any system of parameters is a regular sequence. However, this fails for non CM rings of depth $e < d$: the first e elements in a system of parameters do not necessarily form a regular sequence. If this stronger property nonetheless holds, then we will say that the ring (or module) has "balanced depth" e. I will show that balanced depth can be expressed in terms of the dimensions of the higher canonical modules. (Received January 29, 2014)

1100-13-85 **Roberto Barrera***, Department of Mathematics, Texas A&M University, Mailstop 3368, College Station, TX 77843-3368. *Computing quasidegrees of $\mathbb{Z}^d$-graded modules.* Preliminary report.

Inspired by results on A-hypergeometric systems, we consider $\mathbb{Z}^d$-graded $\mathbb{C}[y]$-modules M and compute the Zariski closure in $\mathbb{C}^d$ of the set $\{\beta \in \mathbb{Z}^d \mid M_\beta \neq 0\}$. This is particularly interesting when $M = H^i_{\mathfrak{m}}(\mathbb{C}[\mathbb{N}A])$, the local cohomology of a semigroup ring with support in the maximal ideal. This is work in progress. (Received January 30, 2014)

1100-13-86 **Tony Se*** (tse@math.ku.edu). *Asymptotic Stability of Associated Primes of $F(M/(I^nM))$.* Preliminary report.

Let R be a commutative Noetherian ring and F a functor from the category of finitely generated R-modules to the category of (finitely generated) R-modules. Let $I \subseteq R$ be an ideal and M a finitely generated R-module. Brodmann has shown that the sets of associated primes $\operatorname{Ass}_R M/(I^nM)$ become independent of n for large n. We will discuss some results on whether or not the same holds for the sets $\operatorname{Ass}_R F(M/(I^nM))$. (Received January 30, 2014)

1100-13-100 **Sean SatherWagstaff*** (sean.sather-wagstaff@ndsu.edu) and **Sandra Spiroff**. *On the structure of S_2-ifications of complete local rings.*

Motivated by work of Hochster and Huneke, we investigate several constructions related to the S_2-ification T of a complete equidimensional local ring R: the canonical module, the top local cohomology module, topological spaces of the form $\operatorname{Spec}(R) - V(J)$, and the (finite simple) graph Γ_R with vertex set $\operatorname{Min}(R)$ defined by Hochster and Huneke. We generalize one of their results by showing, e.g., that the number of maximal ideals of T is equal to the number of connected components of Γ_R. We further investigate this graph by exhibiting a technique for showing that a given graph G can be realized as one of the form Γ_R. (Received February 02, 2014)

1100-13-101 **Chris Francisco*** (chris@math.okstate.edu), 401 MSCS, Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Huy Tai Ha** and **Adam Van Tuyl**. *Developments on the persistence problem.* Preliminary report.

Let I be a squarefree monomial ideal in $R = k[x_1, \ldots, x_n]$. One version of the persistence problem asks: If a prime $P \in \operatorname{Ass}(R/I^s)$, under what conditions is $P \in \operatorname{Ass}(R/I^{s+r})$ for all $r \geq 0$? We will survey progress on this question from the last few years. Work in which I have been involved is joint with Tài Hà and Adam Van Tuyl. (Received February 02, 2014)

1100-13-119 **Saeed Nasseh*** (snasseh2@unl.edu) and **Sean Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu). *Vanishing of Tor over trivial extensions of DG algebras and applications.*

In this talk we discuss some applications of the vanishing of Tor over certain trivial extensions of DG algebras. In particular, we show that a local ring R of embedding codepth at most 3 has at most two semidualizing complexes up to shift-isomorphism, namely, R itself and a dualizing R-complex if one exists. (Received February 04, 2014)

1100-13-136 **Madhav P Sharma*** (msharma2@fau.edu), Florida Atlantic University, Department of Mathematical Sciences, 777 Glades Road, Boca Raton, FL 33431, and **Lee Klingler** and **Thomas G Lucas**. *Maximally Prüfer rings.*

A commutative ring R is said to be a Prüfer ring if every finitely generated regular ideal is invertible, and is said to be a locally Prüfer ring if R_P is a Prüfer ring for every prime ideal P of R. We call the ring R maximally Prüfer if R_M is Prüfer for every maximal ideal M of R. We show that the class of maximally Prüfer rings lies properly between Prüfer rings and locally Prüfer rings. We give a characterization of such rings in terms of the total quotient ring and the core of the regular maximal ideals. We also find a relationship of such rings with strong Prüfer rings. (Received February 05, 2014)

1100-13-154 **Jeff Madsen***, University of Notre Dame, 219 Hayes-Healy Center, Notre Dame, IN 46556-5641. *Rees algebras of parameterized plane curves.* Preliminary report.

If C is a rational parameterized plane curve of degree d, the bihomogeneous coordinate ring of its graph is given by the Rees algebra of an almost complete intersection ideal in $k[x, y]$. The Rees algebra can be viewed as the quotient of the symmetric algebra by its torsion ideal A. Finding a minimal generating set of A is largely an open problem, though it has been solved, for instance, for $d \leq 6$ by the work of Buse and of Kustin, Polini, and Ulrich. I will present results that can be used to find all possible bidegrees of the minimal generators of A when $d = 7$, and show how these degrees correspond to the singularities of C. (Received February 06, 2014)

1100-13-160 **H. Ananthnarayan**, **E. Celikbas** and **Z. Yang***, 203 Avery Hall, Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Associated graded rings and connected sums.*

A connected sum is a construction that can be used to produce Gorenstein rings. We will explore some connections between associated graded rings and connected sums. In particular, we will look at conditions on the associated graded ring of a Gorenstein Artin k-algebra, Q, which force Q to be a connected sum. We will also see some applications at the end. (Received February 06, 2014)

1100-13-175 **Arindam Banerjee*** (ab4cb@virginia.edu), Department of Mathematics, Kerchof Hall, University of Virginia, Charlottesville, VA 22903. *Title: Regularity of Powers of Edge Ideal.*

Abstract: This talk will discuss upper bounds on the regularity of powers of edge ideals of graphs whose complements do not have any induced four cycle . We will discuss some recent developments and some open problems. (Received February 07, 2014)

1100-13-182 **Justin Hoffmeier***, jche60@mail.umkc.edu, and **Liana Sega**. *Generalized Koszul properties of compressed Gorenstein local rings.* Preliminary report.

Compressed Gorenstein local rings have been discussed recently in work of Rossi and Şega; they are defined as those local rings $(R, \mathfrak{m}, k)$ of maximal length among all local Gorenstein Artinian rings of socle degree s, where $\mathfrak{m}^{s+1} = 0 \neq \mathfrak{m}^s$, and embedding dimension $e = \mathrm{rank}_k(\mathfrak{m}/\mathfrak{m}^2)$. When $s = 2$ such rings are Koszul, in the sense that the associated graded ring with respect to $\mathfrak{m}$ is a Koszul algebra. We prove that when $s > 2$ and s is even these rings satisfy various properties which can be understood as *generalized Koszul properties*. In particular, the Yoneda algebra $\mathrm{Ext}_R(k, k)$ is generated in degrees 1 and 2. (Received February 07, 2014)

1100-13-187 **Uwe Nagel*** (uwe.nagel@uky.edu), Department of Mathematics, University of Kentucky, 715 Patterson Office Tower, Lexington, KY 40506-0027, and **Sema Güntürkün**, Department of Mathematics, University of Kentucky. *A construction of homogeneous Gorenstein ideals.*

In 1983 Kustin and Miller introduced a construction of Gorenstein ideals in local Gorenstein rings, starting from smaller such ideals. In birational geometry this method is known as unprojection. We review and modify the construction in the case of graded rings and discuss it within the framework of Gorenstein liaison theory. (Received February 07, 2014)

1100-13-209 **Raymond T Hoobler*** (rhoobler@ccny.cuny.edu). *Rethinking Picard-Vessiot theory.* Preliminary report.

Let A be a Δ algebra containing $\mathbb{Q}$, and (E, ∇) a finitely generated A module with a connection. We first show that the constant frame functor, $\mathcal{CF}_E$, from A, Δ algebras to abelian groups given by

$$\mathcal{CF}_E\,(B) = \{\mathbb{B}/\mathbb{B} \text{ is an ordered basis of } E \otimes_A B \text{ consisting of constant vectors}\}$$

is (co)represented by an A, Δ algebra; that is, there is an A, Δ algebra CF_E such that $\mathcal{CF}_E\,(B) \underset{\approx}{\rightarrow} Hom_{A,\Delta\text{ alg}}\,(CF_E, B)$ for all A, Δ algebras B. If A^Δ is an algebraically closed field, we then easily construct the associated Picard-Vessiot extension and show it is a principal homogeneous space for an affine algebraic group. This then leads naturally and directly to the PV Galois theory. This approach also transfers immediately to parameterized PV theory and difference PV theory. An extension to the case when A^Δ is not a field will also be discussed. (Received February 08, 2014)

1100-13-239 **L. L. Avramov**, **L. Ferraro** and **S. B. Iyengar*** (s.b.iyengar@unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588. *The stable cohomology of a local ring.* Preliminary report.

The multiplicative structure of the stable cohomology of a local ring has been investigated by Avramov and Veliche. The goal of my talk will be to present a new result concerning this structure, and discuss some of its implications. (Received February 09, 2014)

1100-13-245 **Susan Marie Cooper*** (s.cooper@cmich.edu), Department of Mathematics, Central Michigan University, Mt. Pleasant, MI 48859. *Complete and Partial Intersections.* Preliminary report.

Hilbert functions of reduced point sets in projective space are well-understood. However, we have yet to characterize Hilbert functions of fat points. In this talk we will compare Hilbert functions of fat points supported inside grid complete intersections to Hilbert functions of reduced point sets called partial intersections. As an application, we will bound the minimum Hamming distance of a family of linear codes. (Received February 09, 2014)

1100-13-247 **Hailong Dao** and **Eleonore Faber*** (efaber@math.toronto.edu), University of Toronto at Scarborough, 1265 Military Trail, Toronto, Ontario M1A 1C4, Canada, and **Colin Ingalls**. *The global spectrum and noncommutative resolutions of singularities.* Preliminary report.

Motivated by algebraic geometry, one studies non-commutative analogs of non-commutative resolutions of singularities. In short, non-commutative resolutions of commutative rings 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, even for rings of low Krull-dimension. This leads us to consider the so-called global spectrum of a ring, that is, the set of all possible global dimensions of endomorphism rings of Cohen-Macaulay-modules.

In this talk we will address some questions connected with the global spectrum and discuss several examples coming from algebraic geometry. (Received February 09, 2014)

1100-13-249 **Oana Veliche*** (o.veliche@neu.edu), **Lars W. Christensen** and **Jerzy Weyman**. *Constructing non Gorenstein* $\mathbf{G}(r)$ *rings from Gorenstein rings.*

A complete local ring of embedding codepth 3 has a minimal free resolution of length 3 over a regular local ring. Such resolutions carry a differential graded algebra structure, based on which one can classify local rings of embedding codepth 3. The Gorenstein rings of embedding codepth 3 belong to the class called $\mathbf{G}(r)$, which was conjectured not to contain any non Gorenstein rings. For any $r \geq 2$ we construct non Gorenstein rings in $\mathbf{G}(r)$, starting from Gorenstein rings of embedding codepth 3. (Received February 09, 2014)

1100-13-251 **Olgur Celikbas*** (celikbaso@missouri.edu), 323 Math Sciences Bldg., University of Missouri-Columbia, Columbia, MO 65211, and **Arash Sadeghi** and **Ryo Takahashi**. *On the depth formula.*

Let R be a local complete intersection ring and let M and N be nonzero finitely generated R-modules. Huneke and Wiegand proved that, if the pair (M, N) is Tor-independent, i.e., $\mathrm{Tor}_i^R(M, N) = 0$ for all $i \geq 1$, then the *depth formula* holds, i.e., $\mathrm{depth}(M)+\mathrm{depth}(N)=\mathrm{depth}(R)+\mathrm{depth}(M \otimes_R N)$. The depth formula, initially discovered by Auslander for modules of finite projective dimension, has been generalized in several directions and become central to the depth properties of tensor products.

It is not necessarily true that the depth formula implies Tor-independence, in general. In this talk we will discuss certain conditions that force the pair (M, N) to be Tor-independent when it satisfies the depth formula. The talk is based on a recent joint work with Arash Sadeghi and Ryo Takahashi. (Received February 09, 2014)

1100-13-284 **Jesse Burke***, jburke@math.ucla.edu, Los Angeles, CA 90025. *Minimal free resolutions of modules over Golod rings.*

We will discuss how A-infinity structures can be used to transfer a free resolution along a ring map. For a finitely generated module over a local Golod ring, this gives a finite construction of the minimal free resolution. (Received February 10, 2014)

1100-13-290 **Henrik Holm*** (holm@math.ku.dk), Department of Mathematical Sciences, Universitetsparken 5, 2100 Copenhagen, Denmark. *K-groups for rings of finite Cohen–Macaulay type.*

For a local Cohen–Macaulay ring R of finite CM-type, Yoshino has applied methods of Auslander and Reiten to compute the Grothendieck group K_0 of the category $\mathrm{mod}\,R$ of finitely generated R-modules. For the same category, we compute the first Quillen K-group K_1. We also describe the group homomorphism $R^* \to \mathrm{K}_1(\operatorname{mod} R)$ induced by the inclusion functor $\operatorname{proj} R \to \operatorname{mod} R$, where $\operatorname{proj} R$ denotes the category of finitely generated projective R-modules. The results are illustrated with some concrete examples. (Received February 10, 2014)

1100-13-291 **Hailong Dao***, Department of Mathematics, University of Kansas, 405 Snow Hall, 1460 Jayhawk Blvd, Lawrence, KS 66045. *Cohen-Macaulay cones.*

(Joint work with K. Kurano) Let R be a local Cohen-Macaulay ring. Let V be the Grothendick group of modules over R modulo numerical equivalences with real coefficients. The Cohen-Macaulay cone of R is generated by non-negative combinations of the Cohen-Macaulay modules inside V. In this talk I will describe some basic questions and results about these cones. (Received February 10, 2014)

1100-13-296 **Michael R DiPasquale*** (dipasqu1@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Castelnuovo-Mumford Regularity of Spline Modules.* Preliminary report.

The $\mathbb{R}$-algebra $C^r(\mathcal{P})$ of piecewise polynomial functions (splines) of smoothness r on a pure n-dimensional polytopal complex $\mathcal{P} \subset \mathbb{R}^n$ is of fundamental interest in approximation theory and numerical analysis. In the late 1980s, Billera pioneered the use of tools from commutative and homological algebra in the study of splines. Following his approach as well as later refinements by Schenck, Stillman, Stiller, and others, we discuss how several questions may be phrased in terms of Castelnuovo-Mumford regularity and the benefits of using this machinery. We will primarily be concerned with the case $\mathcal{P} \subset \mathbb{R}^2$. (Received February 10, 2014)

1100-13-299 **Branden Stone*** (bstone@bard.edu), **Courtney Gibbons**, **Jack Jeffries**, **Sarah Mayes**, **Claudiu Raicu** and **Bryan White**. *Non-simplicial decompositions of Betti diagrams of complete intersections.*

The theory of Boij and Söderberg allows us to decompose Betti diagrams into pure diagrams. In this talk we relax the requirement that the degree sequences in such pure diagrams be totally ordered. As a result, we were able to define a multiplication law for Betti diagrams that respects the decomposition. Given the Betti diagram of any complete intersection, this new law allows us to write a simple pure diagram decomposition in terms of the degrees of the minimal generators for the complete intersection. This work was done as part of a Mathematical Sciences Research Institute summer graduate workshop in 2011. (Received February 10, 2014)

1100-13-309 **Ragnar-Olaf Buchweitz**, **Graham J. Leuschke*** (gjleusch@math.syr.edu) and **Michel Van den Bergh**. *Non-commutative desingularization of generic determinantal varieties.*

Let $X = (x_{ij})$ be a $m \times n$ matrix of indeterminates over a field k, let $S = k[\{x_{ij}\}]$ be the polynomial ring in those indeterminates, and let $R = S/I_t(X)$ be the quotient by the $t \times t$ minors of X. We construct a maximal Cohen-Macaulay R-module M such that the endomorphism ring $E = \operatorname{End}_R(M)$ is also maximal Cohen-Macaulay, and moreover has finite global dimension. In characteristic zero we give an explicit description of E by generators and relations. The proof is an object lesson in the usefulness of *geometric* homological methods in homological commutative algebra. (Received February 10, 2014)

1100-13-313 **William T Sanders*** (wsanders@ku.edu), Department of Mathematics, 405 Snow Hall, 1460 Jayhawk Blvd, Lawrence, KS 66045, and **Sarang Sane**. *Devissage Statements and Semidualizing Modules.*

Classically, a Witt group of a field k is constructed from isomorphisms between finite dimensional k-vector spaces and their duals. Later this definition was extended by considering the duality on projective modules and perfect complexes given by $\hom(-, R)$ for a ring R, and eventually Witt groups were defined for all exact and triangulated categories with duality. In this talk, we consider Witt groups of categories using the duality $\hom(-, C)$ for a semidualizing module C. In this context, while attempting to generalize the Gersten Witt complex, we explore Devissage statements, relating the Witt groups of larger categories to the Witt groups of smaller categories. (Received February 10, 2014)

1100-13-314 **Chris Francisco**, **Jeff Mermin*** (mermin@math.okstate.edu) and **Jay Schweig**. *An unsatisfying bijection.*

Let I be the smallest Borel-xed ideal containing the monomial $x_1 x_2 \ldots x_n$. Recently we discovered that the graded Betti numbers of I count the pointed pseudo-triangulations of a geometric conguration called the *single chain*. The connection was purely numerical, and so offered no insight into the combinatorial structure of either object.

Now, we define bijections connecting a basis for the resolution of I with pointed pseudo-triangulations and with marked binary trees. These bijections are unsatisfying in the sense that the differential from the resolution does not appear to correspond to a natural map on the spaces of pseudo-triangulations or trees. (Received February 10, 2014)

1100-13-336 **Ashwini Bhat**, **Jennifer Biermann*** (jbierman@mtholyoke.edu) and **Adam Van Tuyl**. *Generalized cover ideals and the persistence property.*

Let I be a square-free monomial ideal in $R = k[x_1, \ldots, x_n]$, and consider the sets of associated primes $\mathrm{Ass}(I^s)$ for all integers $s \geq 1$. Although it is known that the sets of associated primes of powers of I eventually stabilize, there are few results about the power at which this stabilization occurs (known as the index of stability). We introduce a family of square-free monomial ideals that can be associated to a finite simple graph G that generalizes the cover ideal construction. When G is a tree, we explicitly determine $\mathrm{Ass}(I^s)$ for all $s \geq 1$. As consequences, not only can we compute the index of stability, we can also show that this family of ideals has the persistence property (Received February 10, 2014)

1100-13-350 **Takayuki Hibi**, **Akihiro Higashitani**, **Kyouko Kimura** and **Augustine O'Keefe*** (abok222@uky.edu). *Edge ideals of Cameron-Walker graphs.*

Given a finite simple graph $G = ([n], E)$ let $R = k[x_1, \ldots, x_n]$ and $I(G)$ be the edge ideal of G. The Castelnuovo-Mumford regularity of $R/I(G)$ is then bounded above by the matching number of G, $m(G)$, and below by the induced matching of G, $i(G)$. In 2005 Cameron and Walker classified all finite simple graphs for which $m(G) = i(G)$ and so, in particular, one can determine the regularity directly from the graph. In this talk we explore other properties of the edge ideals of Cameron-Walker graphs such as (pure) vertex-decomposability, (pure) shellability, and (sequential) Cohen-Macaulayness. (Received February 10, 2014)

1100-13-356 **Rebecca Egg*** (s-regg1@math.unl.edu) and **Thomas Marley**. *Cohen-Macaulay dimension for coherent rings.*

In this talk, we'll define a notion Cohen-Macaulay (CM) dimension for modules over non-noetherian rings, based on work of A. Gerko in the noetherian case. We can then define a quasi-local coherent ring to be CM if every finitely presented module has finite CM dimension. We will explore properties of CM rings, both as they compare to the usual notion of Cohen-Macaulayness and other generalizations of Cohen-Macaulayness to coherent rings. (Received February 10, 2014)

1100-13-384 **Lourdes Juan*** (lourdes.juan@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Box 1042, Lubbock, TX 79411. *Some remarks on the integration of algebraic functions.*

Bronstein developed an algorithm to compute the logarithmic part of an integral of a function that lies in a tower of transcendental elementary extensions. However, computing the logarithmic part in an algebraic extension has remained difficult. In his PhD dissertation, Brian Miller developed a method to compute the logarithmic part when the function lies in a tower of transcendental elementary extensions followed by an algebraic extension. The method uses Grobner bases and primary decomposition. In this talk we will bring insight into the algebraic justification of the method and discuss some open questions. (Received February 11, 2014)

14 ► Algebraic geometry

1100-14-22 **Jeffrey Lang*** (lang@math.ku.edu), Department of Mathematics, Lawrence, KS 66045. *Singularity conditions on the class groups of Zariski surfaces.*

Let k be an algebraically closed field of characteristic $p \neq 0$ and $X_g \subset A_k^3$ be a normal surface defined by an equation of the form $z^p = g(x, y)$. Assume the number of singularities of X_g is the maximum possible, which is very often the case. This paper defines an equivalence relation on the singularities of X_g in terms of the Hessian from which it derives a fundamental decomposition of the group of Weil divisors of the surface. From the decomposition various results are obtained relating the structure of the equivalence classes to that of the class group. (Received January 12, 2014)

1100-14-26 **Greg Blekherman** and **Zach Teitler*** (zteitler@boisestate.edu), Department of Mathematics, Boise State University, 1910 University Drive, Boise, ID 83725-1555. *On maximum, typical, and generic ranks.*

We show that for several notions of rank including tensor rank, Waring rank, and generalized rank with respect to a projective variety, the maximum value of rank is at most twice the generic rank. We show that over the real numbers, the maximum value of the real rank is at most twice the smallest typical rank, which is equal to the (complex) generic rank. (Received January 13, 2014)

1100-14-42 **Mats Boij**, **Juan C. Migliore*** (migliore.1@nd.edu), **Rosa Maria Miro-Roig**, **Uwe Nagel** and **Fabrizio Zanello**. *On the Weak Lefschetz Property for artinian Gorenstein algebras of codimension 3.*

We study the problem of whether an arbitrary codimension three graded artinian Gorenstein algebra has the Weak Lefschetz Property. We reduce this problem to checking whether it holds for all compressed Gorenstein algebras of odd socle degree. In the first open case, namely Hilbert function $(1, 3, 6, 6, 3, 1)$, we give a complete answer in every characteristic by translating the problem to one of studying geometric aspects of certain morphisms from $\mathbb{P}^2$ to $\mathbb{P}^3$, and Hesse configurations in $\mathbb{P}^2$. (Received January 21, 2014)

1100-14-81 **Jens Forsgård** and **Laura Felicia Matusevich***, Department of Mathematics, Texas A&M University, Mailstop 3368, College Station, TX 77843-3368. *Transformations of A-hypergeometric functions via toric automorphisms.* Preliminary report.

We reinterpret and generalize some of the transformation identities for classical hypergeometric functions in the setting introduced by Gelfand, Graev, Kapranov and Zelevinsky, and show how these transformations arise from automorphisms of the underlying toric variety. This is work in progress. (Received January 30, 2014)

1100-14-92 **Steven Dale Cutkosky*** (cutkoskys@missouri.edu), Dept. Math., University of Missouri, Columbia, MO 65211. *Volumes of graded linear series on projective schemes over arbitrary fields.*

We discuss the meaning of Kodaira-Iitaka dimension in this level of generality, and give some examples of strange growth. We give simple necessary and sufficient conditions on a projective scheme X (over an arbitrary field) for the volume to exist as a limit for all graded linear series of a fixed Kodaira-Iitaka dimension. (Received January 31, 2014)

1100-14-104 **David A. Weinberg*** (david.weinberg@ttu.edu), Dept. of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Singular Points of Algebraic Curves.* Preliminary report.

The equivalence relation that will be discussed is that two singular points of algebraic curves are equivalent provided that the exponents of contact of the pro-branches of their Puiseux expansions coincide. It follows from work of Milnor that such an equivalence relation yields a finite classification for each fixed degree. Results obtained by the speaker together with Nicholas Willis will be summarized, and open problems will be described. (Received February 03, 2014)

1100-14-110 **John Brevik** (john.brevik@csulb.edu), Department of Mathematics and Statistics, California State University at Long Beach, Long Beach, CA 90840, and **Scott Nollet*** (s.nollet@tcu.edu), Department of Mathematics, Box 298900, Texas Christian University, Fort Worth, TX 76129. *Noether-Lefschetz theory and a question of Srinivas.* Preliminary report.

We present a variant of the Noether-Lefschetz theorem for families of surfaces in $\mathbb{P}^3$ with a fixed base locus of dimension at most one, which may be non-reduced, reducible, or unmixed. Using concrete base loci and power series techniques we answer a question of V. Srinivas for rational double point surface singularities. (Received February 03, 2014)

1100-14-118 **Dan Bates*** (bates@math.colostate.edu). *Finding all real solutions of a polynomial system within complex curves and surfaces.*

The methods of numerical algebraic geometry may be used to find numerical approximations of general points on each irreducible component of a complex algebraic set. While this is satisfactory for some users, a decomposition of the real algebraic set would be more useful for others. In this talk, I will briefly survey the main complex methods, then describe a new set of methods for finding all real points within complex curves and surfaces. I will also display some output from our new software package, Bertini Real, designed over the past 15 months. This is joint work with D. Brake, W. Hao, J. Hauenstein, A. Sommese, and C. Wampler. (Received February 04, 2014)

1100-14-188 **James S. Wolper*** (wolpjame@isu.edu), Idaho State University, Department of Mathematics, 921 S. 8th Ave., Mail Stop 8085, Pocatello, ID 83209. *Statistics of the Schottky Problem.* Preliminary report.

The availability of computational tools has enabled a new approach to the classical Schottky Problem of distinguishing jacobians from arbitrary abelian varieties. Torelli's Theorem guarantees that the period matrix of a compact Riemann Surface determines the surface completely, so it can be considered a message about the surface. The small dimension of the moduli space compared to that of the Siegel upper half plane indicates that this message is compressible, which leads to the investigation of statistical properties of the periods. Special statistical properties might distinguish a period matrix from a "random" element of the Siegel upper half plane.

The talk will discuss numerical investigations that have led to theorems and conjectures about the statistics of the periods, as well as the application of statistical methods to the problem. (Received February 07, 2014)

1100-14-215 **Abdelmalek Abdesselam**, **Christian Ikenmeyer*** (ciken@math.tamu.edu) and **Gordon Royle**. *Explicit Formulas for Ottaviani's Invariant of Cubic Threefolds.*

We provide explicit combinatorial formulas for Ottaviani's degree 15 invariant which detects cubics in 5 variables that are sums of 7 cubes. Our approach is based on the chromatic properties of certain graphs and relies on computer searches and calculations. (Received February 08, 2014)

1100-14-220 **Pavel Safronov*** (psafronov@math.utexas.edu). *Hamiltonian reduction and the AKSZ formalism.*

In this talk I will explain how Hamiltonian and quasi-Hamiltonian reductions naturally appear in certain classical field theories: the Wess-Zumino-Witten theory and Chern-Simons. This is achieved by using the language of derived symplectic geometry that I will explain. An application of these ideas is a local computation of symplectic forms on the character varieties and their prequantizations. (Received February 08, 2014)

1100-14-232 **Mike Janssen*** (mkjanssen@gmail.com). *On the fattening of lines in* $\mathbb{P}^3$.

In 2011, Bocci and Chiantini provided a characterization of configurations Z of points in $\mathbb{P}^2$ based on minimal growth of a simple invariant, α, as the points fattened from the reduced subscheme Z to the double scheme, $2Z$. We follow their lead and provide a similar characterization of certain subsets of lines in $\mathbb{P}^3$. (Received February 09, 2014)

1100-14-321 **Hirotachi Abo** and **Chris Peterson*** (peterson@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523-1874. *Eigenschemes for symmetric tensors.*

Several classical algebraic varieties can be viewed as parameter spaces for rank one tensors while their secant varieties have a very close connection to higher rank tensors. The tight connection between algebraic geometry and tensors has led, in recent years, to a fruitful cross fertilization of ideas between geometry, numerical analysis, and statistics. In this talk, we focus on a connection, in the setting of schemes, for the particular case of symmetric tensors. In particular, we describe how bundle techniques and homotopy continuation can be used to understand and compute eigenvectors and eigenschemes for symmetric tensors. (Received February 10, 2014)

1100-14-327 **Hirotachi Abo** and **Chris Peterson*** (peterson@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523-1874. *Construction of special varieties via bundles and k-fold covers.*

This talk will describe a method of constructing special varieties as k-fold covers. The k-fold cover arises as a component of a family of eigenschemes derived from a rank k sheaf on V. A concrete description of the construction will be described and illustrated through a series of examples. (Received February 10, 2014)

1100-14-344 **Corey S Harris*** (charris@math.fsu.edu). *Multidegrees of monomial Cremona transformations.* Preliminary report.

The multidegree of a Cremona transformation on $\mathbb{P}^3$ has the form $(1, d, e, 1)$, where d is the degree of the map and e the degree of the inverse. It is well known that $\sqrt{d} \leq e \leq d^2$ and Pan has shown that all such multidegrees are realized. Johnson has recently shown that for monomial Cremona transformations, not all values in this range are attained. We discuss a recent result of Aluffi that expresses the multidegree in terms of volumes of faces of a generalized polytope associated with the transformation and, in particular, how the result might be used to construct a monomial map with a given multidegree. (Received February 10, 2014)

1100-14-351 **Annika Denkert*** (annika.denkert@unl.edu). *Results on the Containment Problem* $I^{(m)} \subseteq I^r$.

For K be a field of arbitrary characteristic and I a nontrivial homogeneous ideal in $R = K[\mathbb{P}^N]$, we can consider symbolic powers $I^{(m)}$ and ordinary powers I^r of I. We discuss what we can say of the containment $I^{(m)} \subseteq I^r$ in general, what bounds we can give in specific situations, and what computational methods are available to calculate the resurgence $\rho(I) = \sup_{m,r}\{\frac{m}{r} | I^{(m)} \not\subseteq I^r\}$ with any desired accuracy. (Received February 10, 2014)

1100-14-368 **James E Freitag*** (freitag@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, 970 Evans Hall, Berkeley, CA 94720-3840, and **Lance Miller** and **Taylor Dupuy**. *The Kolchin Irreducibility Theorem.* Preliminary report.

We will discuss the Kolchin irreducibility theorem and its meaning from several different perspectives. We will discuss analogues of the theorem in mixed characteristic (for p-arc spaces). Particularly, we will discuss a deformation argument for reducing the problem to arcs over smooth points. (Received February 10, 2014)

1100-14-372 **Colin J Ingalls*** (cingalls@unb.ca), Department of Mathematics and Statistics, University of New Brunswick, Fredericton, NB E3B 5A3, Canada. *Rationality of Brauer-Severi Varities of Sklyanin Algebras.*

Iskovskih's conjecture states that a conic bundle over a surface is rational if and only if the surface has a pencil of rational curves which meet the discriminant in 3 or fewer points, (with one exceptional case). We generalize Iskovskih's proof that such conic bundles are rational, to the case of projective space bundles of higher dimension. The proof involves maximal orders and toric geometry. As a corollary we show that the Brauer-Severi variety of a Sklyanin algebra is rational. (Received February 10, 2014)

1100-14-383 **Paulo Lima-Filho*** (plfilho@math.tamu.edu), Dept. of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Pedro F. dos Santos** (pedro.f.santos@math.ist.utl.pt). *A simple regulator formula for higher Chow groups of real varieties.* Preliminary report.

Using techniques from geometric measure theory and equivariant topology we describe an explicit regulator formula for regulator maps sending higher Chow groups of a smooth real variety into an equivariant version of Deligne homology with integral coefficients. This extends previous work of Kerr, Lewis and Mueller-Stach to cycles with integral coefficients and the approach works for both real and complex varieties. (Received February 11, 2014)

15 ► Linear and multilinear algebra; matrix theory

1100-15-5 **JEEVAN KUMAR NEELAM*** (neelamkushalaiah@gmail.com), 19-6-194, NEAR NEHRU STATUE, RANGSHAIPET, WARANGAL, ANDHRA PRA 506005, India. *DIVISION OF MATRICES AND MIRROR IMAGE PROPERTIES OF MATRICES.* Preliminary report.

In Algebra, Division of matrices is done by Inverse-Multiplication Divisor Matrix with Dividend Matrix. There are two different methods are possible to divide two square or rectangular matrices. The Probability of Matrices Division is 0.5 plus. The overall concept of this paper is Division of Matrices is possible. (Received June 15, 2013)

1100-15-21 **Leiba Rodman*** (lxrodm@gmail.com), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187-8795. *Stable invariant subspaces of real, complex, and quaternion matrices.*

An invariant subspace $\mathcal{M}$ of a complex matrix A is said to be *stable* if every nearby (complex) matrix B has an invariant subspace $\mathcal{L}$ close to $\mathcal{M}$. If, more precisely, the distance between $\mathcal{L}$ and $\mathcal{M}$ is on the order of magnitude of $\|B-A\|^{1/m}$, where m is a positive integer, then we say that $\mathcal{M}$ is m-stable. Analogously, stable and m-stable invariant subspaces of real and quaternion matrices are defined. Characterizations of stable and m-stable invariant subspaces of real and complex matrices are well known in the operator theory literature. Recently, results concerning stable and m-stable invariant subspaces of quaternion matrices have been obtained. The talk is intended as a review of several key results concerning stable and m-stable invariant subspaces of real, complex, and quaternion matrices.

(Received January 11, 2014)

1100-15-23 **Masaki Ogura*** (masaki.ogura@ttu.edu), Texas Tech University, Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409, and **Clyde F Martin** (clyde.f.martin@ttu.edu). *A Characterization of Joint Spectral Radius with the p-radius of Distributions.*

In this talk we show a novel characterization of joint spectral radius, which is an extension of the spectral radius of a single matrix to a set of matrices. We show that the joint spectral radius of a set equals the limit of the so-called p-radius of an associated probability distribution when p tends to ∞ under mild assumptions on the distribution. The obtained formula extends a characterization of the joint spectral radius of a finite set of matrices in the literature by allowing the set to have infinitely many matrices. (Received January 13, 2014)

1100-15-297 **Harm Derksen*** (hderksen@umich.edu). *Tensor Decompositions.*

A d-way array can be viewed as a tensor product: $V = V_1 \otimes V_2 \otimes \cdots \otimes V_d$. For a given tensor $v \in V$, the PARAFAC/CANDECOMP problem asks to find a decomposition $v = v_1 + v_2 + \cdots + v_r$ where $v_1, v_2, \ldots, v_r$ are pure tensors and r is minimal. The number r is called the rank of the tensor v. The PARAFAC/CANDECOMP problem has many applications, for example in psychometrics, chemometrics, signal processing and algebraic complexity theory. I will discuss uniqueness, numerical stability and applications. Instead of minimizing r one may also minimize $\|v_1\| + \|v_2\| + \cdots + \|v_r\|$. This minimal value is the nuclear norm of the tensor v. For $d = 2$ such a decomposition is a Singular Value Decomposition. Things get more complicated for $d \geq 3$. I will discuss ways for generalizing the Singular Value Decomposition for $d \geq 3$, at least for some tensors. (Received February 10, 2014)

1100-15-349 **Victor Camillo** and **Miodrag C Iovanov*** (miodrag-iovanov@uiowa.edu). *On the representatives of the left "regular" Gl_n action and algebraic semigroup structures of the Grassmannians.* Preliminary report.

Row reduced matrices are one of the basic structures that are of unquestionable importance and have applications in many places outside of mathematics. It is perhaps less known (or used) that they are also closed under multiplication, and form a monoid. We show that the row reduced matrices are in fact characterized almost entirely by being set of representatives for the Gl_n action, and closed under multiplication. We determine all such monoid structures - that we call annihilator semigroups, and show they are "simultaneously echelonizable" and very close to row reduced matrices. This also allows one to view the total Grassmaniann G(n) on an n dimensional space as an algebraic semigroup, that is graded by a certain semigroup Π whose 2^n elements are Young tableaux, and the graded components of G(n) are exactly the Schubert cells. Time permitting, we present other results on the structure of these annihilator semigroups, their classification up to isomorphism, and relations to other important mathematical objects as the plactic monoid and Gl_n representations. (Received February 10, 2014)

16 ► Associative rings and algebras

1100-16-8 **Jerry Lodder*** (jlodder@nmsu.edu), Mathematical Sciences, Dept. 3MB, Box 30001, New Mexico State Univ., Las Cruces, NM 88011. *A Comparison of Products in Hochschild Cohomology.*

Recall that the usual Gerstenhaber product in Hochschild cohomology, HH^*, is graded commutative, although the two canonical chain homotopies available to show this are not themselves chain homotopic, which gives rise to the Gerstenhaber bracket. The Hom_k dual of the b-complex in Hochschild homology yields the b^* complex, which supports a simplicial cup product and the construction of Steenrod's cup-i products. The simplicial product is graded commutative in cohomology via an E-infinity algebra. For A the group ring $k[G]$, the cohomology of the b^* complex is isomorphic to the singular cohomology of the free loop space, L, maps of S^1 into BG. Note that BG is naturally a subspace of L by considering constant maps of S^1 into BG. In this talk we transport the cup-i products to Hochschild's original cochain complex defining Hochschild cohomology. In this way, $HH^*(A, A)$ is seen to support two product structures, the Gerstenhaber product and the simplicial cup product. Both products agree for cochains supported on BG. Moreover, Gerstenhaber's pre-Lie product agrees with Steenrod's cup-one product for these cochains. Thus, Gerstenhaber's product can be deformed to an E-infinity product for cochains supported on BG. (Received November 01, 2013)

1100-16-18 **Mihai D Staic***, BGSU, Department of Mathematics and Statistics, Bowling Green, OH 43403. *Secondary Hochschild Cohomology.*

For a B-algebra A, we study algebra deformations $A[[t]]$ that admit a B-algebra structure. The main idea is that a B-algebra structure on A gives a family of products that satisfies a certain generalized associativity condition. We use a Hochschild-like cohomology to describe deformations of this family of products. When $A[[t]]$ has an identity element, we get a B-algebra structure on $A[[t]]$. (Received January 08, 2014)

1100-16-28 **Marju Purin*** (purin@stolaf.edu), Department of Mathematics, Statistics, and Computer Science, St. Olaf College, Northfield, MN 55057. *τ-Complexity.*

Let τ denote the Auslander-Reiten translate. The τ-complexity of a module measures the rate of growth of the dimensions of the modules in its τ-orbit. In this talk we determine the τ-complexity of all modules over cluster-tilted algebras. We show that a module over a cluster-tilted algebra can have only one of the following possible complexities: 0, 1, 2 or infinity. We then explain when each possibility occurs. (Received January 31, 2014)

1100-16-39 **Leonid Krop*** (lkrop@condor.depaul.edu), Department of Mathematical Sciences, DePaul University, Chicago, IL 60614. *Isomorphism Types of Hopf Algebras in a Class of Abelian Extensions.*

There is no systematic general procedure by which isomorphism classes of Hopf algebras that are extensions of kF by k^G can be found. We develop the general procedure for classification of isomorphism classes of Hopf algebras which are extensions of the group algebra kC_p by k^G where C_p is a cyclic group of prime order p and k^G is the Hopf algebra dual of kG, G a finite abelian p-group and k is an algebraically closed field of characteristic 0. We apply the method to calculate the number of isoclasses of commutative extensions and certain extensions of this kind of dimension $\leq p^4$. (Received January 20, 2014)

1100-16-41 **Deepak Naidu*** (dnaidu@math.niu.edu). *Twisted quantum Drinfeld Hecke algebras.*

I will discuss twisted quantum Drinfeld Hecke algebras, which generalize Drinfeld Hecke algebras by incorporating quantum parameters and a 2-cocycle on the associated finite group. I will explain how these algebras can be identified as specializations of deformations of twisted skew group algebras, giving an explicit connection to Hochschild cohomology. (Received January 21, 2014)

1100-16-53 **Liping Li*** (lipingli@math.ucr.edu), 900 University Avenue, Surge 243, Riverside, CA 92521. *On the compact exceptional objects in derived module categories.*

Let A be an Artinian algebra and $D^b(A)$ be the bounded derived module category of finitely generated left A-modules. This talk will be focused on compact exceptional objects in $D^b(A)$, which include tilting objects as special examples. We describe a sufficient condition such that the lengths of all compact exceptional objects in $D^b(A)$ are bounded by the number of isomorphism classes of simple A-modules. Moreover, we show that algebras satisfying this condition are bounded derived simple; that is, $D^b(A)$ has no nontrivial recollements by bounded derived module categories of algebras. (Received January 24, 2014)

1100-16-64 **Ilya Shapiro**, **Xiang Tang*** (xtang@math.wustl.edu) and **Hsian-hua Tseng**. *Mackey machine and discrete torsion.*

Inspired by questions from string theory, we study a duality result between different (twisted) cross product algebras using the idea of the Mackey machine. The Hochschild cohomology computation leads to interesting results in geometry and topology. (Received January 27, 2014)

1100-16-68 **Michaela Vancliff*** (vancliff@uta.edu), Department of Mathematics, University of Texas at Arlington, Arlington, TX 76019-0408. *Defining a Notion of Noncommutative Complete Intersection via Base-Point Modules.*

This talk will focus in part on joint work with T. Cassidy regarding a definition of complete intersection using base-point modules in the context of skew polynomial rings. We will also discuss work by the speaker that extends the definition to more general algebras. (Received January 27, 2014)

1100-16-80 **Mashhoor Refai*** (m.refai@psut.edu.jo), Khalil Al-Saket st., Al Jubaiha, Amman, Amman 11941, Jordan. *On Strongly Graded Prime Submodules.*

Let G be a group with identity e. A ring R is said to be $G-$graded if there exist additive subgroups R_g of R such that $R = \bigoplus_{g\in G} R_g$ and $R_gR_h \subseteq R_{gh}$, for all $g, h \in G$. A $G-$graded ring R is denoted by (R, G). A $G-$graded ring R is said to be strongly graded if $R_gR_h = R_{gh}$, for all $g, h \in G$, or equivalently if $1 \in R_gR_{g^{-1}}$, for all $g \in G$. A $G-$graded $R-$module M is said to be strongly graded if $R_gM_h = M_{gh}$, for all $g, h \in G$. Let N be an

$R-$submodule of M. Then N is called a $G-gr-R-$submodule of M if $N = \bigoplus_{g\in G}(N \cap M_g)$.

In this paper, we introduce the concept of strongly graded prime submodules, and prove that "N is strongly graded prime if and only if N_e is strongly prime R_e-submodule of M_e". Also, we prove that "N_e is strongly prime R_e-submodule of M_e if and only if N_g is strongly prime R_e-submodule of M_g, for all $g \in G$". A survey of my contribution to the field will also be given. (Received January 30, 2014)

1100-16-107 **Travis Schedler*** (schedler@math.utexas.edu) and **Pavel Etingof**. *Invariants of Hamiltonian flow on locally complete intersections.*

We consider the Hamiltonian flow on complex complete intersection surfaces with isolated singularities, equipped with the Jacobian Poisson structure, and generalize to higher dimensionsional complete intersections.

Our main result computes the coinvariants of functions under the Hamiltonian flow. In the surface case this is the zeroth Poisson homology, and our result generalizes those of Greuel, Alev and Lambre, and the authors in the quasihomogeneous and formal cases. Its dimension is the sum of the dimension of the top cohomology and the sum of the Milnor numbers of the singularities. In other words, this equals the dimension of the top cohomology of a smoothing of the variety.

More generally, we compute the derived coinvariants, which replaces the top cohomology by all of the cohomology. Still more generally we compute the D-module which represents all invariants under Hamiltonian flow, which is a nontrivial extension (on both sides) of the intersection cohomology D-module, which is maximal on the bottom but not on the top. For cones over smooth curves of genus g, the extension on the top is the holomorphic half of the maximal extension. (Received February 03, 2014)

1100-16-147 **Padmini P Veerapen*** (pveerapen@tntech.edu) and **Michaela Vancliff**. *Point Modules over Regular Graded Skew Clifford Algebras.*

In this talk we consider point modules over an Artin-Schelter regular graded skew Clifford algebra, A. In particular, we analyze how the factoring of certain noncommutative quadratic forms in the Koszul dual of A determine the number of point modules over Artin-Schelter regular graded skew Clifford algebras. (Received February 06, 2014)

1100-16-165 **Calin Ioan Chindris*** (chindrisc@missouri.edu). *Quiver representations of constant Jordan type.*

In this talk, I will first explain how to associate to a representation of an acyclic quiver a sequence of coherent sheaves on moduli spaces of thin representations. Next, I will focus on those representations for which the corresponding sheaves are locally free. This will lead us to the large class of quiver representations of constant Jordan type. I will also describe this class of representations in algebraic terms via Jordan canonical forms of families of nilpotent operators associated to quiver representations. This is based on joint work with Andrew Carroll and Zongzhu Lin. (Received February 06, 2014)

1100-16-189 **Cris Negron*** (negron@uw.edu). *The Hochschild Cohomology Ring of a Smash Product.*

We will discuss a method for computing the Hochschild cohomology ring of a smash product by way of spectral sequences. Throughout the talk, we will focus on the motivating example of $\mathbb{Z}^n$ acting on n-dimensional affine space by translation. (Received February 07, 2014)

1100-16-199 **Emily Norton*** (emn37@case.edu), Department of Mathematics, 10900 Euclid Avenue-Yost Hall Room 231, Cleveland, OH 44106. *Finite-dimensional representations of the rational Cherednik algebra of H4.* Preliminary report.

Rational Cherednik algebras (at t=1) only admit finite-dimensional representations at special parameters (related to the degrees of the fundamental invariants, and more precisely to the elliptic numbers, of the underlying Coxeter group). Outside of types A, H3, and the dihedral groups, the classification of their finite-dimensional irreducible representations remains an open problem. I will describe the finite-dimensional irreducible representations of the rational Cherednik algebra of H4 and give their lowest weights, dimensions, and characters. (Received February 08, 2014)

1100-16-203 **Iordan Ganev*** (iganev@math.utexas.edu). *Quantum differential operators at a root of unity.* Preliminary report.

We introduce an algebra $\mathcal{D}_q(Q)$ of quantum differential operators associated to a quiver. When the parameter q is a root of unity, the algebra $\mathcal{D}_q(Q)$ contains a large center and is Azumaya over its center. This Azumaya algebra is split by a finite étale cover. A Hamiltonian reduction of $\mathcal{D}_q(Q)$ yields an Azumaya algebra on the multiplicative quiver variety, which is similarly split by a finite étale cover. (Received February 08, 2014)

1100-16-207 **Dan Zacharia*** (zacaria@syr.edu), Department of Mathematics, Syracuse University, Syracuse, NY 13244, and **Edward Green** and **Nicole Snashall**. *The extended degree zero subalgebra of the ext algebra of a linear module.* Preliminary report.

I will talk on joint work with Ed Green and Nicole Snashall. Let $\mathbb{k}$ be a field and let R be a Koszul $\mathbb{k}$-algebra. Let M be a linear $\mathbb{k}$-module and let Γ be the ext-algebra of M. View Γ as a bigraded algebra with the bigrading induced by the homological degree and by the internal grading of M, that is

$$\Gamma = \mathrm{Ext}^*_R(M,M) = \bigoplus_{n\geq 0}\bigoplus_{i\in\mathbb{Z}} \mathrm{Ext}^n_R(M,M)_i.$$

We consider next (for lack of a better name) *the extended degree zero subalgebra* Δ_M of Γ,

$$\Delta_M = \bigoplus_{n\geq 0} \mathrm{Ext}^n_R(M,M)_0$$

It turns out that the extended degree zero subalgebra can be used to obtain a characterization of the graded center of a Koszul algebra. I will also present some other applications of the ideas involved. (Received February 08, 2014)

1100-16-218 **Frauke M. Bleher***, Department of Mathematics, University of Iowa, 14 MacLean Hall, Iowa City, IA 52242, and **Ted Chinburg**, Department of Mathematics, University of Pennsylvania, Philadelphia, PA 19104-6395. *Linear operators and orbit closures.* Preliminary report.

This talk is about joint work with Ted Chinburg. We study the Grassmannian $\mathcal{G}$ of submodules C of a given dimension inside a finitely generated projective module P for a finite dimensional algebra Λ over an algebraically closed field k. The closure $\mathcal{X}$ in $\mathcal{G}$ of the orbit of such a submodule C under the action of $\mathrm{Aut}_\Lambda(P)$ has been considered by a number of authors. We concentrate on the case when P is indecomposable. In this case $\mathcal{X}$ is a rational variety, and there is an affine n-space $\mathbb{A}^n$ in $\mathcal{X}$ with the following property. The embedding of $\mathbb{A}^n$ into $\mathcal{G}$ is given by taking the space spanned by the rows of a matrix of linear polynomials in the n standard coordinates for $\mathbb{A}^n$. For $n = 2$, we show that the generic embedding of $\mathbb{A}^2$ into $\mathcal{G}$ via such a matrix has closure isomorphic to $\mathbb{P}^2$. We also show that there is a positive dimensional family of embeddings for which the closure is the Hirzebruch surface X_2, respectively X_3. While it is known by work of the authors and Birge Huisgen-Zimmermann that X_2 arises from an orbit closure $\mathcal{X}$ as above, this is not known for the surface X_3. (Received February 08, 2014)

1100-16-224 **F. M. Bleher** (frauke-bleher@uiowa.edu), **T. Chinburg** (ted@math.upenn.edu) and **B. Huisgen-Zimmermann*** (birge@math.ucsb.edu). *Linear operators annihilating each other.*

Let V be a finite dimensional vector space over an algebraically closed field K, and r a positive integer. We determine the irreducible components of the variety of r-tuples $(T_1, \ldots, T_r)$ of linear operators $T_j \in \mathrm{End}_K(V)$ which have the property that $T_iT_j = 0$ for all $i, j \in \{1, \ldots, r\}$. Our main theorem generalizes results by Donald-Flanigan and K. Morrison. (Received February 08, 2014)

1100-16-228 **Kenneth Chan*** (kenhchan@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, CA 98195-4350, and **Daniel Chan** and **S Paul Smith**. *Noncommutative quadrics and $\mathbb{Z}\times\mathbb{Z}$-graded algebras.* Preliminary report.

We study a class of $\mathbb{Z}\times\mathbb{Z}$-graded algebras which give rise to noncommutative analogues of quadric surfaces. They occur as double Ore extensions of AS regular algebras of dimension 2, and Zhang-Zhang classified them into 26 families. Following Artin-Tate-Van den Bergh, we re-interpret the Zhang-Zhang classification using geometric data. This is joint work with Daniel Chan and S. Paul Smith. (Received February 09, 2014)

1100-16-250 **Andrew T Carroll*** (carrollat@missouri.edu). *Algebraic realization for modules of constant Jordan type.*

I will introduce some special classes of modules of constant Jordan type with notable algebraic properties and describe the algebraic realization theorem. Additionally, I will demonstrate how all vector bundles on the projective line arise from modules of constant Jordan type over the Kronecker quiver. This is based on joint work with Calin Chindris and Zongzhu Lin. (Received February 09, 2014)

1100-16-252 **Kosmas Diveris***, diveris@stolaf.edu, and **Marju Purin**. *Vanishing of self-extensions over symmetric algebras.*

The Auslander-Reiten (AR) quiver of an Artin algebra is a combinatorial device for organizing the indecomposable modules over the algebra. For symmetric artin algebras, the combinatorial structure of this quiver is well suited for investigating modules with eventually vanishing self-extensions. In fact, one can determine when the vanishing of self-extensions must begin for any such module based on its position in the AR quiver. In this talk, we will explain how one can use the combinatorial data of the AR quiver to prove this and discuss connections with conjectures of Tachikawa, Auslander and Reiten. (Received February 09, 2014)

1100-16-262 **Briana Foster-Greenwood*** (fostbria@isu.edu), Department of Mathematics, Idaho State University, 921 S. 8th Ave Stop 8085, Pocatello, ID 83209. *Hochschild Cohomology and Codimension Posets for Complex Reflection Groups.*

In the case of skew group algebras arising from representations of finite groups, one may exploit invariant theory and combinatorics to describe Hochschild cohomology governing deformations such as graded Hecke algebras. Focusing on skew group algebras of complex reflection groups, we present a comparison of absolute reflection length and codimension of fixed point spaces and use this combinatorial result to deduce information about cohomology structure. (Received February 09, 2014)

1100-16-300 **Anthony Giaquinto*** (tonyg@math.luc.edu) and **Murray Gerstenhaber** (mgersten@math.upenn.edu). *On the cohomology of the Weyl algebra, the quantum plane, and the q-Weyl algebra.*

Deformation theory can be used to compute the cohomology of a deformed algebra with coefficients in itself from that of the original. The invariance of the Euler-Poincare characteristic of the Hochschild complex the under deformation is applied to compute the cohomology of the Weyl algebra, the algebra of the quantum plane, and the q-Weyl algebra. For details, see http://dx.doi.org/10.1016/j.jpaa.2013.10.006 (Received February 10, 2014)

1100-16-307 **Kiyoshi Igusa** (igusa@brandeis.edu), Department of Mathematics, Brandeis University, Waltham, MA, **Kent Orr** (korr@indiana.edu), University of Indiana, Bloomington, IN, **Gordana Todorov** (g.todorov@neu.edu), Northeastern University, Boston, MA , and **Jerzy Weyman*** (jerzy.weyman@uconn.edu), Department of MAthematics, University of Connecticut, Storrs, CT 06249. *Periodic trees and semi-invariants.* Preliminary report.

I will report on joint work in progress with Kiyoshi Igusa, Kent Orr and Gordana Todorov. It gives the description of the cluster complex for the extended A_n quivers in terms of periodic trees. (Received February 10, 2014)

1100-16-360 **Charlie R Beil*** (charlie.beil@bristol.ac.uk), School of Mathematics, University of Bristol, University Walk, Bristol, Bristol BS8 1TW. *Noncommutative desingularization of nonnoetherian singularities.*

Nonnoetherian singularities with finite Krull dimension arise naturally as the centers of certain quiver algebras, such as dimer algebras. I will introduce the 'geometric dimension' of a point, and show how this notion enables such singularities to be viewed geometrically as algebraic varieties with positive dimensional points. I will then describe how the quiver algebras themselves may be viewed as noncommutative desingularizations of their centers, where projective dimension and 'geometric codimension', rather than height, coincide. (Received February 10, 2014)

1100-16-371 **Alexander A Young*** (young.mathematics@gmail.com). *Constructing "slow" algebra counterexamples.*

For any (non-commutative) algebra A generated by a finite dimensional vector space V, the *growth* of A is the monotonically increasing function $f_n(A) = \dim V^n$. Algebras can be stratified into classes of growth, as a refinement of the Gelfand-Kirillov dimension. A similar concept can be examined in groups by connecting it with the growth of its group ring.

Lately, there have been a number of unexpected counterexamples to conjectures about the possible growths of certain types of algebras (such as nil algebras or algebras that are their own Jacobson radical). A particular method of constructing complicated but provably "slow" algebras was originally assembled by Agata Smoktunowicz and T H Lenagan, and refined by them and other authors in subsequent papers. This talk will give a brief run-through of how it works, and the open problems it has so far been unable to do. (Received February 10, 2014)

1100-16-373 **Tom Cassidy**, **Andrew Conner**, **Ellen Kirkman** and **W. Frank Moore*** (moorewf@wfu.edu), 333 Manchester Hall, Wake Forest University, Winston-Salem, NC 27109. *Periodic free resolutions from twisted matrix factorizations.*

The notion of a matrix factorization was introduced by Eisenbud in the commutative case in his study of bounded (periodic) free resolutions over complete intersections. Since then, matrix factorizations have appeared in a number of applications. In this work, we extend the notion of (homogeneous) matrix factorizations to regular normal elements of connected graded algebras over a field.

Next, we relate the category of twisted matrix factorizations of an element over a ring and certain Zhang twists. We also show that in the AS-regular setting, every sufficiently high syzygy module is the cokernel of some twisted matrix factorization. Furthermore, we show that in this setting there is an equivalence of categories between the homotopy category of twisted matrix factorizations and the singularity category of the hypersurface, following work of Orlov. (Received February 10, 2014)

17 ► Nonassociative rings and algebras

1100-17-139 **Jörg Feldvoss*** (jfeldvoss@southalabama.edu). *On the $[p]$-map of a restricted Lie algebra.* Preliminary report.

The $[p]$-map of a restricted Lie algebra (or Lie p-algebra) is compatible with the underlying vector space structure in the sense that it is (up to an error term) an F-semilinear operator with respect to the Frobenius F of the ground field. In this talk we will discuss some properties of the $[p]$-map and how these are related to the structure of the Lie algebra and its representations. (Received February 05, 2014)

1100-17-230 **Justyna Kosakowska*** (justus@mat.umk.pl), Faculty of Mathematics and Computer Science, Nicholaus Copernicus University, 87-100 Torun, Poland. *Combinatorial and geometric aspects of invariant subspaces of linear operators.*

Some algebraic and geometric properties of invariant subspaces of linear operators can be controlled by combinatorial tools (Littlewood-Richardson tableaux, arc diagrams, Hall polynomials). We are interested in short exact sequences of nilpotent linear operators and their algebraic and geometric properties. A combinatorial analysis involving arc diagrams and Littlewood-Richardson tableaux yields a description of properties we are interested in. This talk is an elementary excursion through these problems.

This is a talk about a joint project with Markus Schmidmeier from Florida Atlantic University. (Received February 09, 2014)

18 ► Category theory; homological algebra

1100-18-55 **Piyush Ravindra Shroff*** (prs31@txstate.edu), Department of Mathematics, Texas State University, San Marcos, TX 78666. *Quantum Drinfeld Orbifold Algebras.*

Quantum Drinfeld orbifold algebras are the generalizations of Drinfeld orbifold algebras which are obtained by replacing polynomial rings by quantum polynomial rings. The necessary and sufficient conditions on the defining parameters to obtain Drinfeld orbifold algebras was given by Shepler and Witherspoon. In this talk I will give the generalization of their results. This is also the generalization of the results given by Naidu and Witherspoon about quantum Drinfeld Hecke algebras. (Received January 25, 2014)

1100-18-58 **Daniel Bravo**, **James Gillespie*** (jgillesp@ramapo.edu) and **Mark Hovey**. *Gorenstein AC-injective/projective modules.* Preliminary report.

Much of the development of Gorenstein homological algebra depends on the ring being Noetherian. In our paper The Stable Module Category of a General Ring, we introduce a way to extend Gorenstein homological algebra to arbitrary rings. We strengthen the definition of Gorenstein injective (resp. Gorenstein projective) modules to get what we call Gorenstein AC-injective (resp. Gorenstein AC-projective) modules. We show that, over any ring, they are the right half (resp. left half) of a complete hereditary cotorsion pair. These classes of modules coincide with the usual Gorenstein injective (resp. Gorenstein projective) modules over special rings. For example, if R is Noetherian, the Gorenstein AC-injectives coincide with the usual Gorenstein injectives. If R is coherent the Gorenstein AC-projectives coincide with the previously named "Ding projective" modules. (Received January 26, 2014)

1100-18-60 **Hans-Christian Herbig** (hcherbig@web.de), Prague, Czech Rep, and **Markus J Pflaum*** (markus.pflaum@colorado.edu), University of Colorado UCB 395, Department of Mathematics, Boulder, CO 80309. *Hochschild homology of algebras of smooth functions on orbit spaces.* Preliminary report.

This talk is on work in progress. We show that a localization method in Hochschild homology theory, which essentially goes back to ideas by N. Teleman, can be used to obtain a qualitative picture of the Hochschild homology of the algebra of smooth functions on the orbit space of a compact Lie group action. The striking observation hereby is that this unveils a connection between the orbit type stratification of the orbit space and the Hochschild homology of its algebra of smooth functions. (Received January 26, 2014)

1100-18-91 **Marju Purin***, St. Olaf College, Northfield, MN 55057. *The Generalized Auslander-Reiten Condition for n-Symmetric Algebras.*

A ring Λ is said to satisfy the Generalized Auslander-Reiten Condition if for each Λ-module M with $\mathrm{Ext}^i(M, M\oplus\Lambda) = 0$ for all $i > n$ the projective dimesion of M is at most n. We prove that this condition holds for all n-symmetric algebras of quasitilted type– a broad class of self-injective algebras where every module is ν-periodic. Here ν denotes the Nakayama automorphism. This is joint work with M. Karpicz. (Received January 31, 2014)

1100-18-120 **Van C. Nguyen*** (vcnguyen@math.tamu.edu), Texas A&M University, College Station, TX 77843-3368. *Tate-Hochschild cohomology.*

I will present an overview of the Tate-Hochschild cohomology, which is a generalization of the ordinary Hochschild cohomology to negative degrees. We will discuss what is known, what has been done, and what could be done in this study. In particular, we will focus on results in finite group algebras and finite dimensional Hopf algebras. (Received February 04, 2014)

1100-18-186 **Olgur Celikbas** (celikbaso@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, **Lars Winther Christensen** (lars.w.christensen@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, **Li Liang*** (lliangnju@gmail.com), School of Mathematics and Physics, Lanzhou Jiaotong University, Lanzhou, 730070, Peoples Rep of China, and **Greg Piepmeyer** (gpiepmeyer@columbiabasin.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Stable homology of modules.*

In this talk, we study a stable homology theory for modules that was introduced by Vogel and Goichot. We establish new methods to compute stable homology. Based on them, we discuss properties of stable homology such as balancedness and vanishing. Finally, we show that agreement of stable homology with Tate homology characterizes the rings over which all Gorenstein projective modules are Gorenstein flat. (Received February 07, 2014)

1100-18-191 **Denise Amanda Rangel*** (denise.rangel@mavs.uta.edu), Department of Mathematics, 411 S Nedderman Dr, Arlington, TX 76019. *A Description of the Isomorphism Classes of Totally Reflexive Modules Over a Specific Ring.* Preliminary report.

Totally reflexive modules over a non-Gorenstein ring are an analog to maximal Cohen-Macaulay modules over a Gorenstein ring. It is known that the category of totally reflexive modules over a non-Gorenstein ring is either trivial (consisting only of free modules) or is infinite. When it is infinite it is quite often of wild representation type. In this talk we will investigate this nontrivial category over the ring $k[x, y, z]/(x^2, y^2, z^2, yz)$. Through work of Avramov and Eisenbud we will show that the isomorphism classes of totally reflexive modules are in bijection with the conjugacy classes of certain square matrices. (Received February 07, 2014)

1100-18-219 **Denis Bashkirov*** (bashk003@umn.edu). *Strongly homotopy Lie algebras and BV formalism.* Preliminary report.

Given an L_∞-algebra $\mathfrak{g}$, we equip the symmetric algebra $S(\mathfrak{g}[-1])$ with a homotopy Batalin-Vilkovisky structure. Next, we show how a pure BV_∞-algebra defined on a free graded commutative algebra $S(U)$ gives rise to a canonical L_∞-structure on $U[1]$. This establishes an equivalence between the category of L_∞-algebras (with non-linear morphisms) and a certain nice subcategory of BV_∞-algebras. The construction is used in studying the structure of homotopy Lie bialgebras. (Received February 08, 2014)

1100-18-267 **Olgur Celikbas**, **Srikanth Iyengar**, **Greg Piepmeyer*** (gpiepmeyer@columbiabasin.edu) and **Roger Wiegand**. *Serre conditions and vanishing of Tor.*

In the complete intersection setting, Serre conditions on the tensor product of a pair of modules and on the factors, along with locally free conditions, have been used by H.Dao to show vanishing of Tor. The locally free condition may be replaced by conditions of: eventual finite length of Tor and vanishing of the eta pairing (originally of Dao). With these conditions the Serre conditions can be weakened by one both on the tensor product and on the factors. Our work showing this uses push forward/quasi-lifting constructions. (Received February 09, 2014)

1100-18-385 **Bregje Pauwels*** (bregje@ucla.edu). *Seperable and Galois Extensions in Tensor Triangulated Geometry.* Preliminary report.

For a commutative separable ring object A in a tensor triangulated category K, we study extension-of-scalars to the category of A-modules in K and the induced map on spectra. We describe the map on spectra for Galois extensions and study their degree. We are particularly interested in the homotopy category of perfect complexes over a commutative ring and the stable category of a finite group over a field. (Received February 11, 2014)

20 ► Group theory and generalizations

1100-20-1 **Nir Avni*** (nir@math.northwestern.edu). *To be announced.* Preliminary report.

No text available. (Received May 17, 2013)

1100-20-52 **John D Hutchens*** (jdhutchens@saumag.edu). *Isomorphism classes of k-involutions of G_2.*

Isomorphism classes of k-involutions have been studied for their correspondence to symmetric k-varieties. Let G be a reductive algebraic group defined over a field k and $H = G^\theta$ be the fixed point group of $\theta : G \to G$ an automorphism of order 2 defined over k. If G_k and H_k are the k-rational points of G and H respectively, we call G_k/H_k a symmetric k-variety corresponding to a k-involution θ. Here we begin classifying k-involutions of split algebraic groups of type G_2. (Received January 24, 2014)

1100-20-108 **Randall R. Holmes** and **Huajun Huang*** (huanghu@auburn.edu), Department of Mathematics and Statistics, Auburn University, Auburn, AL 36849, and **Tin-Yau Tam**. *Asymptotic Behavior of Iwasawa and Cholesky Iterations.*

The QR iteration provides one of the most efficient methods for computing the eigenvalues of a matrix. Its counterpart in real semisimple Lie groups is the Iwasawa decomposition. We extend, in the context of a connected real semisimple Lie group, some results on the QR iteration and the Cholesky iteration of a nonsingular matrix. A group theoretic understanding of the abstract mechanisms of the iterations is obtained. (Received February 03, 2014)

1100-20-366 **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 $\operatorname{Spec} H^\bullet(\mathfrak{g}, k)$ 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 February 10, 2014)

22 ► Topological groups, Lie groups

1100-22-29 **Angela Pasquale**, **Joachim Hilgert** and **tomasz przebinda*** (tprzebinda@gmail.com), Tomasz Przebinda, Norman, OK 73019. *Resonances for the Laplace operator on the symmetric space $SL_3(\mathbb{R})/SO_3(\mathbb{R})$.* Preliminary report.

We prove the existence of a meromorphic extension of the resolvent for the Laplace operator on the symmetric space $SL_3(\mathbb{R})/SO_3(\mathbb{R})$ and compute the residue operators. They turn out not to be of finite rank. (Received January 15, 2014)

1100-22-51 **Matvei Libine*** (mlibine@indiana.edu). *Feynman Diagrams, Representations of U(2,2) and Quaternionic Analysis.*

Feynman diagrams are a pictorial way of describing integrals predicting possible outcomes of interactions of subatomic particles in the context of quantum field physics. It is highly desirable to have an intrinsic mathematical interpretation of Feynman diagrams.

In this talk I will describe the representation-theoretical meaning of certain Feynman diagrams. This is done in the context of representations of a Lie group U(2,2) and quaternionic analysis.

No prior knowledge of physics, Feynman diagrams or quaternionic analysis is assumed from the audience. (Received January 24, 2014)

1100-22-67 **Markus Hunziker** (markus_hunziker@baylor.edu), Department of Mathematics, One Bear Place #97328, Waco, TX 76798, **Mark Sepanski*** (mark_sepanski@baylor.edu), Department of Mathematics, One Bear Place #97328, Waco, TX 76798, and **Ronald Stanke** (ron_stanke@baylor.edu), Department of Mathematics, One Bear Place #97328, Waco, TX 76798. *A new Schrödinger model for unitary highest weight representations.*

It follows from the classification of unitary highest weight representations and the work of Kashiwara-Vergne that every unitary reduction point of the metaplectic group $Mp(n,\mathbb{R})$ can be embedded in $L^2(M_{n,k})$ for some $k < n$, where $M_{n,k}$ denotes the space of real $n \times k$ matrices. Furthermore, every reduction point can be embedded in a space of sections of a holomorphic vector bundle on the Segal upper halfplane or—via boundary values—in a degenerate principal series representation. In this paper, we give a new realization of unitary highest weight representations in the kernel of a system of Schrödinger equations on the space $M_{n,k} \times Sym_k$, where Sym_k denotes the space of symmetric real $k \times k$ matrices. Our realization has simple intertwining maps to the previously known realizations mentioned above. (Received January 27, 2014)

1100-22-163 **Raul Gomez*** (gomez@cornell.edu), Mathematics Department, Cornell University, Malott 593, Ithaca, NY 14853. *On a conjecture of Sakellaridis-Venkatesh on the unitary spectrum of a spherical variety.*

In this talk, we will use the theory of dual pairs and θ-lifting of generalized Whittaker models to prove some cases of a conjecture announced in a recent preprint of Sakellaridis and Venkatesh. Furthermore, we will consider a family of examples that seem to suggest that the theory developed by Sakellaridis and Venkatesh may be extendable to a larger class of homogeneous spaces. (Received February 06, 2014)

1100-22-205 **Stephane Merigon***, Dpt of Mathematics, LSU, Baton Rouge, LA 70803. *Integrability of unitary representations on reproducing kernel spaces.*

Let (G, θ) be a symmetric Lie group, $\mathfrak{g} = \mathfrak{h} + \mathfrak{q}$ its Lie algebra, $\mathfrak{g}_c = \mathfrak{h} + i\mathfrak{q}$ the c-dual Lie algebra and G_c the simply connected Lie group with Lie algebra $\mathfrak{g}_c$. Motivated by Representation Theory and Quantum Field Theory one considers:

(i) An involutive representation of an open semigroup S of G invariant under the involution $g^* = \theta(g)^{-1}$.

(ii) A reflection positive representation of (G, θ).

(iii) A local (or virtual) representation of (G, θ).

In each case the representation leads to a representation of $\mathfrak{g}_c$ by skewsymmetric operators on a dense domain $\mathcal{D}$ of a Hilbert sapce $\mathcal{H}$. Using smooth reproducing kernels and reproducing kernels given by distributions we are able to provide a framework unifying all situations above and to prove that the representation of $\mathfrak{g}_c$ integrates to a unitary representation of G_c on $\mathcal{H}$. Our results apply to infinite dimensional Lie groups as well. This is joint work with Karl-Hermann Neeb and Gestur Olafsson. (Received February 08, 2014)

1100-22-217 **Jordan Alexander*** (jordan_alexander@baylor.edu). *Hilbert series and quasi-dominant weights.* Preliminary report.

The notion of quasi-dominance was introduced by Enright and Willenbring as a class of weights whose corresponding unitarizable highest weight modules, when they exist, have strikingly elegant Hilbert series. Specifically, the Hilbert series $H_L(t)$ of the unitarizable highest weight module $L(\lambda)$, with λ quasi-dominant, is given by

$$H_L(t) = R \cdot \frac{H_E(t)}{(1-t)^D}$$

where E is an associated finite-dimensional simple module, R is a rational number, and D is the Gelfand-Kirillov dimension of L. When L is a Wallach representations in the dual pair setting, R is equal to one. This talk centers on two results: a partial characterization of the quasi-dominant weights and the discovery of (other) infinite families of quasi-dominant weights that give $R = 1$. (Received February 08, 2014)

1100-22-248 **Annegret Paul*** (annegret.paul@wmich.edu). *Decomposing Induced Representations Using* `atlas`. Preliminary report.

The `atlas` software uses the Kazhdan-Lusztig-Vogan algorithm to compute the composition series of standard modules for reductive Lie groups. I will address how to decompose more general induced representations using the software. (Received February 09, 2014)

1100-22-260 **Wan-Yu Tsai*** (wanyu@math.umd.edu), 432 Ridge Rd. Apt 8, Greenbelt, MD 20770. *Lift of the trivial representation to a nonlinear cover.* Preliminary report.

Let G be the real points of a simply laced, simply connected complex Lie group, and $\widetilde{G}$ be the nonlinear two-fold cover of G. We'll discuss a set of small genuine representations of $\widetilde{G}$, denoted by Lift($\mathbb{C}$), which can be obtained from the trivial representation of G by a lifting operator. The representations in Lift($\mathbb{C}$) can be characterized by the following properties: (a) the infinitesimal character is $\rho/2$; (b) they have maximal tau-invariant; (c) they have a particular associated variety $\mathcal{O}$. When G is split, we will show that all representations in Lift($\mathbb{C}$) are parametrized by pairs (central character, real form of $\mathcal{O}$) by examples. (Received February 09, 2014)

1100-22-270 **Yoshiki Oshima*** (yoshiki.oshima@ipmu.jp). *Discrete branching laws of Zuckerman's derived functor modules.*

The branching law tells how a given representation of a group decomposes when restricted to a subgroup. The branching laws for infinite dimensional representations of real reductive Lie groups are very complicated and far from being understood in general. However, there are nice classes for the detailed study of branching laws introduced by Kobayashi as "discretely decomposable restrictions". In this talk, we discuss the discrete decomposability of restrictions and give explicit branching laws of Zuckerman's derived functor modules $A_{\mathfrak{q}}(\lambda)$ in this framework by using $\mathcal{D}$-modules on the flag variety. (Received February 09, 2014)

1100-22-282 **Ian Le*** (iantuanle@gmail.com), Department of Mathematics, University of Chicago, 5734 S. University Avenue, Chicago, IL 60637. *Laminations in Higher Teichmuller Theory.*

I will explain what laminations are in higher Teichmuller theory, how they generalize Thurston's theory of measured laminations, and the role that they play in the quantization of the moduli space of local systems on a topological surface. (Received February 10, 2014)

1100-22-287 **Kei Yuen Chan*** (chan@math.utah.edu). *Twisted Euler-Poincaré pairings for graded affine Hecke algebras.*

The inner product for the elliptic representation space of p-adic groups was defined homologically as the Euler-Poincaré pairing by Schneider-Stuhler. Graded affine Hecke algebras were an algebraic structure for studying representations of p-adic groups. In this talk, I shall present a twisted Euler-Poincaré pairing for graded affine Hecke algebras and discuss the corresponding twisted elliptic space. This twisted pairing is motivated by the twisted elliptic representation theory of Weyl groups recently introduced by Ciubotaru-He. (Received February 10, 2014)

1100-22-303 **Roger Zierau*** (zierau@math.okstate.edu). *Some examples of the Computation of Invariants of Harish-Chandra Modules.* Preliminary report.

This lecture will give some examples of how one can compute leading term cycles and associated varieties of certain Harish-Chandra modules. One example is that of irreducible representations in the cell of a minimal representation. Other examples are certain highest weight Harish-Chandra modules, from which one may compute invariants of non highest weight Harish-Chandra modules. These invariants come from algebraic and geometric constructions, but give analytic information about (for example) the global character of an irreducible representation. (Received February 10, 2014)

1100-22-315 **Zhanqiang Bai** and **Markus Hunziker*** (markus_hunziker@baylor.edu). *On the Gelfand-Kirillov dimension of a unitary highest weight module.* Preliminary report.

Using earlier work by A. Joseph, we prove a simple formula for the Gelfand-Kirillov dimension of a unitary highest weight module in terms of its highest weight. Our formula generalizes a result of Enright and Willenbring and is inspired by Wang's formula for the dimension of a minimal nilpotent orbit. (Received February 10, 2014)

1100-22-330 **Matthew G. Dawson*** (mdawso5@math.lsu.edu) and **Gestur Ólafsson** (olafsson@math.lsu.edu). *Conical representations for direct limits of symmetric spaces.*

In the study of analysis on the horocycle space G/MN of a Riemannian symmetric space G/K of noncompact type, a crucial role is played by the so-called conical representations of G. We extend the notion of conical representations to the infinite-dimensional case of propagated direct limits of Riemannian symmetric spaces and classify all conical representations that are holomorphic. (Received February 10, 2014)

1100-22-339 **Jon Middleton*** (jmiddlet@ucsd.edu). *Hessians of Conformal Functionals as Invariant Hermitian Forms.* Preliminary report.

Let M be a compact manifold and $\mathcal{M}$ a tame Fréchet manifold of geometric structures on M. Let $H = \mathrm{diff}(M) \ltimes \exp(C^\infty(M))$, which acts on $\mathcal{M}$. A *conformal functional* F is a real-valued H-invariant function on $\mathcal{M}$ that is twice differentiable in Hamilton's sense. The location of extrema for conformal functionals has been of interest to those in conformal geometry, in which $\mathcal{M}$ is the space of Riemannian metrics and F is the zeta-regularized determinant of a Laplace-type differential operator.

In this talk, we will address both the space of Riemannian metrics and the space of strongly pseudoconvex CR structures on S^{2n-1}. Both spaces are acted upon by a real rank one Lie group G: $SO_0(2n,1)$ in the former case and $SU(n,1)$ in the latter. In each case $\mathcal{M}$ has a distinguished structure on which these groups act conformally. We will see that these structures are critical points for F, that the Hessian of F defines a Hermitian form of an admissible representation of G, and that this representation is an irreducible $A_{\mathfrak{q}}(\lambda)$. (Received February 10, 2014)

26 ► Real functions

1100-26-99 **Pieter C Allaart*** (allaart@unt.edu), Mathematics Department, 1155 Union Circle #311430, Denton, TX 76203-5017. *Zero sets and maximum sets of randomized Takagi functions.*

Takagi's continuous but nowhere differentiable function is defined by

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

where $\phi(x)$ is the distance from x to the nearest integer. In this talk we examine two natural schemes for multiplying the terms in the above series by random signs (while preserving continuity of the limit function). Several results will be presented regarding the set of maximum points and the zero set of the resulting randomized Takagi function. These sets tend to be random fractals, and their almost-sure Hausdorff dimension is of particular interest. This topic offers many opportunities for further research, so the talk will end with a list of open problems. (Received February 02, 2014)

30 ► Functions of a complex variable

1100-30-16 **David A Herron*** (david.herron@uc.edu) and **Albert Clop** (albertcp@mat.uab.cat). *Mappings with subexponentially integrable distortion.* Preliminary report.

We examine mappings of finite distortion whose distortion functions are locally subexponentially integrable. We establish a local modulus of continuity estimate for the inverses of such maps, describe the possible expansion and compression of certain Hausdorff measures and Minkowski contents under such mappings, and exhibit examples that describe the extent to which our results are sharp. (Received January 03, 2014)

1100-30-76 **Richard Fournier*** (fournier@dms.umontreal.ca). *Extremal problems for polynomials and the Clunie-Jack lemma.*

We study two extremal problems concerning bound-preserving operators over classes of polynomials. As a by-product, we obtain two new proofs of the Jack-Clunie lemma. (Received January 29, 2014)

1100-30-102 **Tom D Downs*** (proftddowns@msn.com), 12411 Calico Falls Lane, Houston, TX 77041. *Complex Functions and Spherical Regression.*

Polar forms below provide insight and clarity into potential uses of the bilinear functions Mc for dealing with otherwise difficult or insurmountable problems. Let S be a Reimann sphere centered at the origin 0 of a Euclidean space with an xyt rectangular coordinate system and horizontal extended complex equatorial plane C. The vertical polar axis of S is the t-axis, which intersects S at the poles n=(001) and s=(00-1), and C at 0. This is a rigid configuration. Stereographic projections map unit vectors Z=(xyt) on S to points z=x+iy on C, and vice versa, when the 3 points n,Z,z are collinear. The points n on S and ∞ on C are designated images of one another. Bilinear functions Mc map C on to itself and form a group G1 under composition of mappings; their matrix images also form a group under matrix multiplication. The spherical images M of the Mc operate on points Z on S to form a group G2 under composition of mappings. G2 is isomorphic to G1. For any Mc in G1 the identity Mc $\equiv$ {Mc/$\sqrt{}$(Mc*Mc)}x{$\sqrt{}$(Mc*Mc)} = {Uc}x{Hc} holds, where* means the conjugate transpose of Mc, Uc is unitary, and Hc is pos. def. hermitian with decomposition Hc = B*ΔB where B is unitary and Δ is diagonal. Analogous decompositions apply to the images M of G2. (Received February 03, 2014)

1100-30-114 **Matthew Badger** and **James T. Gill***, 220 N. Grand Blvd, St. Louis, MO 63103, and **Steffen Rohde** and **Tatiana Toro**. *Quasisymmetry and rectifiability of quasispheres.*

We obtain Dini conditions with "exponent 2" that guarantee that an asymptotically conformal quasisphere is rectifiable. In particular, we show that for any $\epsilon > 0$ integrability of

$$(\sup_{1-t<|x|<1+t} K_f(x) - 1)^{2-e} dt/t$$

implies that the image of the unit sphere under a global quasiconformal homeomorphism f is rectifiable. We also establish estimates for the weak quasisymmetry constant of a global K-quasiconformal map in neighborhoods with maximal dilatation close to 1. (Received February 04, 2014)

1100-30-123 **Katrin Fassler**, **Anton Lukyanenko*** (anton@lukyanenko.net) and **Kirsi Peltonen**. *Uniformly quasiregular mappings on sub-Riemannian manifolds.*

A K-quasi-regular (QR) mapping in the plane is the composition of a K-quasi-conformal mapping with a complex-analytic mapping; in a more general context, one considers branched covers with dilatation bounded by K. While QR mappings of Riemannian spaces (especially $\mathbb{R}^n$) have been studied extensively, little is known about their properties for more general metric spaces.

We study QR mappings on sub-Riemannian (sR) metric spaces, focusing on the 3-sphere $S^3 \subset \mathbb{C}^2$ and its quotients the lens spaces. We prove the following:

(1) Every lens space with its natural sR metric admits a uniformly quasi-regular mapping (i.e. a K-QR mapping with K-QR iterates).

(2) Every UQR mapping of a sR manifold admits an invariant measurable conformal structure.

While the first result shows the existence of non-trivial QR mappings, the second indicates a degree of rigidity. (Received February 04, 2014)

1100-30-179 **Pritha Chakraborty*** (pritha.chakraborty@ttu.edu), Texas Tech University, Department of Mathematics & Statistics, Broadway and Boston, Lubbock, TX 79409. *Growth of hyperbolic cells.* Preliminary report.

A hyperbolic cell is a hyperbolic polygon in the disk model with all its vertices on the unit circle. In 1991, Joseph Hersch considered a growth process of such polygons when each n-gon generates an $n(n-1)$-gon by reflecting itself across all of its sides. J. Hersch conjectured that the minimal growth of the conformal radius under this process occurs when a polygon is regular. This conjecture was confirmed by A. Solynin. In connection with this work, A. Solynin raised a question on the growth/decay of other characteristics of hyperbolic cells under this process. In particular, he conjectured that the growth of the Euclidean area will be minimal for the regular n-gons and also posed a more general Majorization problem for the Hersch process of growth of hyperbolic cells.

In this talk, we will discuss our preliminary results toward solution of these Solynin's conjectures. (Received February 07, 2014)

1100-30-180 **Alexander Yu. Solynin*** (alex.solynin@ttu.edu), Texas Tech University, Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409-104. *Conformal invariants and special functions.*

As well known many conformal invariants and other characteristics of planar configurations can be expressed explicitly as combinations of special functions. Typically, such combinations contain Euler's gamma and beta functions, complete and incomplete elliptic integrals, hypergeometric functions, theta functions, etc.

The first goal of this talk is to link certain properties of some special functions with the relevant properties of the conformal invariants.

My second goal will be to draw attention of experts in the area of special functions to some specific open questions concerning behavior of special functions which arose from my work on extremal problems in Complex Analysis and Potential Theory. In many cases resolving a question on special functions will complete a solution of an interesting extremal problem in my area of research. (Received February 07, 2014)

1100-30-201 **Nadya Askaripour*** (nadya.askaripour@gmail.com) and **A. Boivin**. *On closed sets of approximation on non-compact Riemann surfaces.*

Let R be a non-compact Riemann surface. A closed subset E of R is called a set of holomorphic (resp. meromorphic) approximation if every function holomorphic on E can be approximated uniformly on E by functions holomorphic (resp. meromorphic) on R. The characteriza- tion of the sets of approximation (either holomorphic or meromorphic) is still open in general, though it is known in some cases e.g. when E is compact and R arbitrary, or when R is the complex plane, then it is known by N. U. Arakelyan.

Non-compact Riemann surfaces are interesting since they might be of infinite genus and they might have complicated boundary. I will discuss an extension theorem for Riemann surfaces, which is used to improve the characterization of the closed sets of approximation, and recent re- sults in this direction obtained with A. Boivin. (Received February 08, 2014)

1100-30-261 **David Radnell** (dradnell@aus.edu), Department of Mathematics and Statistics, American University of Sharjah, P.O. Box 26666, Sharjah, United Arab Emirates, **Eric Schippers*** (eric_schippers@umanitoba.ca), Department of Mathematics, Machray Hall, 186 Dysart Rd, University of Manitoba, Winnipeg, Manitoba R3T 3A8, Canada, and **Wolfgang Staubach** (wolfgang.staubach@math.uu.se), Department of Mathematics, Uppsala Universitet, Box 256, 751 05, Uppsala, Sweden. *The Weil-Petersson metric on a Teichmuller space of bordered surfaces.*

The Weil-Petersson metric is a Kahler metric on the Teichmuller space of compact surfaces with finitely many punctures. The natural generalization of this metric does not in general converge on infinite-dimensional Teichmuller spaces. It was shown to converge on a refinement of the universal Teichmuller space by Cui, Hui, and Takhtajan/Teo.

In this talk I will discuss generalizations of these results to the case of surfaces of genus g bordered by n closed curves. In particular, there is a refined Teichmuller space of such surfaces with complex Hilbert manifold structure, and a convergent Weil-Petersson metric. Joint work with David Radnell and Wolfgang Staubach. (Received February 09, 2014)

1100-30-263 **Joan Lind*** (joanlind@gmail.com) and **Huy Tran**. *Regularity of Loewner curves.*

The Loewner equation encrypts a growing simple curve in the plane into a real-valued driving function. We show that if the driving function is in C^β with $\beta > 2$ then the Loewner curve is in $C^{\beta+\frac{1}{2}}$. This extends a result of Carto Wong who proved the statement for $1/2 < \beta \leq 2$. (Received February 09, 2014)

1100-30-332 **Jacob S Makaya*** (jac.makaya@ttu.edu), Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409, and **Alexander Yu Solynin** (alex.solynin@ttu.edu), Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409. *Bubbles in the Channel: Complex Potentials and Quadratic Differentials.* Preliminary report.

We will discuss some properties of static and steady state bubbles in a channel filled with incompressible fluid. First, we explain how the theory of quadratic differentials can be used to study the fluid flow and evolution of bubbles in the channel. Then we will use complex potentials and properties of trajectory structure of quadratic differentials to decide when the flow is directed, conservative, with or without critical points inside the fluid domain. Some geometric characteristics of steady state bubbles also will be discussed. (Received February 10, 2014)

1100-30-335 **Alan F. Beardon** and **C. David Minda*** (minda@ucmail.uc.edu), Department of Mathematical Sciences, Cincinnati, OH 45221-0025. *Rescaling non-Lipschitz families of analytic functions.* Preliminary report.

In 1973 Lohwater and Pommerenke proved a rescaling characterization of non-normal functions on the unit disk $\mathbb{D}$. In 1975 Zalcman established a rescaling characterization of non-normal families of meromorphic functions on $\mathbb{D}$ by using an adaptation of the Lohwater-Pommerenke technique. Zalcman's Rescaling Lemma has proved valuable in function theory and related fields. The proofs of these and related scaling results has been analytic. A uniform geometric approach to these and other rescaling results for various non-Lipschitz families of analytic functions is presented. The main tool is a natural non-expanding conformal rescaling of an individual analytic function that provides a systematic geometric approach to rescaling results in a number of contexts. The original affine rescalings of Lohwater-Pommerenke and Zalcman follow from these conformal rescalings by using affine approximations for conformal mappings. (Received February 10, 2014)

1100-30-338 **Aimo Hinkkanen*** (aimo@math.uiuc.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801. *Painlevé transcendents of small growth.*

Transcendental solutions of the second Painlevé equation are meromorphic functions in the complex plane, and have order (as defined in terms of the Nevanlinna characteristic) 3/2 or 3, and the transcendental solutions of the fourth Painlevé equation have order 2 or 4. The solutions of order 3/2 or 2 are exceptional. Ilpo Laine and the speaker have developed a criterion in terms of an auxiliary function to determine which order one obtains for a transcendental solution. In this talk we discuss the determination of the order for the second Painlevé equation in those cases when it turns out to be the smaller one. (Received February 10, 2014)

1100-30-345 **Brett W. Hafferkamp*** (brett.hafferkamp@ttu.edu). *Expected Values of Conformal Radius. Preliminary Report.* Preliminary report.

Conformal radius $R(D,z)$ is an important characteristic of a planar domain D at its point z. It controls scaling under conformal mapping, accuracy of polynomial approximation in the complex plane, and is related to energy and capacity of two-dimensional distributions of charges.

There are numerous publications concerning bounds and estimates for the *maximal value* of the conformal radius when z is varying within D. This study is an attempt to find similar bounds and estimates for the *expected value* $\mathbf{E}(R(D,z))$ of $R(D,z)$ when the reference point z is uniformly distributed over D. In particular, we will discuss a transformation rule of the expected value under conformal mappings and present examples of evaluation of the expected values for some standard geometrical configurations. This is a joint work with A. Yu. Solynin. (Received February 10, 2014)

33 ► Special functions

1100-33-7 **Bruce C. Berndt** and **Atul A Dixit*** (adixit@tulane.edu), 6823 Saint Charles Avenue, New Orleans, LA 70118, and **Arindam Roy** and **Alexandru Zaharescu**. *A series identity, possibly connected with a divisor problem, in Ramanujan's Lost Notebook.*

On page 336 in his lost notebook, S. Ramanujan proposes an identity that may have been devised to attack a divisor problem. Unfortunately, the identity is vitiated by a divergent series appearing in it. We prove here a corrected version of Ramanujan's identity. We also show its connection to an infinite series involving the modified Bessel function $K_s(x)$. A related series identity due to Ramanujan and S. Wigert is also discussed along with its new generalization. This is joint work with Bruce C. Berndt, Arindam Roy and Alexandru Zaharescu. (Received October 15, 2013)

1100-33-47 **Mourad E. H. Ismail*** (mourad.eh.ismail@gmail.com), Department of Mathematics, University of Central Florida, Orlando, FL 32828. *Analytic Properties of Complex Hermite Polynomials.*

We study the complex Hermite polynomials $\{H_{m,n}(z,\bar{z})\}$ in some detail, establish operational formulas for them and prove a Kibble-Slepian type formula, which extends the Poisson kernel for these polynomials. Positivity of the associated kernels is discussed. We also give an infinite family of integral operators whose eigenfunctions are $\{H_{m,n}(z,\bar{z})\}$. Some inverse relations are also given. We give a two dimensional moment representation for $H_{m,n}(z,\bar{z})$ and evaluate several related integrals. We also introduce bivariate Appell polynomials and prove that $\{H_{m,n}(z,\bar{z})\}$ are the only bivariate orthogonal polynomials of Appell type. (Received January 22, 2014)

1100-33-59 **Karl Dilcher*** (dilcher@mathstat.dal.ca), Department of Mathematics and Statistics, Dalhousie University, Halifax, NS B3H4R2, Canada, and **Sinai Robins** (rsinai@ntu.edu.sg), Division of Mathematical Sciences, Nanyang Technological University, Singapore, 637371, Singapore. *Zeros and irreducibility of polynomials with gcd powers as coefficients.*

We study the family of self-inversive polynomials of degree n, whose jth coefficient is $\gcd(n,j)^k$, for each fixed integer $k \geq 1$. We prove that these polynomials have all of their roots on the unit circle, with uniform angular distribution. In the process we prove some new results on Jordan's totient function. We also prove that these polynomials are irreducible, apart from an obvious linear factor, whenever n is a power of a prime, and conjecture that this holds for all n. (Received January 26, 2014)

1100-33-71 **Ibrahim A. Salehbhai*** (ibrahimmaths@gmail.com), Department of Mathematics, V.N. South Gujarat University, Udhna Magdalla Road, SURAT, GUJARAT 395007, India. *Application of Special Functions to Fractional Calculus.*

The subject of fractional calculus deals with derivatives and integrals of arbitrary real or complex order. It has gained considerable popularity and importance during the past three decades or so, due mainly to its demonstrated applications in widespread fields of science and engineering. It does indeed provide several potentially useful tools for solving differential and integral equations, and various other problems involving special functions of mathematical physics as well as their extensions and generalizations in one and more variables. The main objective of the present talk is to discuss the applications of Special Functions in Fractional Calculus. Some particular fractional differential equations have been solved. (Received January 28, 2014)

1100-33-95 **Roger W. Barnard*** (roger.w.barnard@ttu.edu), Dept. Math and Stat, Texas Tech University, Lubbock, TX 79409, **Kent Pearce** (kent.pearce@ttu.edu), Dept. Math and Stat, Texas Tech University, Lubbock, TX 79409, and **Alex Trindade** (alex.trindade@ttu.edu), Dept. Math and Stat, Texas Tech University, Lubbock, TX 79409. *Tail Mean Estimation is More Efficient than Tail Median - Evidence from the Exponential Power Distribution.* Preliminary report.

This talk construct estimates for the asymptotic efficiency of the mean vs median statistics for random variables of extended exponential type. (Received January 31, 2014)

1100-33-112 **Ajay K Shukla*** (ajayshukla2@rediffmail.com), Department of Applied Mathematics & Hum., S V National Institute of Technology, Surat, 395 007, India. *Extention of Sheffer Classification for Two Variables.*

Sheffer [Some properties of polynomial sets of type zero, Duke Math. J. 5 (1939), pp.590-622] studied polynomial sets zero type and many authors investigated various properties and its applications. Brown [On the Sheffer A-type of certain Modified Polynomial sets, Proc. Amer. Math. Soc., Vol. 23, 1969, pp.718-722.] studied Appell sets and Sheffer A- type certain modified polynomial sets. In the sequel to the study, we discuss some generalizations the Sheffer polynomials by using partial differential operator in two variables and some properties of σ-type polynomials in one and two variables, we also include the generalizations of Appell set, Sheffer A-type zero and α-type polynomial sets polynomials in two variables with their properties.
(Received February 04, 2014)

1100-33-121 **Ranjan Kumar Jana*** (rkjana@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, and **Bruce C. Berndt** (berndt@math.uiuc.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801. *Bessel Function Series in connection with Ramanujan's Mathematics.*

Bessel function, also known as the circular cylinder function, is the most commonly used special function in the field of mathematical physics. No other special functions have received such detailed treatment in readily available treaties (G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press, London, 1958) as have the Bessel functions. Due to its importance in Mathematical, Physical, and Engineering Sciences many researcher motivated towards the study of Bessel functions.

In the present talk an attempt is made to discuss Bessel function series, its connection with Ramanujan's Mathematics and its interplay with Number Theory. (Received February 04, 2014)

1100-33-131 **Danna N Naser*** (danna.naser@ttu.edu) and **Roger Barnard**. *Analytic and Geometric Properties of the Hypergeometric Function.*

We will define the hypergeometric function and discuss some of its analytic properties. We will then use Mathematica images to illustrate how varying the parameters of a hypergeometric function changes the images from circular regions to non-convex domains. (Received February 05, 2014)

1100-33-157 **Li-Chien Shen*** (shen@ufl.edu), 358 Little Hall, Gainesville, FL 32611. *A Generalization of Ramanujan's Differential Identities for the Fundamental Automorphic Forms of the Hecke Groups.*

A Generalization of Ramanujan's Differential Identities for the Fundamental Automorphic Forms of the Hecke Groups

Abstract. Let m be a positive integer and $\lambda = 2\cos\frac{2\pi}{m}$. The Hecke group $\mathfrak{G}(\lambda)$ is the group of fractional linear transformations generated by $\tau+\lambda$ and $-\frac{1}{\tau}$. Exploiting the properties of the conformal mapping for a fundamental domain of a Hecke group $\mathfrak{G}(\lambda)$, we construct three fundamental automorphic forms satisfying a system of differential equations. For the special case of $\lambda = 1$, we obtain the well-known Ramanujan's differential equations for the Eisenstein series P, Q and R: $qP' = \frac{P^2-Q}{12}, qQ' = \frac{PQ-R}{3}$ and $qR' = \frac{PR-Q^2}{2}$.
(Received February 06, 2014)

1100-33-193 **Peter Duren*** (duren@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109-1043, and **Martin Muldoon** (muldoon@yorku.ca), Department of Mathematics & Statistics, York University, Toronto, ON M3J 1P3, Canada. *Asymptotic behavior of Bessel functions.*

The Sonin–Pólya theorem provides a simple proof that $J_\nu(x) = O(1/\sqrt{x})$ as $x \to \infty$, whenever $|\nu| \geq \frac{1}{2}$, but it fails to capture this well known result when $|\nu| < \frac{1}{2}$. However, a simple proof for $|\nu| < \frac{1}{2}$ can be obtained by combining the Sonin–Pólya theorem with an elementary theorem of similar nature. Further applications of this method will also be discussed. (Received February 07, 2014)

1100-33-226 **Pratik V Shah*** (pratikshah8284@yahoo.co.in), S V National Institute of Technology, Surat, 3905007, India, and **Ajay K Shukla** (ajayshukla2@rediffmail.com), S V National Institute of Technology, Surat, 395007, India. *Some Properties of Generalized Mittag-Leffler type function and its Applications.*

The present paper deals with some properties of Generalized Mittag-Leffler type function and also its applications in Statistics. The generalized Mittag-Leffler type function $E^{\gamma,q}_{\alpha,\beta}(z)$ is defined by Shukla and Prajapati[J. Math. Anal. Appl. No 336 (2007), 797-811] as,

$$E^{\gamma,q}_{\alpha,\beta}(z) = \sum_{n=0}^{\infty} \frac{(\gamma)_{qn}}{\Gamma(\alpha n+\beta)} \cdot \frac{z^n}{n!}$$

where, $\alpha, \beta, \gamma \in \mathbf{C}, \Re(\alpha) > 0, \Re(\beta) > 0, q \in (0,1) \cup \mathbf{N}$ (Received February 09, 2014)

1100-33-268 **James G Mc Laughlin*** (jmclaughlin2@wcupa.edu), Mathematics Department, West Chester University, West Chester, PA 19383. *A General Multi-sum Transformation and Some Implications.*

We give a general transformation that allows certain quite general basic hypergeometric multi-sums of arbitrary depth, sums that involve an arbitrary sequence $\{g(k)\}_{k=0}^{\infty}$, to be reduced to an infinite q-product times a single basic hypergeometric sum. For double sums, the sequence $\{g(k)\}_{k=0}^{\infty}$ may be extended to a bilateral sequence $\{g(k)\}_{k=-\infty}^{\infty}$. Various applications are given, including summation formulae for some q orthogonal polynomials, and various multi-sums that are expressible as infinite products. (Received February 09, 2014)

1100-33-289 **Snehal B. Rao** (sbr_msub@yahoo.com), Department of Applied Mathematics, M. S. University of Baroda, Vadodara, India, Vadodara, India, and **Shrinivas J Rapeli*** (shrinu0711@gmail.com), Dept. of Applied Mathematics and Humanities, S V National Institute of Technology, Surat, India.

Wright Type Generalized Hypergeometric Function and fractional operators

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The present paper deals with the study of fractional integral and differential operators while applied on the Wright type Generalized Hypergeometric Function. This is denoted as :

$${}_2R_1(a,b;c;\tau;z) = \frac{\Gamma(c)}{\Gamma(b)} \sum_{k=0}^{\infty} \frac{(a)_k \Gamma(b+\tau k)}{\Gamma(c+\tau k)\ k!} z^k;\ \mathrm{Re}\,(a) > 0,\ \mathrm{Re}\,(b) > 0, \mathrm{Re}\,(c) > 0, \tau > 0,\ |z| < 1$$

We define operator as

$$\left(R^{\omega\,;\,a,b}_{\alpha+;\tau,c}\, f\right)(x) = R^{\omega\,;\,a,b}_{\alpha+;\tau,c}\, f\,(x) = \int_{\alpha}^{x} (x-t)^{c-1}\, R\,(a,b;c;\tau;\omega\,(x-t)^{\tau})\, f\,(t)\, dt, \qquad (x > \alpha)\,,$$

where, $a, b, c, \omega \in;$ $\mathrm{Re}\,(a) > 0, \mathrm{Re}\,(b) > 0, \mathrm{Re}\,(c) > 0;$ $\tau > 0$ have been derived. We also obtain some properties of aforesaid operator.
(Received February 10, 2014)

1100-33-295 **S B Rao**, Vadodara, India, and **J P Sharma*** (sbr_msu@yahoo.com), Vadodara, India. *Wright Type Generalized Hypergeometric Function and Fractional operators.*

Virchenko et al. [Some Results on a Generalized Hypergeometric Function, Integral Transforms and Special Functions, Vol. 12, Issue No.1 (2001), 89-100.] gave some results on the Wright type Generalized Hypergeometric Function ${}_2R_1(a,b;c;\tau;z) = \frac{\Gamma(c)}{\Gamma(b)} \sum\limits_{k=0}^{\infty} \frac{(a)_k \Gamma(b+\tau k)}{\Gamma(c+\tau k)\ k!} z^k;$ $\mathrm{Re}\,(a) > 0,$ $\mathrm{Re}\,(b) > 0, \mathrm{Re}\,(c) > 0, \tau > 0,$ $|z| < 1$. Gauss Hypergeometric Function is a special case of Wright type Hypergeometric Function, this is given as : $F(a,b;c;z) = \sum\limits_{k=0}^{\infty} \frac{(a)_k (b)_k}{(c)_k k!} z^k$. The object of the paper is to obtain some results on Fractional Integral and Differential operators related to the function ${}_2R_1\,(a,b;c;\tau,z)$. (Received February 10, 2014)

1100-33-308 **Howard S. Cohl*** (howard.cohl@nist.gov), 100 Bureau Drive, Mail Stop 8910, Gaithersburg, MD 20899, **Hans Volkmer** (volkmer@uwm.edu), EMS Building, Room E403, Milwaukee, WI 53201-0413, and **Michael Baeder** (mabaeder@gmail.com), 320 W. Foothill Blvd., Claremont, CA 91711. *Generalizations of generating functions for hypergeometric and q-hypergeometric orthogonal polynomials.*

In this talk, we present generalized generating functions for hypergeometric and q-hypergeometric orthogonal polynomials. These generalized expansions are obtained by re-expressing the polynomials in the generating functions using multi-parameter connection relations. The resulting multi-summation expressions are rearranged with justification in order to identify the coefficients of the generalized generating function expansions. The coefficients of these expansions are given in terms of generalized and basic hypergeometric series. We also produce definite integral relations by applying orthogonality to our generalized expansions. We give generalizations of generating functions for Gegenbauer, Jacobi, Laguerre, Wilson, continuous Hahn, continuous dual Hahn, Meixner-Pollaczek, q-ultraspherical/Rogers, q-Laguerre, and little q-Laguerre polynomials. (Received February 10, 2014)

1100-33-320 **Victor H Moll*** (vhm@tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118, and **Christophe Vignat** (cvignat@tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118. *Probabilistic proofs of identities for Special Functions.*

A variety of identities in Special Functions, involving sums and integrals of classical functions, may be established by identifying the components of the identity in terms of moments of a random variable. A selection of examples is presented. (Received February 10, 2014)

1100-33-322 **David M. Bradley*** (dbradley@member.ams.org), Department of Mathematics & Statistics, University of Maine, 5752 Neville Hall, Orono, ME 04469. *On generating series for certain infinite families of multiple polylogarithms.*

We consider vector spaces of functions satisfying a certain class of differential equations. Special cases include generating series for multiple polylogarithms whose argument lists form an ultimately periodic sequence. (Received February 10, 2014)

1100-33-326 **Yuk J Leung*** (yleung@math.udel.edu), Department of Mathematical Sciences, Newark, DE 19716. *Clustering of complex zeros of special functions.* Preliminary report.

It is known that the complex zeros of certain special functions lie close to the trajectories of a quadratic differential (or anticlinals as called by Hille). If the special function is a solution of a second order differential equation of the form $y''(z) + Q(z)y(z) = 0$, then the quadratic differential is defined by $Q(z)dz^2$. For various classes of hypergeometric polynomials generated with varying parameters, the work of Martinez-Finkelshten, Rakhmanov, Duren and many others showed that the complex zeros accumulate along the trajectories of a quadratic differential as the degree of the polynomial goes to infinity. We will examine how the classical work of Hille and Schiffer can be applied to obtain similar conclusions. (Received February 10, 2014)

1100-33-355 **Robert S. Maier*** (rsm@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *Three-dimensional quadratic differential systems and the Painlevé property.*

A finite-dimensional nonlinear differential system is a system of coupled nonlinear ordinary differential equations. The solutions of such a system cannot necessarily be expressed in terms of elementary or (known) higher transcendental functions, even if the nonlinearities are of the seemingly simple quadratic type. Interesting three-dimensional quadratic systems include (i) generalized Darboux–Halphen systems and (ii) 3-species Lotka–Volterra systems. Solving either can be reduced to solving a certain nonlinear third-order scalar ODE, which we call a generalized Schwarzian equation. By appealing to a partial classification of third-order ODEs with the Painlevé property, due to C. Carton-LeBrun, we can characterize the parameter values for which our systems have the property. Moreover, we can integrate any such system in terms of elementary or elliptic functions, or Painlevé transcendents. Quadratic differential systems with invariant curves of genus greater than unity lie outside this classification, and remain to be treated. (Received February 10, 2014)

34 ► *Ordinary differential equations*

1100-34-73 **Gro Hovhannisyan*** (ghovhann@kent.edu) and **Oliver Ruff** (oruff@kent.edu). *On oscillatory solutions of linear differential equations with complex constant coefficients.* Preliminary report.

We consider the initial value problems for the second and third order linear differential equations with complex constant coefficients. We describe the necessary and sufficient conditions of the existence of oscillatory solutions. Proofs are based on analysis of the zeros of solutions represented as a linear combination of exponential functions. (Received January 28, 2014)

1100-34-115 **Jacob J. Weiss*** (weissjj@unk.edu), 905 W. 25th St., 2040 Founders Hall, Kearney, NE 68849. *Multiple Positive Solutions to a Second Order Dynamic Equation.*

We establish some criteria for the existence of multiple positive solutions, including conditions for any number of positive solutions, for certain two point boundary value problems for the dynamic equation

$$-u^{\Delta\Delta} = f(t, u^{\sigma})$$

on a time scale $\mathbb{T}$. (Received February 04, 2014)

1100-34-146 **Carlos E. Arreche*** (carreche@gc.cuny.edu), The Graduate Center, Mathematics Department, 365 Fifth Ave., Room 4208, New York, NY 10016. *Computing unipotent radicals of parameterized Picard-Vessiot groups: the case of second-order equations.*

We present a new method to compute the unipotent radical $R_u(G)$ of the parameterized Picard-Vessiot (PPV) group G associated to a second order linear differential equation with differential parameters. Our procedure relies on an earlier algorithm to compute $R_u(G)$, due to Dreyfus, which is effective under the assumption that the reductive quotient $G/R_u(G)$ is differentially constant. When this condition is not satisfied, we compute a new set of parametric derivations such that the PPV group G' (relative to the new parametric derivations) has the properties that: $G'/R_u(G')$ is differentially constant; and $R_u(G')$ is defined by the same differential equations as $R_u(G)$. (Received February 06, 2014)

1100-34-181 **Glenn E Lahodny Jr.*** (glahodny@cvm.tamu.edu), Veterinary Integrative Biosciences, Texas A&M University, 4458 TAMU, College Station, TX 77840, and **R Gautam** and **R Ivanek**. *The Role of Intermittent Shedding in Transmission of Infectious Diseases: Salmonellosis in Pigs Example.*

Salmonellosis is the most common foodborne disease in the United States, and contaminated pork products have been identified as a source of human infection. A model is developed for the transmission of salmonellosis among pigs in a grower-finisher facility. The model accounts for indirect transmission, intermittent shedding of infected pigs, growth of free-living Salmonella, and environmental decontamination. The basic reproduction number is used to determine the long-term behavior of the model regarding disease persistence or extinction. To evaluate the role of intermittent fecal shedding, we consider two cases: (1) infected pigs shed Salmonella into the environment continuously during their infected period, and (2) infected pigs cycle through periods of active shedding and non-shedding throughout their infected period. The value of $\mathcal{R}_0$ and the slaughter-age prevalence of infection are computed for each case to determine the impact of the intermittent shedding pattern of infected pigs on the modeling predictions about infection spread. The results indicate that neglecting the intermittent pattern of infectiousness results in overestimation of $\mathcal{R}_0$ and infection prevalence. These findings have implications for farm management and infection control. (Received February 07, 2014)

1100-34-236 **Teresa Crespo*** (teresa.crespo@ub.edu), Departament d'Algebra i Geometria, Universitat de Barcelona, Gran Via de les Corts Catalanes 585, 08007 Barcelona, Spain, and **Zbigniew Hajto** and **Marius van der Put**. *Real and p-adic Picard-Vessiot fields.*

For a differential module over a real (resp. p-adic) differential field such that its field of constants is real closed (respectively p-adically closed), we obtain the existence and unicity of a real (respectively p-adic) Picard-Vessiot field. The proof uses Deligne's work on Tannakian categories and a result of Serre on Galois cohomology. (Received February 09, 2014)

1100-34-255 **Abhishek Pandey*** (abhishe@g.clemson.edu), **Jan Medlock** and **Anuj Mubayi**. *The introduction of dengue vaccine may temporarily cause large spikes in prevalence.*

A dengue vaccine is expected to be available within few years. Once vaccine is available, policy makers will need to find suitable vaccine-allocation policies. Mathematical models of dengue transmission predict complex temporal patterns in prevalence, driven by seasonal oscillations in mosquito abundance, and may include a transient period immediately after vaccine introduction where prevalence can spike higher than in the pre-vaccine period. These spikes in prevalence could lead to doubts about the vaccination program among the public and among even decision makers, possibly impeding the vaccination program. Using simple dengue-transmission models, we show that the presence of transient spikes in prevalence is a robust phenomenon that occurs when vaccine efficacy and vaccination rate are not either both very high or both very low. Despite the presence of transient spikes in prevalence, the models predict that vaccination does always reduce the total number of infections in the 15 years after vaccine introduction. Policy makers should prepare for spikes in prevalence after vaccine introduction to mitigate the burden of these spikes and any resulting perception of inefficacy of the vaccine program. (Received February 09, 2014)

1100-34-259 **Elvan Akin** (akine@mst.edu), Rolla, MO 65401, and **Ozkan Ozturk*** (oo976@mat.edu), Missouri University of Science & Technology, Department of Mathematics & Statistics, 1870 Miner Cir, Rolla, MO 65401-0020. *Asymptotic Behavior of Emden-Fowler Dynamic Equations on Time Scales.*

We present asymptotic behavior of nonoscillatory solutions of the Generalized Emden-Fowler Dynamic Equations on Time Scales based on suitable integrals. We also investigate the convergence or divergence relationships between those integrals. (Received February 09, 2014)

1100-34-340 **Elvan Akin*** (akine@mst.edu), 1000 W 12th Street, Rolla, MO 65401, and **Said Grace** and **Ravi Agarwal**. *Oscillatory Theorems for Certain Second Order Damped Dynamic Inclusions with Distributed Deviating Arguments.*

We establish some new criteria for the oscillation of second order nonlinear damped dynamic inclusions with distributed deviating arguments on time scales. (Received February 10, 2014)

1100-34-341 **Alex Wang*** (alex.wang@ttu.edu), Department of Math & Stat, Texas Tech University, Lubbock, TX 79409-1042. *A Simple Proof of Hartman-Grobman Theorem.*

A Simple Proof of Hartman-Grobman Theorem is introduced. (Received February 10, 2014)

1100-34-362 **Susmita Sadhu*** (susmita.sadhu@gcsu.edu) and **Saikat Chakraborty Thakur**. *Mixed mode oscillations and chaos in a predator-prey-competing scavenger model with Holling type II functional response.* Preliminary report.

We report existence of mixed mode oscillations [MMO], crash-recovery-outbreak phenomena [CRO] and chaos in a predator-prey-scavenger model with Holling type II functional response and added competition. The prey is the primary source of the population dynamics. The scavenger feeds on the carcasses of the predator and also hunts the common prey, thus bringing in competition to the predator. We extend earlier predator-prey-scavenger models which had a type I functional response and without competition. The normalized equations can be set as a singularly perturbed system that can explain the observed CRO phenomenon. In addition we find MMO and period doubling route to chaos for both the CRO and MMO states of the system as we vary one of the system parameters. Numerical results show cascades of period doubling bifurcations and rich dynamics. We conjecture the existence of a folded singularity in the system that gives rise to canards. (Received February 10, 2014)

35 ► Partial differential equations

1100-35-17 **Katarina Jegdic*** (jegdick@uhd.edu), University of Houston - Downtown, Department of Mathematics and Statistics, One Main Street, Houston, TX 77002. *A free boundary approach for solving a Riemann problem for the isentropic gas dynamics equations.*

In this talk we consider a two-dimensional Riemann problem for the isentropic gas dynamics equations. The initial data is chosen in such a way that the resulting solution corresponds to the case of transonic (or strong) regular shock reflection. We rewrite the problem in self-similar coordinates and we obtain a mixed free boundary problem for the reflected shock and the subsonic state behind the shock. We further rewrite the problem using the Rankine-Hugoniot shock equations and we obtain a second order elliptic problem for density, two hyperbolic equations for pseudo-velocities and an ordinary differential equation for the reflected shock. Using the theory of second order elliptic equations with mixed boundary conditions by Lieberman, Trudinger and Gilbarg, as well as various fixed point arguments, we prove existence of a solution to the above Riemann problem in a neighborhood of the reflection point. (Received February 03, 2014)

1100-35-30 **Patrick Guidotti*** (gpatrick@math.uci.edu), 340 Rowland Hall, Department of Mathematics, University of California at Irvine, Irvine, CA 92697-3875. *Equilibria and their stability for a quasi-stationary droplet model.*

A classical fluid dynamics model is considered for the contact angle evolution of a viscous droplet on a homogeneous substrate. Mathematically it takes the form of a moving boundary problem. It is shown that the evolution is globally well-posed in the vicinity of the manifold of equilibria and that solutions, starting close to the manifold, converge exponentially back to a specific equilibrium on it. The proposed approach is direct, explicit, and relies on the choice of a convenient "natural" coordinate system in the "space of shapes" for the domain evolution which yields a particularly simple normal form. (Received January 15, 2014)

1100-35-31 **David S Gilliam*** (david.gilliam@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Box 41042, Lubbock, TX 79409, and **Edward Allen** (edward.allen@ttu.edu) and **John A Burns** (jaburns@vt.edu). *Incorrect Convergence of Computational Solutions for a Burgers' Problem.*

A simple example for Burgers equation is used to illustrate that even theoretically convergent numerical schemes can produce numerical steady state solutions that do not correspond to steady state solutions of the boundary value problem. This phenomenon should be considered in any computational study of non-unique solutions to partial differential equations that govern physical systems such as fluid flows. The erroneous solutions arise from the use of finite floating point arithmetic which is inherent in every digital computer. We claim that the erroneous solutions are actually real solutions of a "nearby" boundary value problem containing a nonzero parameter which is considered zero in a finite floating point number system on a computer. (Received January 15, 2014)

1100-35-36 **Joseph A. Iaia*** (iaia@unt.edu), University of North Texas, 1155 Union Circle, P.O. Box 311430, Denton, TX 76203. *Spreading of Charged Microdroplets.* Preliminary report.

We consider the spreading of a charged microdroplet on a flat dielectric surface whose spreading is driven by surface tension and electrostatic repulsion. This leads to a third order nonlinear partial differential equation that gives the evolution of the height profile. It can be shown that the height profile $h(r,t)$ of a circular drop satisfies:

$$h_t + \frac{1}{r}\frac{\partial}{\partial r}\left[\frac{r}{3\mu}h^3\frac{\partial}{\partial r}\left(\frac{Q^2}{2\epsilon_0(4\pi a(t))^2}\frac{1}{a^2(t)-r^2} + \gamma(h_{rr} + \frac{h_r}{r})\right)\right] = 0$$

where $a(t)$ is the radius of the drop and the boundary conditions are:

$$h_r(0,t) = h_{rrr}(0,t) = 0 \text{ (due to the circular symmetry), and}$$

$$h(a(t),t) = 0.$$

Here γ is the free surface tension coefficient, ϵ_0 is the permittivity of the gas above the drop, μ is the viscosity, and Q is the total charge.

We seek a self-similar solution such that the radius of the drop $a(t)$ satisfies a power law, i.e. $a(t) = At^{\beta}$. This gives an ordinary differential equation and we discuss existence and uniqueness of the solution of this equation. (Received February 07, 2014)

1100-35-43 **Gary M. Lieberman*** (lieb@iastate.edu), Department of Mathematics, Iowa State University, 396 Carver Hall, Ames, IA 50011. *Boundary regularity for solutions of singular elliptic equations without boundary conditions.*

In 1951, Keldysh showed that solutions of degenerate elliptic equations, which are equivalent to the singular equation

$$u_{xx} + u_{yy} + \frac{b}{y}u_y = 0$$

with $b \geq 1$, have a peculiar property compared to solutions of the Laplace equation. The solutions are uniquely determined on any subdomain of the upper half-plane by their boundary data off of the x-axis. Such results can be rephrased as uniqueness of the solution in terms of an assumed regularity up to the x-axis. In this talk, we give a sketch of the corresponding results for more general elliptic equations, including some very recent results by a number of authors in a general framework. Similar results were proved in great generality by Fichera but here we present sharper estimates under appropriate hypotheses. (Received January 22, 2014)

1100-35-44 **Luan T. Hoang**, Box 41042, Lubbock, TX 79409, **Truyen V. Nguyen**, 302 Buchtel Common, Akron, OH 44325, and **Tuoc V. Phan*** (phan@math.utk.edu), 227 Ayress Hall, 1403 Circle Drive, Knoxville, TN 37996. *Self-Diffusion and Cross-Diffusion Equations: $W^{1,p}$-Estimates and Global Existence of Smooth Solutions.*

We investigate the global time existence of smooth solutions for the Shigesada-Kawasaki-Teramoto system of cross-diffusion equations of two competing species in population dynamics. If there are self-diffusion in one species and no cross-diffusion in the other, we show that the system has a unique smooth solution for all time in bounded domains of any dimension. We obtain this result by deriving global $W^{1,p}$-estimates of Calderón-Zygmund type for a class of nonlinear reaction-diffusion equations with self-diffusion. These estimates are achieved by employing Caffarelli-Peral perturbation technique together with a new two-parameter scaling argument. (Received January 22, 2014)

1100-35-45 **Dung Le***, Department of Mathematics, UTSA, One UTSA Circle, San Antonio, TX 78249. *Regularity for Fully Nonlinear P-Laplacian Parabolic Systems: the Degenerate Case.*
We will discuss nonlinear heat approximation and L^∞ preserving homotopy techniques and investigate regularity properties of bounded weak solutions of strongly coupled p-Laplacian parabolic systems which consist of more than one equation defined on a domain of any dimension. The main results imply everywhere Hölder continuity of bounded weak solutions and the global existence of strong solutions to nonlinear p-Laplacian parabolic systems. (Received January 22, 2014)

1100-35-48 **Alexander I. Nazarov*** (`al.il.nazarov@gmail.com`). *On the existence of extremal function in the Maz'ya–Sobolev inequality.*
Denote by $x=(y;z)$ a point in $R^n=R^m\times R^{n-m}$, $n\geq 3$, $2\leq m\leq n-1$. By P we denote the subspace $\{x\in R^n:\ y=0\}$.

Let G be a domain in R^n. We denote by $\dot W_p^1(G)$ the closure of $C_0^\infty(G)$ w.r.t. the norm $\|\nabla v\|_{p,G}$.

For $0\leq s\leq\min\{1,\frac{n}{p}\}$ we put $p_s^*=\frac{np}{n-sp}$. We discuss the sharp constant in the Maz'ya–Sobolev inequality

$$\||y|^{s-1}v\|_{p_s^*,G}\leq N\|\nabla v\|_{p,G}.$$

Note that the case $p<n$, $s=1$ gives usual Sobolev inequality. For $m=1$ our problem degenerates in a sence. For $m=n$ see the survey [1].

For $p<n$ and $0<s<1$ the sharp constant easily is not attained for any G provided $G\cap P\neq\emptyset$.

We consider more complicated case $G\cap P=\emptyset$, $\partial G\cap P\neq\emptyset$. First, we deal with G being a wedge $\mathcal{K}=K\times R^{n-m}$ (K is an open cone in R^m) or a perturbed wedge for all $1<p<\infty$ and $0\leq s<\min\{1,\frac{n}{p}\}$. Then we consider the case of a bounded domain for $p=2$ and $0<s<1$.

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[1] A.I. Nazarov, J. Global Optim. **40** (2008), 289-303.
[2] A.I. Nazarov, Calc. Var. and PDEs. DOI 10.1007/s00526-012-0586-0, 21p. (Received January 24, 2014)

1100-35-54 **Nils Ackermann***, nils@ackermath.info, and **Andrzej Szulkin**. *A concentration phenomenon for elliptic equations with indefinite nonlinearities.*
For a domain $\Omega\subset\mathbb{R}^N$ we consider the equation

$$-\Delta u+V(x)u=Q_n(x)|u|^{p-2}u$$

with zero Dirichlet boundary conditions and $p\in(2,2^*)$. Here $V\geq 0$, and the Q_n are bounded functions that are positive in a region contained in Ω and negative outside, and such that the sets $\{Q_n>0\}$ shrink to a point $x_0\in\Omega$ as $n\to\infty$. We show that if u_n is a nontrivial solution corresponding to Q_n, then the sequence (u_n) concentrates at x_0 with respect to the H^1 and certain L^q-norms.

This equation serves as the model for a linearly polarized wave propagating in a waveguide composed of two optical materials: a self-focusing core and a defocusing cladding. Our result says that as we reduce the diameter of the core, the light intensity and energy concentrates at the core. (Received January 25, 2014)

1100-35-75 **Avner Friedman** and **King-Yeung Lam*** (`lam.184@math.ohio-state.edu`). *Are Small Granulomas Stable?*
In the present study we develop a simple free-boundary type model of granuloma, which refers to collection of immune cells in human. The model involves just macrophages and bacteria, and was introduced earlier, in the radially symmetric case, in [Friedman-Kao-Leander, submitted]. We fi rst establish the existence of radially symmetric steady state granulomas with any radius R; 0 < R < R*, where R* is given explicitly by the model's parameters. Then we consider mathematically the linearized stability/instability of small radially symmetric steady states. This is joint work with Avner Friedman (OSU). (Received January 29, 2014)

1100-35-90 **Igor E. Verbitsky*** (`verbitskyi@missouri.edu`), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Finite energy and weak solutions of quasilinear elliptic equations.*
We study finite energy and weak solutions to the homogeneous quasilinear equation $-\triangle_p u-\sigma\, u^q=0$, $u>0$, on $\mathbf{R^n}$ in the case $0<q<p-1$, where $\triangle_p$ is the p-Laplacian and $\sigma\in L^1_{loc}$ is an arbitrary nonnegative function (or measure) on $\mathbf{R^n}$. Necessary and sufficient conditions for the existence, and bilateral pointwise estimates of solutions will be presented, along with a discussion of regularity and uniqueness questions. This is joint work with Cao Tien Dat. (Received January 31, 2014)

1100-35-96 **Peter Polacik*** (polacik@math.umn.edu). *On the large time behavior of bounded solutions of semilinear heat equations on the entire space.*

One of the results to be presented shows the locally uniform convergence to an equilibrium for all bounded positive solutions with compact initial support. Other results exhibit different behaviors of solutions which do not have compact initial support. (Received January 31, 2014)

1100-35-124 **Murat Akman*** (murat.akman@uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40508. *On the Hausdorff dimension of a measure arising from a positive weak solution to a quasilinear elliptic PDE in the plane.* Preliminary report.

In this talk we study the Hausdorff dimension of a measure μ_f related to a positive weak solution, u, of a certain quasilinear elliptic partial differential equation in $\Omega \cap N$ where $\Omega \subset \mathbb{C}$ is a bounded simply connected domain and N is a neighborhood of $\partial\Omega$. u has continuous boundary value 0 on $\partial\Omega$ and is a positive weak solution to

$$\sum_{i,j=1}^{2} \frac{\partial}{\partial x_i}(f_{\eta_i\eta_j}(\nabla u(z))\, u_{x_j}(z)) = 0 \text{ in } \Omega \cap N.$$

Also $f(\eta)$, $\eta \in \mathbb{R}^2$ is homogeneous of degree p, $1 < p < 2$, and uniformly convex in the plane. Put $u \equiv 0$ in $N \setminus \Omega$. Then μ_f is the unique positive finite Borel measure, called generalized $p-$harmonic measure, with support on $\partial\Omega$.

Then it is shown that $\mu_f \ll \mathcal{H}^\lambda$ for $1 < p < 2$ where

$$\lambda(r) = r \exp A\sqrt{\log 1/r \, \log\log\log 1/r}, 0 < r < 10^6.$$

Our work generalizes work of Lewis in [L12] when the above PDE is the p-Laplacian, $1 < p < 2$, (i.e, $f(\eta) = |\eta|^p$) in the complete generalization.

[L12]: John Lewis. p-harmonic measure in simply connected domains revisited. Transactions of the American Mathematical Society, To appear. (Received February 04, 2014)

1100-35-127 **Zachary Bradshaw*** (zb8br@virginia.edu), 4300 Smithdeal Ave, Richmond, VA 23225, and **Zoran Grujic**. *Geometric measure-type regularity criteria for the 3D Navier-Stokes equations in Besov spaces.* Preliminary report.

A local anisotropic geometric measure-type condition on the super-level sets of the Littlewood-Paley dyadic blocks associated with a solution to the 3D NSE is specified which prevents the formation of a finite-time singularity. Related criteria are developed in scenarios where Besov space quantities “close to” the energy space are controlled uniformly in time. (Received February 05, 2014)

1100-35-171 **Andrey Minchenko*** (an.minchenko@gmail.com), Weizmann Institute, Department of Mathematics, 7610001 Rehovot, Israel. *Central extensions of simple linear differential algebraic groups.*

The structure theory of linear differential algebraic groups (LDAGs) has proven to be essential for creating algorithms that compute Galois groups of linear differential equations.

We will discuss the structure of central extensions of simple LDAGs. We will see, in particular, that a non-commutative simple LDAG of differential type m has a universal central extension (in the category of LDAGs), whose center is a vector group of differential type m and of rank $\frac{m(m-1)}{2}$. The proof is based on the Cassidy's description of simple LDAGs and on the results of Steinberg and Matsumoto in the algebraic K-theory.

One of the consequences of our main result is that almost simple non-commutative LDAGs, introduced by Cassidy and Singer, are simple. (Received February 07, 2014)

1100-35-195 **Bingsheng Zhang*** (shanby.bing@gmail.com), **Ciprian Foias** (foias@math.tamu.edu), **M S Jolly** (msjolly@indian.edu) and **Yong Yang** (yytamu@gmail.com). *On zero in the global attractor of 2D Navier-Stokes equations.*

In this talk, I will first present a particular function class $\mathcal{C}(\sigma)$ of C^∞.This function class is derived when studying the consequences of zero being in the global attractor of the 2D NSE. Some elementary properties of this function class are also listed. This function class is closely related to the Gevrey class. Secondly, the relations between this class and a particular Gevrey class $E(b)$ are given. Using a metric on a Frechet space, the set of nonzero external forces for which the zero function is in the global attractor of the 2D Navier-Stokes equations is shown to be meagre in this space. Lastly, a concrete criterion in terms of a Taylor expansion in complex time is used to characterize the forces in this set. A simple application of this criterion to prove that zero is not in the global attractor in the particular case of Kolmogorov forcing is demonstrated. (Received February 08, 2014)

1100-35-200 **Mikhail D Surnachev*** (peitsche@yandex.ru), Keldysh Institute of Applied Mathematics, Miusskaya Sq. 4, Moscow, 125047, Russia. *On regularity of solutions to nonlinear parabolic equations degenerating on a part of the domain.*

In this talk I will discuss regularity of solutions to nonlinear parabolic equations uniformly degenerating on a part of the domain. Consider the equation $\omega_\varepsilon(x)u_t = div(\omega_\varepsilon(x)|\nabla u|^{p-2}\nabla u)$, $x = (x_1, \ldots, x_n) \in \Omega \subset \mathbb{R}^n$, $t \in [0,T]$, where $\omega_\varepsilon(x_1, \ldots, x_{n-1}, x_n) = 1$ if $x_n < 0$, $\omega_\varepsilon(x_1, \ldots, x_{n-1}, x_n) = \varepsilon$ for $x_n > 0$. In any cylinder $(\Omega \cap \{|x_n| > \delta > 0\}) \times [0,T]$ the equation falls in the framework of the theory developed by E. DiBenedetto, U. Gianazza, V. Vespri and other authors - solutions are Hölder continuous, locally bounded, and satisfy an intrinsic form of Harnack's inequality. However, if we work in a domain which crosses the interface $\{x_n = 0\}$ the standard methods give results which degenerate with respect to the small parameter ε. I obtain regularity estimates independent of ε. This work extends earlier results obtained for the linear parabolic equations by Yu.A. Alkhutov and V. Liskevich. The method works for general nonlinear parabolic equations of the p-Laplace type. The author was partially supported by RFBR grant no. 12-01-00058-a and Russian Ministry of Science and Education grant no. 14.B37.21.0362 (Received February 08, 2014)

1100-35-202 **Truyen Nguyen*** (tnguyen@uakron.edu). *Gradient estimates for nonlinear elliptic equations in divergence form.*

We study regularity for solutions to some nonlinear elliptic equations in divergent form. By employing a perturbation argument, we establish L^p- estimates for gradient of weak solutions to these equations. The class of equations under investigation is quite general and it includes the p-Laplace equations and some equations arising in the habitat segregation phenomena between two species competing in the same domain. (Received February 08, 2014)

1100-35-221 **Juraj Foldes*** (foldes@ima.umn.edu), Institute for Mathematics and its Application, University of Minnesota, 207 Church Street SE, Minneapolis, MN 55455, and **Vladimir Sverak** (sverak@math.umn.edu), School of Mathematics, University of Minnesota, 206 Church Street SE, Minneapolis, MN 55455. *Symmetry properties of maximal entropy solutions for 2D Euler's equation.*

Two dimensional turbulent flows for large Reynold's numbers can be approximated by solutions of incompressible Euler's equation. As time increases, the solutions of Euler's equation are increasing their disorder; however, at the same time, they are limited by the existence of infinitely many invariants. Hence, it is natural to assume that the limit profiles are functions which maximize an entropy given the values of conserved quantities. Such solutions are described by methods of Statistical Mechanics and are called maximal entropy solutions. Nevertheless, there is no general agreement in the literature on what is the right notion of the entropy. We will show that on the two dimensional torus, independently of the choice of entropy, the maximal entropy solutions with small energy depend only on one variable. This agrees with numerical experiments where one can observe characteristic bar states. We will also discuss the shapes of the entropy solutions on other symmetric domains. (Received February 08, 2014)

1100-35-222 **Ciprian Foias*** (foias@math.tamu.edu) and **Bingsheng Zhang** (shanby.bing@gmail.com). *Properties of the solutions of the 2D NSE (with $g \in H \setminus \{0\}$) not in $\mathcal{A}$.*

This is a report on an ongoing study by B.Zhang and the speaker of the solutions of the 2D Navier-Stokes equations which do not intersect the global attractor. The aim of the study, which in fact is inspired by the paper "DIRICHLET QUOTIENTS AND 2D PERIODIC NAVIER-STOKES EQUATIONS"(by P. Constantin, C.Foias, I.Kukavica and J.Majda), is to classify the possible behavior of those solutions. (Received February 08, 2014)

1100-35-234 **Changfeng Gui*** (changfeng.gui@uconn.edu), Department of Math, U-9, University of Connecticut, Storrs, CT 06269, and **Tingting Huan** and **Mingfeng Zhao**. *Traveling wave solutions to reaction diffusion equations with fractional Laplacians.*

In this talk, I will discuss the existence and asymptotic behavior of traveling wave solutions to Allen-Cahn equation with fractional Laplacians where the double well potenotial has unequal depths. A key ingredient is the estimate of the speed of the traveling wave in terms of the potential, which seems new even for the classical Allen-Cahn equation. I will also discuss nonexistence of traveling wave solutions to a nonlocal combustion model. The talk is based on recent results obtained jointly with Tingting Huan and with Mingfeng Zhao respectively. (Received February 09, 2014)

1100-35-240 **Igor Kukavica**, **Walter Rusin*** (walter.rusin@okstate.edu) and **Mohammed (Nabil) Ziane**. *Higher regularity for the primitive equations with Dirichlet boundary conditions.*

We consider the primitive equations of the ocean. The well-posedness in the case of H^1 initial data has been shown by Cao and Titi in the case of boundary conditions that are physically motivated. In later work, Kukavica and Ziane proved an analogous result in case of Dirichlet boundary conditions. In this talk, we will be concerned with higher regularity of these equations, in particular we will analyze the case of Dirichlet conditions. (Received February 09, 2014)

1100-35-377 **Yuan He*** (yuan@math.utexas.edu). *Recovering physical parameters in electrocardiology models from boundary data.*

We consider parameter identification problems for reaction-diffusion models, mainly the FitzHugh-Nagumo model and the bidomain model, in electrocardiology where the objective is to reconstruct physical parameters in these models from boundary measurement of electrical potential. We construct some iterative schemes for the reconstruction problem and show numerical simulations to demonstrate the performance of the proposed methods. (Received February 10, 2014)

1100-35-382 **Alexey Cheskidov***, UIC, MSCS, 322 SEO, 851 S. Morgan Street, Chicago, IL 60607. *Pullback attractors for the 3D Navier-Stokes equations.*

In this talk we will discuss some new results concerning the long-time behavior of weak solutions to the nonautonomous Navier-Stokes equations. (Received February 10, 2014)

1100-35-391 **Ray Treinen*** (rt30@txstate.edu), 601 University Dr., San marcos, TX 78666. *On the classification and asymptotic behavior of the symmetric capillary surfaces.*

The symmetric configurations for the equilibrium shape of a fluid interface are given by the geometric differential equation mean curvature is proportional to height. The equations are explored numerically to highlight the differences in classically treated capillary tubes and sessile drops, and what has recently emerged as annular capillary surfaces. Asymptotic results are presented. (Received February 11, 2014)

37 ► Dynamical systems and ergodic theory

1100-37-3 **Jean-Luc Thiffeault*** (jeanluc@math.wisc.edu), Department of Mathematics, University of Wisconsin, 480 Lincoln Dr, Madison, WI 53706. *pseudo-Anosovs with small or large dilatation.*

Homeomorphisms of a surface to itself can be classified using the well-known Thurston-Nielsen theorem. The most interesting topological class contains pseudo-Anosov mappings: they stabilize a pair of transverse singular foliations with a finite number of singularities. These foliations are called unstable and stable, and are respectively expanded and compressed by an algebraic constant called the dilatation. Characterizing the possible values of these dilatations for a given suface is an open problem. Here I discuss a method to find the minimum value of the dilatation on closed surfaces of a given genus, for the special case where the foliations are orientable. I will then address the opposite problem: how to find pseudo-Anosovs with large dilatations. Unlike the minimizer problem, this is not well-defined – the answer is infinity – unless we add a constraint. Constraints can arise from practical optimization problems in engineering, and I will show some optimal solutions that can be incorporated in devices called taffy pullers. (This is joint work with Erwan Lanneau and Matt Finn.) (Received February 10, 2014)

1100-37-93 **Xueying Wang*** (xueying@math.wsu.edu), Department of Mathematics, Washington State University, Pullman, WA 99164-3113, and **Jin Wang** (j3wang@odu.edu), Department of Mathematics & Statistics, 2212 Engr and Comp Sci Bldg, Norfolk, VA 23529. *Dynamics of Generalized Cholera Epidemic Models.*

Cholera is an infectious disease caused by aquatic bacterium Vibrio cholerae. It remains a significant threat to public health. In the first part of this work, we develop a new and unified cholera epidemic ODE model that incorporates a general formation of direct and indirect transmission and incorporates the growth of the vibrios and the immunity loss of recovered human. In particular, we show that the basic reproduction number R_0 serves a disease threshold and prove the global stability of endemic state when $R_0 > 1$. In the second part, we extend it to a PDE model with inclusion of diffusion. We numerically compute R_0. Our results show that the influence of diffusion in the disease transmission. (Received January 31, 2014)

1100-37-128 **Shuguan Ji**, **Weishi Liu** and **Mingji Zhang*** (mzhang@math.msu.edu), 619 Red Cedar Road, Room C314, East Lansing, MI 48824. *Poisson-Nernst-Planck (PNP) systems for ion flow through membrane channels: Permanent charge effects on I-V relations.*

In this work, we analyze a one-dimential steady-state Possion-Nernst-Planck system for ionic flow through a membrane channel from one reservoir to another with fixed boundary ion concentrations (charges) and electric potentials. We study the PNP system for two ion species, one positively charged and one negatively charged, with three regions of piecewise constant permanent charge. Reservoirs are represented by outer regions with zero permanent charge. The model is treated as a boundary value problem (BVP) of a singularly perturbed differential system. Our analysis is based on the geometric singular perturbation theory but, most importantly, on specific structures of this concrete model. The existence of solutions to the BVP for small permanent charge is established, and treating the permanent charge as a small parameter, we also derive an approximation of the I-V (current-voltage) relation and identify two critical potentials or voltages for permanent charge effects. Under electroneutrality conditions, the two critical potentials separate the potential into three regions over which the permanent charge effects are qualitatively opposite, more precisely, the effects are the same over two of the regions and, opposite to the third one determined by the boundary ion concentrations. (Received February 05, 2014)

1100-37-129 **Hong Lu*** (ljwenling@163.com), 37 Xueyuan Rd. Haidian Strict, Beijing, Beijing 100191, Peoples Rep of China, and **Peter Bates**, **Shujuan Lv** and **Mingji Zhang**. *Dynamics of 3D fractional complex Ginzburg-Landau equation.*

In this work, we study the initial boundary value problem of the fractional complex Ginzburg-Landau equation in *three* spatial dimensions with the dissipative effect given by the *fractional* Laplacian. The priori estimates, which is crucial to study the well-posedness, is derived for the equation with fractional Laplacian and nonlinear terms in *three* spatial dimensions. Using Galerkin's method, the existence and uniqueness of the global smooth solution is established. Furthermore, the existence of the global attractor is proved, and the estimates of the upper bounds of Hausdorff and fractal dimensions for the global attractor are obtained. (Received February 05, 2014)

1100-37-133 **Wen Huang** (wenh@mail.ustc.edu.cn), Department of Mathematics, University of Science and Technology of China, Hefei, Anhui 230026, and **Kening Lu*** (klu@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84604. *ENTROPY, CHAOS AND WEAK HORSESHOE FOR INFINITE DIMENSIONAL RANDOM DYNAMICAL SYSTEMS.*

In this talk, we give an answer to the problem on the implication of positive entropy of a random dynamical system. We show that if a random dynamical system has a compact random invariant set such as random attractor with positive topological entropy, then the system is chaotic and has a weak horseshoe. As a corollary, we have the same conclusion for a deterministic dynamical system with a compact invariant set of positive topological entropy. The chaotic behavior we have here is due to the positive entropy, not the randomness of the system. (Received February 05, 2014)

1100-37-145 **Wen Huang*** (wenh@mail.ustc.edu.cn), Department of mathematics, University of Science and Technology of Chia, Hefei, Anhui 230026, Peoples Rep of China. *Affine embeddings and Intersections of Cantor sets.*

Let $E, F \subset \mathbb{R}^d$ be two self-similar sets. Under mild conditions, we show that F can be C^1 embedded into E if and only if it can be affinely embedded into E; furthermore if F can not be affinely embedded into E, then the Hausdorff dimension of the intersection $E \cap f(F)$ is strictly less than that of F for any C^1 diffeomorphism f on $\mathbb{R}^d$. Under certain circumstances, we prove the logarithmic commensurability between the contraction ratios of E and F if F can be affinely embedded into E. As an application, we show that

$$dim_H(E \cap f(F)) < \min\{dim_H(E), dim_H(F)\}$$

when E is any Cantor-p set and F any Cantor-q set, where $p, q \geq 2$ are two integers with $\log p / \log q \notin \mathbb{Q}$.

This is a joint work with Prof. Feng and Prof. Rao. (Received February 06, 2014)

1100-37-152 **David Samuel Simmons*** (simmons.465@osu.edu), 231 W. 18th St, Columbus, OH 43210. *Geometry and dynamics of groups acting on Gromov hyperbolic metric spaces.*

In this talk, I will discuss two theorems about groups acting by isometries on Gromov hyperbolic metric spaces. The first theorem is a generalization of a theorem of Bishop and Jones ('97) and Paulin ('97) to this setting. The second is a construction of Patterson-Sullivan measures in a setting where compactness is not assumed.

Both theorems are part of an ongoing collaboration with Tushar Das (University of Wisconsin - La Crosse) and Mariusz Urbański (University of North Texas). (Received February 06, 2014)

1100-37-161 **Nicolai T A Haydn*** (nhaydn@usc.edu), Department of Mathematics, University of Southern California, Los Angeles, CA 90089. *Limit laws and the theorem of Shannon-McMillan-Breiman.*

The theorem of Shannon-McMillan-Breiman states that for every generating partition on an ergodic system of finite entropy the exponential decay rate of the measure of cylinder sets equals the metric entropy almost everywhere. We will discuss under what conditions the measure of n-cylinders is lognormally distributed in the limit (i.e. a Central Limit Theorem). We will also provide conditions under which the logarithm of the measure of n-cylinder, the information function, satisfies the almost sure invariance principle. For this we have to require that the measure is β-mixing. This extends previous results due to Philipp and Stout who deduced the ASIP when the measure is strong mixing and satisfies an L^1-type Gibbs condition. We get a similar results for the recurrence time. (Received February 06, 2014)

1100-37-166 **Yong Yang*** (yytamu@math.tamu.edu). *Time analyticity with higher norm estimates for the 2D Navier-Stokes equations.*

I will talk about two main results which are contained in our accepted paper (http://arxiv.org/abs/1312.0929). The first result is that if 0 is in the global attractor then the attractor is in a special function class, which can be derived after we obtain higher norm estimates. The second result is one property about this new function class that is named as "one=all" law. (Received February 07, 2014)

1100-37-167 **Johannes Jaerisch*** (jaerisch@cr.math.sci.osaka-u.ac.jp), Osaka University, Department of Mathematics, Graduate School of Science, 1-1 Machikaneyama, Toyonaka, Osaka, 560-0043 Japan, and **Hiroki Sumi** (sumi@math.sci.osaka-u.ac.jp), Osaka University, Department of Mathematics, Graduate School of Science, 1-1 Machikaneyama, Toyonaka, Osaka, 560-0043 Japan. *Multifractal analysis of limit state functions in random complex dynamical systems.*

We consider the dynamics of semigroups of rational maps on the Riemann sphere and random complex dynamical systems. Under certain conditions, in the limit stage of a transition operator associated with a random complex dynamical system, a complex analogue of a devil's staircase function appears ([Hiroki Sumi: Random complex dynamics and semigroups of holomorphic maps, Proc. London Math. Soc. (1) (2011), no. 102, 50-112]). In this talk, we employ the multifractal formalism in ergodic theory to investigate the spectrum of the Hölder exponents of these functions. More precisely, we are able to relate the Hausdorff dimension of points with a prescribed Hölder exponent to dynamical properties of the semigroup. In this way, we obtain a refined gradation between chaos and order in random complex dynamical systems. (Received February 07, 2014)

1100-37-174 **Nicholas Long*** (longne@sfasu.edu), PO Box 13040, SFA Station, Nacogdoches, TX 75962. *Flip Commuting Maps of the 2-Shifts.*

Let (X_2, σ_2) be the 2-shift and let f be the flip map. We wish to study $Aut(\sigma_2, f)$, the group of automorphisms that commute with the flip map. We will take two perspectives to this study. First, we will construct some automorphisms in $Aut(\sigma_2, f)$ other than the shift, its powers, and the flip map. Second, we will look at how large $Aut(\sigma_2, f)$ is as an abstract group. This is done primarily by examining the shift of finite type obtained by the quotient space of (X_2, σ_2) by the action of f. (Received February 07, 2014)

1100-37-178 **Vladimir Dragovic***, University of Texas at Dallas, 800 West Campbell Rd., FO 35, Richardson, TX 75080. *Discriminantly separable polynomials and integrable dynamical systems.*

The class of discriminantly separable polynomials as a distinguished class of polynomials has been introduced and studied by the author some years ago [1]. It appeared in the context of the celebrated Kowalevski top. Very recently, in joint efforts with Katarina Kukic, such polynomials were classified in the case of three variables. There is a subtle connection between the classification of the polynomials and the classification of pencils of conics. Different integrable dynamical systems, both continuous [2] and discrete, can be related with the discriminantly separable polynomials of three variables.

[1] Dragović, Vladimir: Geometrization and generalization of the Kowalevski top. Comm. Math. Phys. 298 (2010), no. 1, 37–64.

[2] Dragović, Vladimir; Kukić, Katarina: New examples of systems of the Kowalevski type. Regul. Chaotic Dyn. 16 (2011), no. 5, 484–495 (Received February 07, 2014)

1100-37-216 **Viorel Nitica*** (vnitica@wcupa.edu), Department of Mathematics, West Chester University, 25 University Avenue, West Chester, PA 19383, and **Andrew Torok** (torok@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX. *Stable topological transitivity of Heisenberg group extensions of hyperbolic systems.*

We consider skew-extensions with fiber the real Heisenberg group of a uniformly hyperbolic dynamical system.

We show that among the C^r extensions $(r > 0)$ that avoid an obvious obstruction, topological transitivity is an open and dense property. We show that a Heisenberg extension is transitive if and only if the abelian extension given by the abelianization of the Heisenberg group is transitive.

A new tool that we introduce, of independent interest, is a diophantine approximation result.We show, under general conditions, the existence of an infinite set of approximate positive integer solutions for a diophantine system consisting of a quadratic indefinite form and several linear equations. The set of approximate solutions can be chosen to point in a certain direction. The direction can be chosen from a residual subset of full measure of the set of real directions solving the system of equations exactly.

Another contribution, which is used in the proof of the main result, but it is also of independent interest, is the solution of the so called semigroup problem for the Heisenberg group. We show that for a subset S of the Heisenberg group, that avoids any maximal semigroup with non-empty interior, the closure of the semigroup generated by S is actually a group. (Received February 08, 2014)

1100-37-225 **Mrinal Kanti Roychowdhury*** (roychowdhurymk@utpa.edu), Dept of Mathematics, University of Texas-Pan American, Edinburg, TX 78539. *Quantization.*

Given a Borel probability measure μ on $\mathbb{R}^d$, a number $r \in (0, +\infty)$ and a natural number $n \in \mathbb{N}$, the nth *quantization error of order* r of μ is defined by

$$V_{n,r}(\mu) := \inf\{\int d(x, \alpha)^r d\mu(x) : \alpha \subset \mathbb{R}^d, \text{card}(\alpha) \leq n\},$$

where $d(x, \alpha)$ denotes the distance from the point x to the set α with respect to a given norm $\|\cdot\|$ on $\mathbb{R}^d$. A set α for which the infimum is achieved is called an *optimal set of n-means*. 'Quantization dimension' gives the speed how fast the specified measure of the error (also called the distortion or noise, between the quantized distribution and the original distribution) goes to zero as n goes to infinity. I will talk about it. (Received February 09, 2014)

1100-37-233 **Romain Aimino**, **Huyi Hu**, **Matthew Nicol**, **Andrew Török*** (torok@math.uh.edu) and **Sandro Vaienti**. *Polynomial loss of memory for maps of the interval with a neutral fixed point.*

We give an example of a sequential dynamical system consisting of intermittent-type maps which exhibits loss of memory (the counterpart, for non-stationary systems, of decay of correlations) at a polynomial rate. The maps may be chosen in any sequence from the given family. Decay of correlations for iterates of a single map from this family is (sharp) polynomial as well. (Received February 09, 2014)

1100-37-238 **Patrick Shipman*** (shipman@math.colostate.edu), 1874 Campus Delivery, Colorado State University, Fort Collins, CO 80523-1874, and **Stephen Thompson**. *Patterns and Oscillations: Dynamics and Fractals in Vapor-to-Particle Reaction Zones.*

We report on a set of topochemically organized, nanoparticulate experimental systems in which vapor diffuses and convects to form spatially defined reaction zones. In these zones, a sequence of catalyzed protron-transfer, nucleation, growth, aggregation, andcharging processes, produce rings, tubes, spirals, pulsing crystals, oscillating fronts, "microtornadoes," fractal structures, and patterns such as Liesegang rings. We mathematically analyze these structures using reaction-diffusion-convection models and reductions to dynamical systems. (Received February 09, 2014)

1100-37-256 **Filiz Tumel*** (ftumel@na.edu), 5959 FM 1960 Rd. W, Apt. 1336, Houston, TX 77069. *Random Walks on a Lattice with Deterministic Local Dynamics.*

In this talk we prove statistical properties of dynamical systems on a lattice with randomly occurring jumps. The original model of this type, called a hybrid system, was introduced by E. Kobre and L. S. Young in 2007. We use different methods to derive the drift rate and the averaged Central Limit Theorem. We generalize their results to piecewise uniformly expanding maps with countable partitions. We obtain an upper bound for the speed of convergence in the Central Limit Theorem and prove that the convergence is with tight maxima. We prove Large Deviation results. We also prove a quenched Central Limit Theorem, subject to a condition that can be verified following existing techniques for maps that are sufficiently expanding. Finally, we expand the drift rate results and averaged Central Limit Theorem to certain non-uniformly expanding systems. (Received February 09, 2014)

1100-37-288 **Hiroki Sumi*** (sumi@math.sci.osaka-u.ac.jp), Department of Mathematics, Graduate School of, Science, Osaka University, 1-1, Machikaneyama, Toyonaka, Osaka 560-0043, Japan, and **Mariusz Urbanski** (urbanski@unt.edu), Department of Mathematics, University of North Texas, Denton, TX 76203-1430. *Transversality family of expanding rational semigroups and contracting IFSs with overlaps.*

We study finitely generated expanding semigroups of rational maps with overlaps on the Riemann sphere and contracting IFSs with overlaps. We show that if a d-parameter family of such semigroups satisfies the transversality condition, then for almost every parameter value the Hausdorff dimension of the Julia set is the minimum of 2 and the zero of the pressure function. Also, if the zero of the pressure function is greater than 2, then typically the 2-dimensional Lebesgue measure of the Julia set is positive. Moreover, the Hausdorff dimension of the exceptional set of parameters is estimated. We also show that a family of small perturbations of the Sierpinski gasket system satisfies that for a typical parameter value, the Hausdorff dimension of the Julia set (limit set) is equal to the zero of the pressure function, which is equal to the similarity dimension. Combining the arguments on the transversality condition, thermodynamical formalisms and potential theory, we show that for each complex number a with $|a| \neq 0, 1$, the family of small perturbations of the semigroup generated by $\{z^2, az^2\}$ satisfies that for a typical parameter value, the 2-dimensional Lebesgue measure of the Julia set is positive. Reference: Adv. Math. 234 (2013) 697–734. (Received February 10, 2014)

1100-37-301 **Volodymyr Nekrashevych*** (nekrash@math.tamu.edu), 2407 Newark cir, College Station, TX 77845. *Metric and measure on hyperbolic groupoids.* Preliminary report.

We will define canonical classes of measures and metric on the unit spaces of hyperbolic groupoids. Connections will classical constructions of harmonic and Patterson-Sullivan measures will be discussed. Some approaches to "quantized calculus" on fractals related to hyperbolic groupoids will be described. (Received February 10, 2014)

1100-37-312 **David Kerr*** (kerr@math.tamu.edu) and **Hanfeng Li**. *Combinatorial independence and sofic entropy.*

We investigate the phenomenon of combinatorial independence with the framework of entropy for actions of sofic groups on compact metrizable spaces. In particular, we use independence to show that positive entropy for such actions implies Li-Yorke chaos, generalizing a result of Blanchard, Glasner, Kolyada, and Maass for single transformations. As a corollary, we deduce that the entropy of a distal action of a sofic group is either zero or minus infinity, and in particular is always zero when the group is amenable, extending a result of Parry for single transformations. (Received February 10, 2014)

1100-37-317 **Anushaya Mohapatra*** (am87@rice.edu), TX , and **William Ott** (ott@math.uh.edu). *Memory loss for nonequilibrium open dynamical systems.*

We introduce a notion of conditional memory loss for nonequilibrium open dynamical systems. We show that this type of memory loss occurs at an exponential rate for nonequilibrium open systems generated by one-dimensional piecewise-differentiable expanding Lasota-Yorke maps. This result may be viewed as a prototype for time-dependent dynamical systems with holes. (Received February 10, 2014)

1100-37-369 **Rich Stankewitz*** (rstankewitz@bsu.edu), Dept. of Mathematical Sciences, Ball State University, Muncie, IN 47306, and **Sumi Hiroki**, Osaka, Japan. *Random Backward Iteration Algorithm for Julia sets of Rational Semigroups.*

We provide proof that a random backward iteration algorithm, previously proven to work in the context of iteration of a rational function of degree two or more, extends to rational semigroups (of a certain type). We also provide some consequences of this result. (Received February 10, 2014)

1100-37-386 **Edward W Hooton***, exh121730@utdallas.edu. *Towards understanding global behaviour of branches of periodic solutions in systems of symmetrically coupled Van der Pol equations.* Preliminary report.

We investigate a system of 8 Van der Pol oscillators, which are coupled in the formation of a cube. In this setting topological degree methods which are sensitive to the symmetry of the system have allowed us to understand the Hopf bifurcations from the trivial stationary solution. There are 4 Hopf points which due to symmetry have many periodic branches born at each. The equivariant degree method identifies the spatio-temporal symmetry characteristics the periodic orbits born at each hopf point will have. Using this information we identify flow invariant subspaces which are of much smaller dimension then the full system.

Inside these flow invariant subspaces we investigate behaviour of the periodic branches for all values of the bifurcation parameter. We ask do branches grow unboundedly, or perhaps they collapse and are annihilated at another Hopf point, or maybe the collide with another periodic solution and are annihilated in a fold bifurcation.

We also investigate stability of the orbits within the flow invariant subspace, and the possibility to stabilise them using a combination of linear control and time delayed feedback control. (Received February 11, 2014)

39 ▶ Difference and functional equations

1100-39-24 **Lih-Ing W Roeger*** (lih-ing.roeger@ttu.edu), 2500 Broadway Avenue, Lubbock, TX 79409. *Some exact finite difference schemes.*

I would like to present many exact finite difference schemes for ODEs (ordinary differential equations) and PDEs (partial differential equations) in this talk. The exact finite difference schemes are usually presented and displayed in the form that is corresponding to the associated differential equations in order to provide the close link and relation between differential equations and difference equations; this helps to provide the insight into the construction of better finite difference schemes for more general differential equations. The majority of the examples provided in this talk are NSFD (nonstandard finite difference) schemes and therefore, I will demonstrate and highlight the values and insights of Mickens's NSFD schemes. (Received January 13, 2014)

1100-39-38 **MURAT ADIVAR*** (murat.adivar@gmail.com), Department of Mathematics, Balcova, 35330 Izmir, Turkey, **CAN KOYUNCUOGLU** (can.koyuncu.oglu@gmail.com), Department of Mathematics, Balcova, 35330 Izmir, Turkey, and **YOUSSEF N RAFFOUL** (yraffoul1@udayton.edu), Department of Mathematics, Dayton, OH 45469-2316. *Existence of periodic solutions in shifts $\delta_{\pm}$ for neutral nonlinear dynamic systems.*

In this study, we focus on the existence of a periodic solution for the neutral nonlinear dynamic systems with delay

$$x^{\Delta}(t) = A(t)x(t) + Q^{\Delta}\left(t, x\left(\delta_{-}(s,t)\right)\right) + G\left(t, x(t), x\left(\delta_{-}(s,t)\right)\right).$$

We utilize the new periodicity concept in terms of shifts operators, which allows us to extend the concept of periodicity to time scales where the additivity requirement $t \pm T \in \mathbb{T}$ for all $t \in \mathbb{T}$ and for a fixed $T > 0$, may not hold. More, importantly, the new concept will easily handle time scales that are not periodic in the conventional way such as; $\overline{q^{\mathbb{Z}}}$ and $\cup_{k=1}^{\infty}\left[3^{\pm k}, 2.3^{\pm k}\right] \cup \{0\}$. Hence, we develop a tool that enables the investigation of periodic solutions of q-difference systems. Since we are dealing with systems, in order to convert our equation to an integral systems, we resort to the transition matrix of the homogeneous Floquet system $y^{\Delta}(t) = A(t)y(t)$ and then make use of Krasnoselskii's fixed point theorem to obtain a fixed point. (Received January 20, 2014)

1100-39-142 **Lucia Di Vizio** (divizio@math.cnrs.fr), Laboratoire de Mathématiques CNRS UMR 8100, UVSQ, 45 avenue des Etats-Unis, 78035 cede Versailles, France, **Charlotte Hardouin*** (hardouin@math.univ-toulouse.fr), University Paul Sabatier, 31062 Toulouse, France, and **Michael Wibmer**, Lehrstuhl fur Mathematik (Algebra), RWTH Aachen, 52056 Aachen, Germany. *A Galoisian interpretation of discrete integrability.*

We will detail some applications of Galois theory of linear differential equations, equipped with a discrete action on "parameters". In this theory, the Galois groups are difference algebraic groups and they control the possible difference algebraic relations between the solutions of a given linear differential system. We will focus on examples and show how contiguity relations, Frobenius structure for p-adic differential equations, semi-discrete equations as well as discrete isomonodromy can be understood in terms of the parametrized Galois group. We will conclude with some classification theorems for difference algebraic groups and their application to discrete integrability. (Received February 06, 2014)

1100-39-143 **Lucia Di Vizio*** (divizio@math.cnrs.fr), Laboratoire de Mathématiques CNRS UMR 8100, 45 avenue des États-Unis, 78035cedex Versailles, France, **Charlotte Hardouin**, Institute of Mathematics of Toulouse, University Paul Sabatier, 31062 Toulouse, France, and **Michael Wibmer**, Lehrstuhl fur Mathematik (Algebra), RWTH Aachen, 52056 Aachen, Germany. *Difference Galois theory of differential equations.*

I'll explain how one can construct a Galois theory for differential equations that takes into account the action of a difference operator, i.e., an endomorphisms, on the solutions. This is a situation that appears naturally in many frameworks.

The theory attaches to a linear differential equation a group scheme, which encodes the algebraic difference relations among the solutions of the differential equation.

The applications of this Galois theory will be explained in C. Hardouin's talk. (Received February 06, 2014)

1100-39-150 **Chris Ahrendt*** (ahrendcr@uwec.edu), **Amy Wells** and **Tristan Williams**. *A comparison of the behavior of solutions of the two logistic dynamic equations on time scales.*

We examine the behavior of the two so-called logistic equations on time scales. It is well-known that solutions of the dynamic logistic equation $x^\Delta = [p \ominus (fx)]x$ behave very similarly to solutions of the classical logistic differential equation, regardless of time scale. The focus of this presentation is on the behavior of the solutions of the other dynamic logistic equation, $y^\Delta = [\ominus(p+fy)]y$. Conditions are given when the behavior is much like that of the classical logistic differential equation, and in this case the two dynamic logistic equations are compared. However, there are numerous cases in which the solutions of the logistic equation $y^\Delta = [\ominus(p+fy)]y$ behave markedly different than those of $x^\Delta = [p \ominus (fx)]x$. In this talk, we will explore these differences. (Received February 06, 2014)

1100-39-158 **Abigail M Brackins*** (s-abracki1@math.unl.edu), University of Nebraska-Lincoln, Mathematics Department, Avery Hall 203, Lincoln, NE 68588-0130. *Green's Functions for Fractional Self-Adjoint Nabla Boundary Value Problems.*

In this talk, we consider the fractional self-adjoint nabla difference equation $-\nabla_a^\nu(p\nabla y)(t) = h(t)$. We derive the Green's function for the related boundary value problem with homogeneous boundary conditions and discuss some of its properties. We then find the Green's function for the boundary value problem with general boundary conditions. We conclude by examining the difference between the nabla and delta cases. These results will be useful to establish existence and uniqueness of positive solutions to fractional self-adjoint boundary value problems. (Received February 06, 2014)

1100-39-159 **Julia St. Goar*** (s-jstgoar1@math.unl.edu), UNL: Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588. *Nabla vs. Delta.*

Most definitions in delta fractional calculus, including that of the derivative, are defined using the delta difference and forward jump operator. However, with some modifications of the domain one may also construct a derivative and other definitions using the nabla difference and backward jump operator, resulting in nabla fractional calculus. This talk will focus on the properties of nabla fractional calculus, particularly where striking differences arise between nabla and delta fractional calculus. (Received February 06, 2014)

1100-39-169 **Ronald E. Mickens***, Clark Atlanta University, , Atlanta, GA 30314. *Genesis of NSFD Schemes.*

We provide a historical overview of the genesis of the NSFD discretization methodology and how its two fundamental "rules" were derived from the "experimental mathematics" studies by R.E. Mickens. We then demonstrate the application of this technique by means of examples from a broad range of topics in the natural and engineering sciences. In particular, we show how to determine the denominator functions and the discrete structures of nonlinear terms for several special classes of ODE's and PDE's. We also discuss the "physical" interpretations of the NSFD methodology and contrast them to the "mathematical" foundations used in the standard analysis of numerical techniques. Some unresolved issues and problems will also be discussed.

References

1) R.E. Mickens, Nonstandard Finite Difference Models of Differential Equations (World Scientific, Singapore, 1994). (Received February 07, 2014)

1100-39-305 **Raegan Higgins*** (raegan.higgins@ttu.edu), Department of Mathematics & Statistics, Box 41042, Lubbock, TX 79409. *Oscillation of Second-order Half-linear Delay Dynamic Equations on Time Scales.* Preliminary report.

In this talk we consider the second-order half-linear delay dynamic equation

$$\left(\left(y^\Delta(t)\right)^\gamma\right)^\Delta + q(t)y^\gamma(\tau(t)) = 0$$

on a time scale $\mathbb{T}$, where $\gamma \geq 1$ is the quotient of odd positive integers and $q(t)$ is a positive right-dense continuous function on $\mathbb{T}$. We assume that $\tau(t) \leq t$ and $\tau : \mathbb{T} \to \mathbb{T}$. Our goal is to establish some new oscillation results for this equation and to establish the theory of lower and upper solutions for related dynamic equations. (Received February 10, 2014)

41 ► Approximations and expansions

1100-41-35 **Mark Iwen*** (iwenmark@msu.edu), Department of Mathematics, Michigan State University, 619 Red Cedar Road, East Lansing, MI 48824, and **Felix Krahmer**. *Fast Subspace Approximation via Greedy Least-Squares.*

I will discuss fast and deterministic dimensionality reduction techniques for a family of subspace approximation problems. Let $P \subset \mathbf{R}^N$ be a given set of M points. The techniques discussed find an $O(n \log M)$-dimensional subspace that is guaranteed to always contain a near-best fit n-dimensional hyperplane $\mathcal{H}$ for P with respect to the cumulative projection error $\left(\sum_{\mathbf{x}\in P} \|\mathbf{x} - \Pi_{\mathcal{H}}\mathbf{x}\|_2^p\right)^{1/p}$, for any chosen $p > 2$. The deterministic algorithm runs in $\tilde{O}\left(MN^2\right)$-time, and can be randomized to run in only $\tilde{O}\left(MNn\right)$-time while maintaining its error guarantees with high probability. In the case $p = \infty$ the dimensionality reduction techniques can be combined with efficient algorithms for computing the John ellipsoid of a data set in order to produce an n-dimensional subspace whose maximum ℓ_2-distance to any point in the convex hull of P is minimized. The resulting algorithm remains $\tilde{O}\left(MNn\right)$-time. (Received February 07, 2014)

1100-41-87 **Ben Adcock*** (adcock@purdue.edu), **Anders C Hansen**, **Clarice Poon** and **Bogdan Roman**. *Getting even more from less: A new framework for compressed sensing.*

Compressed sensing concerns the recovery of signals and images from seemingly incomplete data sets. Introduced nearly a decade ago, it has since become an intensive area of research in applied mathematics, engineering and computer science. However, in many practical problems in which compressed sensing is currently applied, e.g. Magnetic Resonance Imaging, the observed reconstruction quality is not explained by existing theoretical results. In this talk I will present a new theory for compressed sensing that bridges this gap, and as a by-product, shows that compressed sensing is possible under substantially relaxed conditions. In doing so, I will also explain why sparsity alone is not an adequate model for natural images and signals, and that in practice, the structure of the sparsity must also be taken into account. Finally, I will show how leveraging this inherent structure allows one to get even more from less in many compressed sensing applications: that is, obtain better reconstructions in a computationally efficient manner than purely sparsity-based algorithms. (Received January 30, 2014)

1100-41-257 **Simon Foucart*** (foucart@math.uga.edu), The University of Georgia, Department of Mathematics, 321C Boyd Building, Athens, GA 30602. *New Iterative Algorithms in Sparse Approximation.*

Orthogonal matching pursuit, or orthogonal greedy algorithm as it is known in the approximation theory community, has been used for at least twenty years to find near-best s-term approximations. Thanks to recent advances in compressive sensing, it has been realized that, under some conditions on the underlying dictionary, (weak) orthogonal matching pursuit only requires a number of iterations at most proportional to the sparsity level s. I will first show that algorithms in the hard thresholding pursuit family enjoy a similar property, which can in fact be strengthened in a nonuniform setting. I will then emphasize the striking resemblance between orthogonal matching pursuit and the earlier nonnegative least squares algorithm of Lawson and Hanson. This algorithm is particularly well suited for sparse nonnegative recovery, as illustrated by an application in metagenomics. I will also indicate how the algorithm can be exploited to approach ℓ_1-minimizers after sidestepping the nonnegativity assumption. (Received February 09, 2014)

1100-41-266 **Michael B. Wakin*** (mwakin@mines.edu), EECS Department, Colorado School of Mines, 1500 Illinois St., Golden, CO 80401. *Applications of Discrete Prolate Spheroidal Wave Functions in Sparse Recovery Problems.*

The discrete prolate spheroidal wave functions (DPSWFs) and discrete prolate spheroidal sequences (DPSSs) studied by Slepian et al. are remarkable for their time/frequency concentration properties. In this talk we highlight two modern applications of these functions in regularizing ill-posed inverse problems. First, we describe how DPSSs can be used to construct an efficient dictionary for reconstructing samples of sparse analog multiband signals from discrete compressive sensing measurements. Second, we describe how DPSWFs can be used in a new greedy algorithm for super-resolution, where given the low-frequency part of the spectrum of a sequence of impulses, the objective is to estimate their positions. This is joint work with Mark Davenport and Armin Eftekhari. (Received February 09, 2014)

1100-41-333 **Benjamin A Bailey*** (benjamin.bailey@uconn.edu), Department of Mathematics, University of Connecticut, 196 Auditorium Road, Storrs, CT 06269-3009, and **Wolodymyr R Madych**. *Representation by the cardinal sine series.*

Many aspects of the cardinal sine series, particularly those associated with the mathematical theory of sampling in signal processing, are very well known due to its role in the classical sampling theorems. The objective of this talk is to highlight several extensions of these classical theorems and to provide corresponding examples. We present (i) necessary and sufficient conditions for convergence of the series, (ii) general convergence properties and growth rates of the series, and (iii) several new classes of entire functions that can be represented via such series. Some of these classes contain members that may be unbounded on the real axis. (Received February 10, 2014)

43 ► *Abstract harmonic analysis*

1100-43-177 **Fulton B Gonzalez*** (fulton.gonzalez@tufts.edu), Department of Mathematics, Tufts University, Medford, MA 02155. *The Midpoint Locus Transform on a Compact Symmetric Space.* Preliminary report.

Let $X = U/K$ be a simply connected compact symmetric space. For each point $p \in X$, the set A_p of all midpoints of shortest closed geodesics through p is called the *midpoint locus* of p. The set A_p is both a totally geodesic submanifold and a compact symmetric space. When $\text{rank}(X) = 1$, the midpoint locus A_p is the set of all points at maximum distance from p. We consider the transform that integrates any continuous function on X over all midpoint loci A_p of X, including questions of injectivity and inversion. (Received February 07, 2014)

1100-43-243 **Christine E Offerman*** (ceofferman@gmail.com). *Multi-temporal Wave Equations on Riemannian Symmetric Spaces.*

In 1976, Semenov-Tjan-Shansky introduced a formulation of the classical Cauchy problem for Riemannian symmetric spaces. In this case, the partial differential equation becomes a system of equations involving invariant differential operators on the symmetric space and multiple 'time' variables along with initial conditions involving the Weyl group harmonic polynomials. In 1999, Helgason studied this multi-temporal system on noncompact symmetric spaces using Fourier analysis. I will discuss recent results, obtained in collaboration with F. Gonzalez, for the cases of flat and compact symmetric spaces. I will begin by giving solution forms for the system involving the Fourier and Radon transforms. I will then talk about some properties of these solutions and the issue of uniqueness. In addition, I will present an energy form for this system as well as some of its properties, including its relation to the Fourier transform and a Plancherel-type result. (Received February 09, 2014)

46 ► *Functional analysis*

1100-46-20 **Peter G. Casazza*** (casazzap@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Phase Retrieval By Projections.*

Phase retrieval is critical for a number of areas of engineering including: electron microscopy, diffractive imaging, x-ray tomography, optics, inline phase contrast x-ray imaging and much more. In some applications, such as x-ray crystallography, a problem arises with crystal twinning and more which makes it necessary to retrieve phase from projections onto subspaces. We will present the mathematical solution to this problem showing that phase can be retrieved with a very small number of arbitrary dimensional subspaces. We will give a number of related results some of which are quite surprising, (Received January 11, 2014)

1100-46-117 **Youssef N Raffoul*** (yraffoul1@udayton.edu), yraffoul1@udayton.edu, Dayton, OH 45469-2316, and **Mehmet Unal**. *Qualitative Analysis of Solutions of Nonlinear Delay Dynamic Equation.*

Using fixed point theory, weinvestigate the qualitative analysis of solutions of nonlinear delay dynamic equation of the form

$$x^{\Delta}(t) = -a(t)g(x(\delta(t)))\delta^{\Delta}(t), \quad t \in \lfloor t_0, \infty)_{\mathbb{T}} \tag{1}$$

on an arbitrary time scale $\mathbb{T}$ which is unbounded above, where the functions a and g are $rd-$continuous, the delay function $\delta : [t_0, \infty)_{\mathbb{T}} \to [\delta(t_0), \infty)_{\mathbb{T}}$ is strictly increasing, invertible and delta differentiable such that $\delta(t) < t$, $\left|\delta^{\Delta}(t)\right| < \infty$ for $t \in \mathbb{T}$, and $\delta(t_0) \in \mathbb{T}$.

We illustrate our our results by applying them to various kind of time scales. (Received February 04, 2014)

47 ► Operator theory

1100-47-56 **Raul E Curto*** (raul-curto@uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242. *Aluthge transforms of 2-variable weighted shifts.* Preliminary report.

Let H be a separable infinite-dimensional Hilbert space, and let L(H) be the algebra of bounded linear operators on H. A (contractive) representation of $\mathbb{Z}_+^2$ by weighted shifts is a map $T : \mathbb{Z}_+^2 \longrightarrow L(H)$ for which there exists a Hilbert space isomorphism $V : H \longrightarrow \ell^2(\mathbb{Z}_+^2)$ such that $VT(\mathbf{m})V^* = U_+(\mathbf{m})W_+(\mathbf{m})$, where W_+ is given by a function w_+ such that $w_+(\mathbf{m}+\mathbf{n};\mathbf{k}) = w_+(\mathbf{m};\mathbf{n}+\mathbf{k})w_+(\mathbf{n};\mathbf{k})$ for all $\mathbf{m},\mathbf{n},\mathbf{k} \in \mathbb{Z}_+^2$. A 2-variable weighted shift is a pair of the form $(T(1,0), T(0,1))$.

In joint work with Jasang Yoon, we introduce the Aluthge transform of 2-variable weighted shifts and study its basic properties. We first prove that, in contrast to the 1-variable case, this transform may not preserve the (joint) hyponormality of a commuting pair. Next, we study how the Taylor and Taylor essential spectra of 2-variable weighted shifts behave under the Aluthge transform. Finally, we show that, within the class of commuting *hyponormal* 2-variable weighted shifts whose cores are of tensor form, the above mentioned joint spectra are preserved under the Aluthge transform. (Received January 25, 2014)

1100-47-63 **Jeremy Sain*** (jeremy.sain@clarendoncollege.edu). *Operator Systems as Quantum Sets, and Applications to Orbits of Quantum Groups.*

Motivated by ideas in classical geometry and in quantum mechanics, in this talk we develop a viewpoint of operator systems as a quantum set theory. We also construct analogs of orbits and stabilizers for actions of compact quantum groups, we and show that the quantum orbit of a state under a quantum group action is an image of a certain quantum homogeneous space determined by the quantum stabilizer of the state. (Received January 27, 2014)

49 ► Calculus of variations and optimal control; optimization

1100-49-2 **Alessio Figalli*** (figalli@math.utexas.edu). *Stability results for the semisum of sets in R^n.*

Given a Borel A in R^n of positive measure, one can consider its semisum S=(A+A)/2. It is clear that S contains A, and it is not difficult to prove that they have the same measure if and only if A is equal to his convex hull minus a set of measure zero. We now wonder whether this statement is stable: if the measure of S is close to the one of A, is A close to his convex hull? More generally, one may consider the semisum of two different sets A and B, in which case our question corresponds to proving a stability result for the Brunn-Minkowski inequality. When n=1, one can approximate a set with finite unions of intervals to translate the problem to the integers Z. In this discrete setting the question becomes a well-studied problem in additive combinatorics, usually known as Freiman's Theorem. In this talk, which is intended for a general audience, I will review some results in the one-dimensional discrete setting and describe how to answer to the problem in arbitrary dimension. (Received February 04, 2014)

1100-49-359 **Methma M Rajamuni*** (methma.rajamuni@ttu.edu), 2717 3rd street, Apt 504, Lubbock, TX 79415. *Optimal control problems in Binocular vision.*

Human eye movement can be looked at, as a rotational dynamics on the space SO(3) with constraints on axis of rotation. A typical binocular eye movement can be decomposed into two systems that go by the name 'version' and 'vergence'. Herring's law proposes that the version system of the eye movement is identical in both eyes. A classic eye-pair movement would be regarded as a concatenation of version followed by vergence. Version eye movement is used to take the general direction of the target, and vergence eye movement rotate eyes in opposite direction to focus on target. In this talk, we will discuss such eye movements using unit quaternion, with constraints. Assuming that the eyes are perfect spheres with their mass distributed uniformly and rotating about their own centers, eye movement models are constructed using classical mechanics. Optimal eye movement trajectories are simulated for target in near field, for which both version and vergence eye movements are required, where the goal is to minimize a quadratic cost function on the energy of the applied control torques. (Received February 10, 2014)

1100-49-361 **Sanath D Kahagalage*** (sanath-darshana.kahagalage@ttu.edu), 2717 3rd street, Apt 504, lubbock, TX 79415. *Optimal Orientation Control satisfying Listing's and Donders' constraints.*

Human eye and head movements can be looked at, as a rotational dynamics on the space **SO(3)** with constraints that have to do with the axis of rotation. Eye movements satisfy Listing's constraint, wherein the axis vector is restricted to a fixed plane called the Listing's plane. On the other hand, head movements satisfy Donders' constraint, wherein the axis vector, after a suitable scaling, is assumed to lie in a surface called Donders' surface. Various descriptions of the Donders' surface are in the literature and in this talk we assume that the surface originates from the Fick gimbals. Rigid body dynamics is described on the space constrained by Listing's and Donders' laws. Assuming boundary values on the states, optimal movement trajectories are constructed where the goal is to transfer the state between an initial to a final value while minimizing a quadratic cost function on the energy of the, externally applied, control torques. (Received February 10, 2014)

1100-49-364 **Bhagya Athukorallage*** (bhagya.athukorala@ttu.edu), Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409, **Larry Zhang** (larryzhang101@gmail.com), Coldwater Canyon Ave, Studio City,, CA 91604, and **Ram Iyer** (ram.iyer@ttu.edu), Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409. *Energy dissipation due to the contact line motion of a droplet on a surface with contact angle hysteresis.*

A capillary surface is an interface that forms between two nonmiscible fluids. When a capillary surface contacts with a non-ideal solid surface, the motion of the three-phase contact line (solid-liquid-gas) results in an energy dissipation. This energy dissipation mainly results due to the contact angle hysteresis phenomenon and the viscous friction in the fluid involved.

In this talk, we consider a droplet on a solid surface, and experimentally measure the droplet radius, height, and contact angles while varying its volume. Using an energy minimization principle, we propose a mathematical model for the liquid interface of a symmetric liquid droplet. With the aid of the experimental data, we numerically obtain droplet meniscus profiles for given capillary pressures, and calculate the energy dissipation due to the contact angle hysteresis effect. Our computations show that the contribution to the energy loss from wetting energy dominates the surface energy and the volume energy. (Received February 10, 2014)

1100-49-376 **Indika B Wijayasinghe*** (ixw001@shsu.edu). *Differential geometric methods in eye movement problems.*

The space of eye orientations is viewed as a submanifold of unit quaternions, endowed with a Riemannian metric. The movement dynamics is derived by writing the associated Euler Lagrange's equation, with a generalized torque as control. (Received February 10, 2014)

51 ► Geometry

1100-51-9 **Derege Haileselassie Mussa*** (derege.mussa@tamuc.edu), 2600 South Neal Street, Commerce Texas 75428, Commerce, TX 75428. *Refined Tetrahedra.* Preliminary report.

A Tetrahedron (plural tetrahedra) is a three dimensional solid having four vertices,four triangular faces and six edges which don't lie in a single plane.Many problems in geometry benefit from considering familiar situation using a partition perspective.The partitions of n are the ways of writing n as the sum of positive integers. We classify the Tetrahedron according to the edges since the tetrahedron has six edges then there are 11 partitions.These 11 classes all exists as 3D type but not as a degenerate 2D type because a 3D type may not exist in the plane. The refined approach taking some geometric information (but not relative size of edges) into account leads to potentially 25 classes as was determined by D.Mussa.Mussa's partition not only enumerates the refined number of partition classes but determines for each of these classes if there is an integer collection of lengths for a tetrahedron in this class exists. When raising questions about Tetrahedra,1.one can ask which partition types the phenomenon being looked at can hold for. 2.What happens when we try to classify faces by partition type with regard to congruence?The paper also discuss a partition pair together with a congruence type partition to pin down exactly which of the 25 types of Tetrahedra we are looking at. (Received November 09, 2013)

53 ► Differential geometry

1100-53-62 **Alexander Karabegov*** (axk02d@acu.edu), 215 Foster Science Building, ACU Box 28012, Abilene, TX 79699. *Graph-theoretic formulas of star products on Kaehler manifolds.*

We will discuss explicit graph-theoretic formulas of star products on Kähler manifolds recently obtained by Niels Gammelgaard, Hao Xu, and the author. We will outline an alternative proof of Gammelgaard's formula for a star product with separation of variables on a Kähler manifold and its generalization to deformation quantization of the endomorphism bundle of a Hermitian vector bundle on a Kähler manifold. (Received January 26, 2014)

1100-53-78 **Sergey Grigorian*** (grigorians@utpa.edu), Department of Mathematics, University of Texas - Pan American, Edinburg, TX 78539. *Flows of G_2-structures.*

G_2-structures on 7-dimensional manifolds play a very important role in both geometry and physics. One of the ways of better understanding the relationships between different types of G_2-structures is to study their flows. In this talk, we will consider Laplacian flows of either closed or co-closed G_2-structures. Since the Laplacian is itself determined by the underlying G_2-structure, these flows give rise to non-linear partial differential equations. We will show that these flows share many similarities, such as the corresponding flow of the associated metric being equal to the Ricci flow to the leading order, but also some major differences. It turns out that unlike the flow of closed G_2-structures, the Laplacian flow of co-closed G_2-structures is not even weakly parabolic. We then show that this flow can be modified to make it weakly parabolic at least in certain directions and prove short-time existence and uniqueness of solutions for this new flow. (Received January 29, 2014)

1100-53-151 **Gabriel D Kerr***, Cardwell Hall, Mathematics Department, Kansas State University, Manhattan, KS 66506. *Tropical D-branes, tropical solitons.*

The mirror to a toric variety, or DM toric stack, is a Landau-Ginzburg model on the complex torus. A generating set of D-branes for an open string theory can be identified with the vanishing thimbles of the Landau-Ginzburg potential. On a fiber of the potential, the vanishing thimbles give their respective cycles which are Lagrangian spheres. In this talk, I will explain how a tropical version of this story allows one to locate vanishing cycles geometrically and identify their intersections. This results in a partial description of the Fukaya-Seidel category of the Landau-Ginzburg model. (Received February 06, 2014)

1100-53-254 **Robert L Foote*** (footer@wabash.edu), Dept of Math & CS, Wabash College, Crawfordsville, IN 47933, and **C K Han** and **J W Oh**. *Infinitesimal Isometries along Curves and Generalized Jacobi Equations.*

A variation of a geodesic segment on a Riemannian manifold M gives rise to a Jacobi field along the segment in a well-known way. We define a rigid variation of a C^2 curve on M and show that it gives rise to a generalized "Jacobi field" that is a section of the bundle of 1-jets of vector fields along the curve. This defines a connection on this bundle. We study the curvature and holonomy of this connection, which are obstructions to local infinitesimal isometries, and discuss possible applications. This is joint work with C.K. Han and J.W. Oh of Seoul National University. (Received February 09, 2014)

1100-53-279 **Kwok-Kun Kwong*** (kwong@math.miami.edu), Department of Mathematics, Ungar Building, University of Miami, Coral Gables, FL 33146. *Monotone quantities involving a weighted σ_k integral along inverse curvature flows.*

Monotone quantities along hypersurfaces evolving under the inverse mean curvature flow have many applications in geometry and relativity. In this talk, I will discuss a family of new monotone increasing quantities along inverse curvature flows in the Euclidean space. I will also discuss a related geometric inequality for closed hypersurfaces with positive k-th mean curvature. This is joint work with Pengzi Miao. (Received February 09, 2014)

1100-53-319 **Bijoy K Ghosh*** (bijoy.ghosh@ttu.edu), Mathematics and Statistics Dept., University and Broadway, Texas Tech University, Lubbock, TX 79409-1042. *Optimal Control Problems in Eye and Head Movement Control.*

In this talk, we introduce optimal control problems that can be directly applied to controlling the rotational motion of eye and head. We model eye and head as a sphere rotating about its center, where the axes of rotation is physiologically constrained, as was proposed originally by Listing and Donders. The movement dynamics is derived on SO(3) or on a suitable sub manifold of SO(3) after describing a Lagrangian. The associated Euler-Lagrange's equation is written together with externally applied control torque. From the control system, so obtained, we propose a class of optimal control problem that minimizes the norm of the applied external torque. Our proposed control objective is to point towards a stationary point target, also called the regulation problem. (Received February 10, 2014)

1100-53-337 **Ian M Anderson*** (ian.anderson@usu.edu), Department of Mathematics, Utah State University, Logan, UT 84322. *Variational Bicomplexes.*

In this talk I will review the general construction and properties of variational bicomplexes, briefly describe some standard applications,and discuss recent work on the cohomology of invariant variational bicomplexes. (Received February 10, 2014)

1100-53-358 **Jeffrey M Lee***, Department of Mathematics and Statistics, Texas Tech University, Mail stop 1042, Lubbock, TX 79409, and **Lance Drager**, Lubbock, TX 79409. *Back to basics on bundles with structure group.* Preliminary report.

The speaker will discuss a common misunderstanding in the literature concerning the coordinate bundle definition of a G-bundle or G-bundle structure on a fiber bundle. The crucial point is the difference between strict equivalence and equivalence in terms of cohomologous cocycles. The difference is analogous to the distinction between atlases on manifolds that define the same smooth structure as opposed to diffeomorphic smooth structures. Several simple examples are given that make it clear that the two notions of equivalence for coordinate bundle are not the same and that only the first is appropriate for the definition of the primary notion of G-bundle structure. We show how choosing the wrong definitions leads to conflict with other well accepted notions. A discussion of the role of a non-effective group action in bundle theory is also addressed and it is shown that there are nontrivial issues that arise contrary to what seems to be implied in the literature. (Received February 10, 2014)

54 ► General topology

1100-54-211 **Clement Boateng Ampadu*** (drampadu@hotmail.com), 31 Carrolton Road, Boston, MA 02132. *On the monotone property of Bhaskar and Lakshmikantham in the setting of Partially Ordered G-Metric Spaces.*

In this talk we extend the coupled fixed point theorems for mixed monotone operators [T.G. Bhaskar, V. Lakshmikantham, Fixed point theorems in partially ordered metric spaces and applications, Nonlinear Anal. TMA 65(2006) 1379-1393] by significantly weakening the involved contractive condition. (Received February 08, 2014)

1100-54-237 **Amit Sharma*** (sharm121@umn.edu) and **Alexander A Voronov**. *Dijkgraaf-Witten theory using cohomology with coefficients in Picard groupoids.*

Dijkgraaf-Witten theory, a gauge theory with finite gauge group, was introduced in a paper of Dijkgraaf and Witten. A detailed description of this theory was given by Freed and Quinn in a subsequent paper in which they carry through all the steps of the path integral quantization. In this joint work with Alexander Voronov, we reconstruct the Dijkgraaf-Witten theory using techniques of categorical topology. The integration defined in Freed and Quinn's paper is captured in a cap product between homology and cohomology with coefficients in Picard groupoids. This language allows us to go beyond Freed and Quinn's theory. (Received February 09, 2014)

57 ► Manifolds and cell complexes

1100-57-83 **Lance D. Drager**, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, **Jeffrey M. Lee**, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, **Efton Park*** (e.park@tcu.edu), Department of Mathematics, Box 298900, Texas Christian University, Fort Worth, TX 76129, and **Ken Richardson**, Department of Mathematics, Box 298900, Texas Christian University, Fort Worth, TX 76129. *Smooth Distributions are Finitely Generated.*

A subbundle of variable dimension inside the tangent bundle of a smooth manifold is called a smooth distribution if it is the pointwise span of a family of smooth vector fields. We prove that all such distributions are finitely generated, meaning that the family may be taken to be a finite collection. Further, we show that the space of smooth sections of such distributions need not be finitely generated as a module over the smooth functions. Our results are valid in greater generality, where the tangent bundle may be replaced by an arbitrary vector bundle. (Received January 30, 2014)

1100-57-141 **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20052. *Knot Theory motivated t-simplicial modules.*

We propose to study t-simplicial modules: homological algebra structures motivated by knot theory, or more precisely by distributive (e.g. rack) homology. We start from the presimplicial module (M_n, d_i) and equip it with $n+1$ level preserving, commuting homomorphisms $t_i : M_n \to M_n$, $0 \leq i \leq n$ such that $d_i t_j = t_{j-1} d_i$ for $i < j$, $d_i t_i = 0$, and $d_i t_j = t_j d_i$ for $i > j$. A basic example is given by a very weak simplicial module (M_n, d_i, s_i) with $t_i = d_i s_i - d_{i+1} s_i$. This example, in turn is motivated by the rack chain complex of a shelf (RDS - right self-distributive magma). The theory of t-simplicial modules begins with the observation that we have a filtration $F_p^t(C_n) = span(t_0(C_n), t_1(C_n), ..., t_p(C_n))$ of $C_n^{(t)}) = F_n^t(C_n)$, and $C_n^{(t)}$ is a subchain complex (not necessarily acyclic) of (C_n, ∂_n), where $\partial_n = \sum_{i=0}^n (-1)^i d_i$. (Received February 06, 2014)

1100-57-144 **Louis H Kauffman*** (kauffman@uic.edu), Math UIC, 851 South Morgan Street, Chicago, IL 6060707045. *Khovanov Homology and Quantum Infomation.*

This talk will discuss fundamentals of Khovanov homology and its relationship with formulations of quantum information and models in statistical mechanics. (Received February 06, 2014)

1100-57-170 **Yu Tsumura*** (ytsumura@math.purdue.edu), 400 N River Rd Apt 1435, West Lafayette, IN 47906. *A 2-categorical extension of the Reshetikhin-Turaev theory.*

I will discuss a concrete construction of a 2-categorical extended topological field theory that extends the Reshetikhin-Turaev TQFT. An extended TQFT is defined to be a 2-functor from a 2-category of cobordisms with corners to the Kapranov-Voevodsky 2-vector spaces. As an intermediate 2-category between these 2-categories, a 2-category of special ribbon graphs is introduced. (Received February 07, 2014)

1100-57-173 **Charles D Frohman*** (charles-frohman@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242, and **Joanna Kania-Bartoszynska**. *The Kauffman bracket skein algebra at a root of unity as a Frobenius algebra.* Preliminary report.

The Kauffman bracket skein algebra of a compact oriented surface with boundary , where $A = e^{\pi \mathbf{i}/N}$, and N is odd, is a ring extension of coordinate ring the Sl_2C-character variety of the fundamental group of the surface. We explore the existence of a linear functional from the skein algebra to the coordinate ring, so that when we extend to the functional field makes the extended skein algebra into a Frobenius algebra. (Received February 07, 2014)

1100-57-235 **Uwe Kaiser*** (ukaiser@boisestate.edu), Department of Mathematics, 1910 University Drive, Boise, ID 83725. *Skein Modules and String Topology of oriented 3-manifolds.* Preliminary report.

Chas and Sullivan defined the structure of a Lie bialgebra on the reduced equivariant homology of the free loop space of an oriented 3-manifold. It has been proved by Turaev that there is an associated bi-Poisson bialgebra structure on the symmetric algebra of any given Lie bialgebra. He used this to define a notion of biquantization and proved that certain skein algebras of surfaces are examples of such a biquantization. In 2003 I proved some results *relating* the string topology Lie algebra of an oriented 3-manifold with Hoste and Przytycki's homotopy skein module. I will discuss some new attempts how more general skein modules of oriented 3-manifolds can be related to the string topology Lie bialgebra. This is based on the idea of replacing families of loops by transversal families. (Received February 09, 2014)

1100-57-241 **Charles D. Frohman** and **Joanna Kania-Bartoszynska*** (jkaniaba@nsf.gov). *Example of an Extended Topological Quantum Field Theory.*

We give a skein theoretic description of an extended Topological Quantum Field Theory that underlies the Witten- Reshetikhin-Turaev invariants of 3-manifolds. (Received February 09, 2014)

1100-57-275 **Mieczyslaw K. Dabkowski*** (mdab@utdallas.edu) and **Changsong Li**. *Catalan States of Generalized Crossing.* Preliminary report.

We show which Catalan connections between $2(m+n)$ points on boundary of $m \times n$ rectangle P can be realized as Kauffman states of a generalized crossing $L(m, n)$ and we give an explicit formula for number of such connections. (Received February 09, 2014)

58 ► Global analysis, analysis on manifolds

1100-58-88 **Tushar Das***, University of Wisconsin - La Crosse, 1725 State Street, La Crosse, WI 54601. *Topological rigidity in conformal dynamics.*

In 2009 M. Kapovich, following up on a line of research from the late '70s (Bowen, Sullivan, Tukia, Bishop-Jones, Yue, Xie), proved that for a geometrically finite Kleinian group in Isom($\mathbb{H}^n$), if the topological dimension of the limit set equals its Hausdorff dimension, then the limit set is a geometric sphere. We present results from joint-work with David Simmons (Ohio State) and Mariusz Urbański (North Texas) that extend Kapovich's theorem to certain geometrically infinite groups, and prove analogous rigidity results on the rational maps side of Sullivan's dictionary. Time permitting, we present our generalization to analogues of Kleinian group actions on infinite-dimensional real hyperbolic space, where finite-dimensional arguments break down and the proof is necessarily far more intricate. (Received January 30, 2014)

1100-58-264 **Jochen Bruening**, **Franz W Kamber** and **Ken Richardson*** (k.richardson@tcu.edu). *Index problems on foliations.*

A Riemannian foliation is a partition of a manifold by immersed submanifolds (leaves) such that the normal bundle to the leaves is endowed with an invariant metric. We discuss the so-called basic index problem for such foliations and show how to convert it to an invariant index problem for the action of a compact Lie group of isometries on a Riemannian manifold. We describe our formula for this integer index, which involves characteristic forms and eta invariants. Finally, we demonstrate the use of this formula in computing the index of the basic Euler and basic signature operators. (Received February 09, 2014)

1100-58-280 **Igor Prokhorenkov*** (i.prokhorenkov@tcu.edu), Department of Mathematics, TCU Box 298900, Fort Worth, TX 76129, and **Ken Richardson** (k.richardson@tcu.edu), Department of Mathematics, TCU Box 298900, Fort Worth, TX 76129. *Perturbations of Dirac operators on Riemannian foliations.*

We will explain how to obtain an expression for the basic index of a transversal Dirac operator over a Riemannian foliation in terms of local quantities associated to the singular set of a foliated bundle map satisfying certain admissibility and nondegeneracy conditions. (Received February 09, 2014)

60 ► Probability theory and stochastic processes

1100-60-183 **Sukhitha W. Vidurupola*** (sukhitha.vidurupola@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Box 41042, 2500 Broadway, Lubbock, TX TX 79409. *The Impact of Variability in Stochastic Models of Bacteria-Phage Dynamics Applicable to Phage Therapy.*

Bacteriophages, more commonly known as phages, are viruses that kill bacteria. Phages are used to treat food or animals infected with bacteria, thereby killing the bacteria. Phages attach to a bacterium, inject their DNA or RNA, multiply inside the bacterium, then burst from the bacterium, releasing many new phage particles. Mathematical models for bacteria-phage dynamics that account for uninfected bacteria, B, two stages for phage-infected bacteria, L and I, and phage particles P are formulated and analyzed. Two new stochastic models are derived based on an ordinary differential equation model. A continuous-time Markov chain model and a stochastic differential equation model account for variability due to adsorption, reproduction and release of phage particles. The basic reproduction number in the deterministic model defines a threshold in terms of model parameters. If this threshold is less than one, phage cannot persist and will not kill the bacteria. This same threshold applies to the stochastic models. A branching process approximation yields an estimate for the probability of phage extinction. Numerical examples highlight the importance of variability in modeling phage. (Received February 07, 2014)

1100-60-370 **Jose Angel Islas*** (joseislas@my.unt.edu), University of North Texas, Department of Mathematics, Union Circle #311430, Denton, TX 76203, and **Pieter Allaart**, University of North Texas, Department of Mathematics, Union Circle #311430, Denton, TX. *Stopping near the top of a random walk.* Preliminary report.

This talk discusses the problem of maximizing the probability of stopping with one of the two highest values in a Bernoulli random walk with arbitrary parameter p and finite time horizon n. The optimal strategy (continue or stop) depends on a sequence of threshold values (critical probabilities p_n^*) which has an intriguing oscillating pattern. Several properties of this sequence were proven and others conjectured in a 2010 paper by P. Allaart. This talk will discuss recent progress toward proving the conjectures. (Received February 10, 2014)

62 ► Statistics

1100-62-89 **Dan Cheng*** (dcheng2@ncsu.edu), NCSU Statistics Department, 2311 Stinson Drive, Campus Box 8203, Raleigh, NC 27606, and **Armin Schwartzman**. *Multiple Testing of Local Maxima for Peak Detection.*

We propose a topological multiple testing scheme for signals over N-dimensional domains where the tests are performed only at the local maxima of the smoothed observed signals. Assuming unimodal true peaks with finite support and isotropic Gaussian noise, it is shown that the algorithm with Bonferroni or Benjamini-Hochberg correction provides asymptotic strong control of the family wise error rate and false discovery rate, and is power consistent, as the search space and the signal strength get large, where the search space may grow exponentially faster than the signal strength. Simulations show that error levels are maintained for non-asymptotic conditions, and that power is maximized when the smoothing kernel is close in shape and bandwidth to the signal peaks, akin to the matched filter theorem in signal processing. (Received February 03, 2014)

1100-62-135 **Sebastian Kurtek*** (kurtek.1@stat.osu.edu), 1958 Neil Avenue, 404 Cockins Hall, Columbus, OH 43082, and **Qian Xie**, **Ian H Jermyn** and **Anuj Srivastava**. *Elastic Statistical Shape Analysis of 3D Objects Using Square Root Normal Fields.*

We present a comprehensive Riemannian framework for statistical shape analysis of 3D objects represented by their boundaries, which form parameterized surfaces. This framework provides tools for registration, comparison, averaging, summarizing variability, and statistical modeling of shapes. It is based on a special representation of surfaces called square root normal fields (SRNFs) and a related elastic Riemannian metric. The main advantages of this method are: (1) the elastic metric provides an intuitive interpretation of shape deformations that are being quantified, (2) this metric is invariant to re-parameterizations of surfaces, and (3) under the SRNF representation, the complicated elastic metric becomes the standard L2 metric, simplifying parts of the implementation. We present numerous examples of shape comparisons for various types of surfaces in different application areas including medical imaging and graphics. We also compute shape averages, covariances and perform principal component analysis. These quantities can then used to define generative models on the shape space and for random sampling. (Received February 05, 2014)

1100-62-155 **Jingyong Su*** (jingyong.su@ttu.edu), Texas Tech University, Department of Mathematics & Statistics, Lubbock, TX 79424. *Rate-Invariant Analysis of Trajectories on Riemannian Manifolds.*

We consider the statistical analysis of trajectories on Riemannian manifolds that are observed under arbitrary temporal evolutions. Past methods rely on cross-sectional analysis, with the given temporal registration, and consequently may lose the mean structure and artificially inflate observed variances. We introduce a quantity that provides both a cost function for temporal registration and a proper distance for comparison of trajectories. This distance is used to define statistical summaries, such as sample mean and covariance, of synchronized trajectories. It is invariant to identical time-warpings (or temporal reparameterizations) of trajectories. This is based on a novel mathematical representation of trajectories, termed transported square-root vector field (TSRVF), and the L2 norm on the space of TSRVFs. (Received February 06, 2014)

1100-62-223 **Leif Ellingson***, Texas Tech University, Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79409. *An Introduction to Statistics on Manifolds.*

Researchers are increasingly interested in analyzing data arising on sample spaces that are differentiable manifolds. Example of such spaces are: (1) spheres, which arise in directional data analysis, (2) projective spaces, which arise in shape analysis, and (3) the space of symmetric, positive definite matrices, which arise in diffusion tensor imaging and as covariance matrices. Because these spaces need only to be locally homeomorphic to a Euclidean space, traditional statistical methodologies developed for univariate and multivariate data cannot directly be applied. Parameters for distributions of random objects on a manifold, along with their corresponding sample statistics, are commonly defined with respect to distances on the manifold. These distances are typically defined by either equipping the manifold with a Riemannian structure, which leads to an intrinsic analysis, or embedding the manifold in a Euclidean space, which leads to an extrinsic analysis. This talk will discuss these approaches and provide motivation through examples. (Received February 08, 2014)

1100-62-265 **Mingfei Qiu*** (info@stat.fsu.edu), 214 OSB 117 N. Woodward Ave. P.O. Box 3064330, Tallahassee, FL 32306-4330, **Vic Patrangenaru** (info@stat.fsu.edu), 214 OSB 117 N. Woodward Ave. P.O. Box 3064330, Tallahassee, FL 32306-4330, and **Leif Ellingson** (math.dept@ttu.edu), Broadway and Boston, Lubbock, TX 79409-104. *Neighborhood Hypothesis Testing for Mean Contour Shapes of Corpus Callosum Mid Sections.*

Shape is the residual structural of a configuration of points, modulo some group of transformations of R^m. Direct similarity shapes of contours can be regarded as points on a projective space of a complex Hilbert separable space. Asymptotic tests on this Hilbert manifold fail, given that the extrinsic sample covariance matrix is always degenerate. Here we present the neighborhood hypothesis testing methodology on a Hilbert manifold as developed by Ellingson et. al. (2013), and apply it to shape analysis of contours of corpus callosum midsagittal sections data extracted from MRI images given in Fletcher (2013). (Received February 09, 2014)

1100-62-274 **Chalani Prematilake*** (chalani.prematilake@ttu.edu), Texas Tech University, Department of Mathematics and Statistics, Box 41042, Lubbock, TX 49409-1042, and **Leif Ellingson** (leif.ellingson@ttu.edu), Texas Tech University, Department of Mathematics and Statistics, Box 41042, Lubbock, TX 79409-1042. *Prediction of Lower Bounds for the Number of Sampling Points for Approximating Shapes of Planar Contours.* Preliminary report.

This talk is concerned about finding a lower bound for the number of sampling points for approximating similarity shapes of planar contours. Contours in this context may be thought of as the ranges of simple closed curves. While contours are by their very nature infinite-dimensional, in order for computations to be performed with digital images, discretization is unavoidable and results in some amount of approximation error. To aid in the quantification of this error, we use a polygonal approximation for the contours by evaluating the contours at k times. We explore a model for determining a rough lower bound for k based on curvature and illustrate these methods using some examples. (Received February 09, 2014)

1100-62-348 **Hemalika Abeysundara***, hemalika.abeysundara@ttu.edu, Department of Mathematics & Statistics, Texas Tech University, Lubbock, TX , and **Frits Ruymgaart**, h.ruymgaart@ttu.edu, Department of Mathematics & Statistics, Texas Tech University, Lubbock, TX. *Minimum Hellinger Distance Estimator for Random Design in Regression Model.*

There are several methods to estimate parameters of a statistical model based on maximizers and minimizers. Some methods are efficient but not robust. Beran proposed an estimator based on Minimum Hellinger Distance (MHD) method that turned out to be both efficient and robust. Here we exploit his idea in the context of regression estimation. We consider a regression problem with random design where the regression function is defined on an arbitrary measurable space and is assumed to belong to a parametric family which is a compact subset of the real line. The design variable is drawn form an unknown, completely arbitrary probability distribution on the design space. The error variable is assumed to have a known density with a finite second moment and zero mean. We assume that the design variable and the error variable are stochastically independent. The estimation procedure uses two different estimators for the density of the response variable. One is entirely nonparametric and the other one is tailored to a specific parametric value. The MHD estimator for the parameter is obtained as the minimizer of Hellinger distance between these two. After some elementary properties of the proposed MHD estimator, we prove consistency and asymptotic normality. (Received February 10, 2014)

1100-62-375 **Daniel Eugene Osborne*** (daniel.osborne@famu.edu), Department of Mathematics, 1617 S Martin Luther King Jr. Blvd, 314 Jackson-Davis Hall, Tallahassee, FL 32307. *Nonparametric Two-Sample Tests on Homogeneous Riemannian Manifolds, Cholesky Decompositions and Diffusion Tensor Image Analysis.*

This paper addresses much needed asymptotic and nonparametric bootstrap methodology for two-sample tests for means on Riemannian manifolds with a simply transitive group of isometries. In particular, we develop a two-sample procedure for testing the equality of the generalized Frobenius means of two independent populations on the space of symmetric positive matrices. The new method naturally leads to an analysis based on Cholesky decompositions of covariance matrices which helps to decrease computational time and does not increase dimensionality. The resulting nonparametric matrix valued statistics are used for testing if there is a difference on average at a specific voxel between corresponding signals in Diffusion Tensor Images (DTI) in young children with dyslexia when compared to their clinically normal peers, based on data that was previously analyzed using parametric methods. (Received February 10, 2014)

65 ► Numerical analysis

1100-65-4 **Rachel Ward*** (rward314@gmail.com), 2515 Speedway, Austin, TX 78712. *Sampling theorems for efficient dimensionality reduction and sparse recovery.*

Embedding high-dimensional data sets into subspaces of much lower dimension is important for reducing storage cost and speeding up computation in several applications, including numerical linear algebra, manifold learning, and theoretical computer science. Moreover, central to the relatively new field of compressive sensing, if the original data set is known to be sparsely representable in a given basis, then it is possible to efficiently 'invert' a random dimension-reducing map to recover the high-dimensional data via e.g. l1-minimization. We will survey recent results in these areas, and then show how near-equivalences between fundamental concepts such as restricted isometries and Johnson-Lindenstrauss embeddings can be used to leverage results in one domain and apply to another. Finally, we discuss how these and other recent results for structured random matrices can be used to derive sampling strategies in various settings, from low-rank matrix completion to function interpolation. (Received February 11, 2014)

1100-65-12 **Lisha Wang*** (wanglisha1986@hotmail.com), No.2, Wenhua West Road, Weihai, Shandong 264209, Peoples Rep of China, **Xiaohua Ding** (mathdxh@126.com), No.2, Wenhua West Road, Weihai, Shandong 264209, Peoples Rep of China, and **Lih-ing Wu Roeger** (lih-ing.roeger@ttu.edu), Lubbock, TX 79409-1042. *New nonstandard finite difference schemes for a class of nonlinear advection-diffusion-reaction equations.* Preliminary report.

In this paper, our main purpose is to derive, using the subequation method, some new nonstandard finite difference (NSFD) schemes for a class of advection-diffusion-reaction equations having constant coefficients. An exact finite difference scheme is firstly constructed for a special class of nonlinear PDEs (partial differential equations) with a higher order polynomial reaction term. A detailed discussion of the mathematical structure of the exact finite difference equation is also given. Then the same analysis is extended to the cases of two- and s-dimensional nonlinear PDEs without diffusion, respectively. Secondly, some new NSFD schemes who have nonlinear denominator functions of the step sizes and nonlocal approximation of nonlinear terms in the reaction terms, are presented for the one- and two-dimensional models, respectively. Thirdly, under certain conditions on the parameters of the models and the right combination of spatial and temporal step sizes, the NSFD schemes are capable to preserve the non-negativity or the boundedness of the solutions of the models if the initial values are non-negative or bounded. Finally, some classical simulations from the literature are provided to verify the validity of our analytical results. (Received November 19, 2013)

1100-65-13 **Ilija Jegdic*** (i_jegdic@yahoo.com), Department of Mathematics, University of Houston, Houston, TX 77204-3008. *Analysis of a Large Time Step and Overlapping Grids method for hyperbolic conservation laws.*

We propose a new method for approximate solving of hyperbolic conservation laws. The method is based on a finite volume method and its significance is twofold. First, we introduce a novel idea for a large time step, which allows us to march faster in time. Secondly, we consider overlapping grids which is an important issue for many practical applications. We prove that in one spatial dimension, the method converges to the entropy solution of the conservation law. We also present numerical simulations for Burger's equation and for the Lax shock tube problem for Euler gas dynamics equations. (Received December 08, 2013)

1100-65-37 **Maxim A Olshanskii*** (molshan@math.uh.edu). *A finite element method for PDEs posed on evolving surfaces.*

Partial differential equations posed on surfaces arise in mathematical models for many natural phenomena: diffusion along grain boundaries, lipid interactions in biomembranes, pattern formation, and transport of surfactants on multiphase flow interfaces to mention a few. Numerical methods for solving PDEs posed on manifolds recently received considerable attention. In this talk we briefly review some existing approaches and focus on an Eulerian finite element method for the discretization of elliptic and parabolic partial differential equations on surfaces. The method uses traces of volume finite element space functions on a surface to discretize equations posed on the surface. The approach is particularly suitable for problems in which the surface is given implicitly by a level set function and in which there is a coupling with a problem in a fixed outer domain. If the surface evolve, then the method employs DG space-time finite elements for a space-time weak formulation of a surface PDE problem. In this case, trial and test surface finite element spaces consist of traces of standard volumetric elements on a space-time manifold resulting from the evolution of a surface. (Received January 17, 2014)

1100-65-40 **Weizhong Dai*** (dai@coes.latech.edu), Mathematics and Statistics, College of Engineering and Science, Louisiana Tech University, Ruston, LA 71272. *A G-FDTD Scheme for Solving Multi-Dimensional Open Dissipative Gross-Pitaevskii Equations.*

Behaviors of dark soliton propagation, collision, and vortex formation in the context of a non-equilibrium condensate are interesting to study. This can be explored by solving open dissipative Gross-Pitaevskii equations (dGPE's) in multiple dimensions, which are a generalization of the standard Gross-Pitasvskii equation that includes effects of the condensate gain and loss. In this article, we present a generalized finite-difference time-domain (G-FDTD) scheme, which is explicit and stable and permits an accurate solution with simple computation, for solving the multi-dimensional dGPE. Moreover, it is shown that the stability condition for the scheme offers a more relaxed time step restriction than the popular pseudo-spectral method. The G-FDTD scheme is then employed to simulate the dark solution propagation, collision, and vortex formation. (Received January 20, 2014)

1100-65-66 **Thinh T. Kieu*** (thinh.kieu@ttu.edu), 4306 16th Street Quaker Pines Apt#5, Lubbock, TX 79416, and **akif Ibraguimov** (akif.ibraguimov@ttu.edu), 2500 Broadway and Boston Ave, Lubbock, TX 79409. *A mixed finite element method for generalized Forchheimer flows in porous media.*

The nonlinear Forchheimer equations are used to describe the dynamics of fluid flows in porous media when Darcy's law is inadequate. We consider the generalized Forchheimer equations for slightly compressible fluids and study the mixed finite element method to approximate the resulting degenerate parabolic equation for pressure with the Dirichlet boundary condition. The optimal error estimates are proved in L^2-norm for the approximated solution in both continuous and discrete time procedures. The convergence rate is also established for the pressure in L^∞-norm and Sobolev norm. (Received February 09, 2014)

1100-65-172 **Jean M.S. Lubuma*** (jean.lubuma@up.ac.za), Dept of Mathematics and Applied Mathematics, University of Pretoria, Pretoria, 0002, South Africa, and **Yibeltal A Terefe**, Dept of Mathematics and Applied Mathematics, University of Pretoria, Pretoria, 0002, South Africa. *A nonstandard finite difference scheme for the SIS-Volterra integral equation model.*

We follow P. van den Driessche and J. Watmough (*J. Math. Biol.*, **40** (2000), 523-540): the contact rate is a function of the infective population and the period of infectivity is incorporated into the model by considering the SIS-Volterra integral equation. Unlike the classical SIS-model, where the value $\mathcal{R}_0 = 1$ of the basic reproduction number is a forward bifurcation, there exist two threshold parameters $\mathcal{R}_0^c \leq \mathcal{R}_0^m$, $\mathcal{R}_0^m \geq 1$, and the considered model can undergo a backward bifurcation as follows. The disease-free equilibrium (DFE) is the only equilibrium and it is globally asymptotically stable (GAS) when $\mathcal{R}_0 < \mathcal{R}_0^c$; there exists only one endemic equilibrium (EE), which is locally asymptotically stable (LAS) when $\mathcal{R}_0 > \mathcal{R}_0^m$ with DFE being unstable when $\mathcal{R}_0 > 1$; for $\mathcal{R}_0^c < \mathcal{R}_0 < 1$, the DFE is LAS and co-exists with at least one LAS endemic equilibrium. We design a NSFD scheme that preserves positivity and boundedness of the solution as well as the stability properties of equilibria. (Received February 09, 2014)

1100-65-196 **Son-Young Yi*** (syi@utep.edu), Department of Mathematical Sciences, 500 W. University Ave., University of Texas at El Paso, El Paso, TX 79968, and **Maranda Bean** (mlbean@miners.utep.edu), Department of Mathematical Sciences, 500 W. University Ave., University of Texas at El Paso, El Paso, TX 79968. *Iterative coupling algorithms for Biot's consolidation model.*

In this talk, we consider numerical algorithms for modeling of the time-dependent coupling between the fluid flow and deformation in elastic porous medium. Modeling the mechanical behavior of fluid-saturated porous media is of great importance in a wide range of science and engineering fields including reservoir engineering, soil mechanics, environmental engineering, and, more recently, biomechanical engineering.

Here, we employ a new mixed finite element method for the 2D Biot's model introduced by Yi. We present four different iteratively coupled methods, known as drained, undrained, fixed-strain, and fixed-stress splits, in which the diffusion operator is separated from the elasticity operator and the two subproblems are solved in a staggered way while ensuring full convergence of the solution at each time step.

A-priori convergence results for each iterative coupling are presented. We also present some numerical results to support the convergence estimates and to show the effectiveness of the algorithms. (Received February 08, 2014)

1100-65-227 **Runchang Lin*** (rlin@tamiu.edu), 5201 University Boulevard, LBVSC 317, Laredo, TX 78041. *A finite element simulation of the FitzHugh-Nagumo equations.*

In this talk, a least-squares finite element algorithm is developed to solve the FitzHugh-Nagumo equations. The present method is stable and accurate. Numerical results are given to demonstrate the performance of the algorithm in long-time integrations. (Received February 09, 2014)

1100-65-244 **JaEun Ku*** (jku@math.okstate.edu), 401 Mathematical Sceinces, Stillwater, OK 74078. *Numerical approximation for Optimal control problems governed by elliptic equations.*

In this talk, we present a numerical method solving optimal control problems governed by elliptic partial differential equations. When the objective functional involves the flux variable, least-squares(LS) approach based on a first-order system has advantages over other methods since the scalar(state) variable and its flux are simultaneously approximated. Our method is based on a least-squares approach solving first-order system of equations. Such a system of equations is obtained by applying the Lagrange multiplier rule. In most cases, this results in at least doubling the number of unknowns. Our approach increases the number of unknowns slightly. We provide optimal error estimates based on the L_2 norm appeared in the objective functional, not usual energy norm associated with the LS functional. (Received February 09, 2014)

1100-65-278 **Richard Baraniuk**, **Simon Foucart**, **Deanna Needell**, **Yaniv Plan** and **Mary Wootters*** (wootters@umich.edu). *Exponentially decaying error via adaptive quantization in one-bit compressed sensing.* Preliminary report.

In one-bit compressed sensing, one observes the signs of a few linear measurements of a sparse signal, and wishes to reconstruct the signal. It has recently been shown that in this setting, signal reconstruction is still quite feasible: to be precise, an s-sparse signal in $\mathbb{R}^n$ can be accurately reconstructed from $O(s\log(n/s))$ one-bit measurements. In this work, we focus on optimizing the decay of the error as a function of the *over-sampling factor* $\lambda := m/(s\log(n/s))$, where m is the number of measurements. It is known that the error in reconstructing the signal from standard one-bit measurements is at least $\Omega(\lambda^{-1})$. Without adjusting the way measurements are taken, there is no way to improve on this polynomial error decay rate. However, we show that by adaptively choosing the threshold used for quantization, one may improve the error to $e^{-O(\lambda)}$. This improves upon guarantees for other methods of adaptive thresholding as proposed in $\Sigma\Delta$ quantization. We give a simple recursive framework to achieve this exponential decay and a few specific polynomial-time methods based on linear programming and hard-thresholding which fall into this framework. (Received February 09, 2014)

1100-65-302 **qingguo hong** (qingguo.hong@ricam.oeaw.ac.at), Johann Radon Institute, for Computational and Applied Mathematics, (RICAM), Altenberger Strasse, Linz , Australia, **Young ju Lee*** (yjlee@txstate.edu), 601 University Drive., San Marocs, TX 78666, and **jinchao xu** (xu@math.psu.edu), 314 McAllister Building, Pennsylvania State University, University Park, PA 16802. *Two stable discretizationsns for Non-Newtonian Flow Models.*

In this talk, we present some stable discretization schemes for solving the 3-dimensional non-Newtonian flow models which include a Discontinuous Galerkin (DG) discretization scheme and a nonconforming discretization scheme. Contrary to the classic finite element discretizations, these discretizations can maintain the exact divergence free of the solution using lower-order polynomial. By these discretizations, the accuracy of the velocity can match the accuracy of the conformation tensor, and hence the accuracy is optimal. Moreover, the robustness of the algorithms has also been demonstrated by the stability analysis using the discrete analogue of energy estimates. (Received February 10, 2014)

1100-65-318 **Varis Carey*** (varis@ices.utexas.edu), TX , and **Robert Moser**. *Region of Influence Sensitivity Derivatives for Multiphysics Systems.* Preliminary report.

We present an algorithm for the computation of adjoint-based sensitivity derivatives of space-time localized quantities of interest(QoI), applicable to multiscale/multiphysics systems. The algorithm trades space-time storage of primal solution state for the solution of additional auxiliary adjoint problems, making this approach attractive for high-performance computing(HPC) architectures. We illustrate this approach on some simple model problems, as well as the computation of flame speed sensitivity to chemistry in combustion, (Received February 10, 2014)

1100-65-354 **Arvind Baskaran*** (baskaran@math.uci.edu), **Zhen Guan** (zguan2@math.uci.edu) and **John Lowengrub** (lowengrb@math.uci.edu). *Energy Stable Finite Difference Methods for Hydrodynamic Models of Freezing.*

This talk will outline the development of unconditionally energy stable finite difference methods for hydrodynamic models of freezing of liquids. The class of models considered take the form of compressible isothermal Navier

Stokes equations with source terms. The source terms are in turn defined as gradients of chemical potentials. The variational formulation underlying the models will be discussed. The general frame work of development of unconditionally energy stable convex splitting methods for these models will be outlined. The development and implementation of the method will be detailed for the case of the hydrodynamic phase field crystal model. Some numerical examples and application of the model to study the effect of flow on freezing of liquids will also be discussed. (Received February 10, 2014)

1100-65-363 **Michael Holst**, **Sara Pollock** and **Yunrong Zhu*** (zhuyunr@isu.edu), Mathematics Department, Idaho State University, 921 S. 8th Ave, Stop 8085, Pocatello, ID 83209-8085. *Convergence Analysis of Goal-Oriented Adaptive Finite Element Method for Semilinear PDE.*

In this talk, we develop convergence theory for a class of goal-oriented adaptive finite element (GOFEM) algorithms for second order semilinear elliptic equations. One of the main challenges in the nonlinear problem that we don't see in the linear case is the dependence of the dual problem on the exact solution. As it is not practical to work with a dual problem we can not compute, we develop a practical adaptive algorithm in which the mesh refinement is driven both by residual-based estimator for the approximation of the primal solution, and in a sequence of approximate dual problems which relies only on the numerical solution obtained from the previous step. We show the contraction of the adaptive finite element algorithm. Numerical experiments support the theoretical results. (Received February 10, 2014)

1100-65-365 **Alessandro Veneziani*** (avenez2@emory.edu), 400 Dowman Dr, Suite N418, Atlanta, GA 30322. *Challenges for the efficient solution of PDEs in patient-specific geometries with applications to cardiovascular diseases.*

Mathematical and numerical modeling of cardiovascular problems has experienced a terrific progress in the last years, evolving into a unique tool for patient-specific analysis. However, the extensive introduction of numerical procedures in an established clinical routine still presents methodological challenges. A rigorous merging of available data (images, measures) and mathematical models is expected to reduce the uncertainty intrinsic in mathematical models featuring parameters that would require a patient-specific quantification; and to improve the overall quality of information provided by measures. Computational costs of assimilation procedures may be quite high, as typically we need to solve inverse problems. In this talk, we will address some methods developed to bring operatively numerical simulations into the clinical routine. In particular, (1) geometrical problems related to the reconstruction of patient-specific morphologies in coronaries after deployment of vascular prostheses; (2) parameter estimation of fluid dynamics and electrocardiology; (3) hierarchical modeling of the solution of partial differential equations in domains featuring a prevalent mainstream, like arteries will be considered. (Received February 10, 2014)

1100-65-378 **Xiaozhe Hu*** (hu_x@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802, and **Youngju Lee**, **Jinchao Xu** and **Chensong Zhang**. *On Adaptive Eulerian–Lagrangian Method for Linear Convection–Diffusion Problems.*

In this talk, we consider the adaptive Eulerian–Lagrangian method (ELM) for linear convection–diffusion problems. Unlike the classical a posteriori error estimations, we estimate the temporal error along the characteristics and derive a new a posteriori error bound for the ELM semi-discretization. Furthermore, by combining this error bound with a standard residual-type estimator for the spatial error, we obtain a posteriori error estimators for a fully discrete scheme. Numerical tests are presented to demonstrate the efficiency and robustness of our adaptive algorithm. (Received February 10, 2014)

1100-65-380 **Dongwoo Sheen*** (dongwoosheen@gmail.com), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Stable cheapest nonconforming finite element methods for the Stokes equations.*

We will begin by a short review on the recent development in nonconforming finite elements on rectangular/quadrilateral/hexahedral domains. These elements can be applied to approximate the velocity field of Stokes equations with the piecewise constant element to approximate pressure field. We examine the discrete inf-sup condition for these elements. Finally, we introduce a stable cheapest finite element pair for solving the Stokes equations.

The results presented in this talk have been obtained by several collaborators: Chunjae Park (Konkuk Univ.), Byeongchun Shin (Chonnam National Univ), Youngmok Jeon (Ajou Univ.), Kwanshin Shim (ADD, Korea), Hyun Nam (KIAPS, Korea), Hyeongjun Choi (POSTECH). In particular, the last part of this talk is extracted from a joint work with Sihwan Kim and Jaeryun Yim of Seoul National University. (Received February 10, 2014)

68 ► Computer science

1100-68-168 **Ruyong Feng*** (ryfeng@amss.ac.cn), No.55 Zhongguancun East Road, Beijing, 100190, Peoples Rep of China. *Computing the Galois groups of linear differential equations.*

Hrushovski presents an algorithm to find the Galois groups for linear differential equations in his paper entitled "Computing the Galois Group of a Linear Differential Equation". In this talk, we will describe and explain his algorithm. (Received February 07, 2014)

1100-68-192 **Afonso S Bandeira***, Prog. Applied & Comp. Math., Princeton Univ., Fine Hall 218, Washington Road, Princeton, NJ 08540, and **Moses Charikar**, **Amit Singer** and **Andy Zhu**. *Multireference Alignment using Semidefinite Programming.*

The multireference alignment problem consists of estimating a signal from multiple noisy shifted observations. Inspired by existing Unique-Games approximation algorithms, we provide a semidefinite program based relaxation which approximates the maximum likelihood estimator (MLE) for the multireference alignment problem. Although we show that the MLE problem is Unique-Games hard to approximate within any constant, we observe that our poly-time approximation algorithm for the MLE appears to perform quite well in typical instances, outperforming existing methods. (Received February 07, 2014)

70 ► Mechanics of particles and systems

1100-70-111 **Taylor Farley***, taylor.farley@ttu.edu, and **Mark Vaughn**. *Molecular and mesoscale properties of pores.*

Understanding the mechanisms by which small particles move through pores in a thin substrate is important for rational design of filter and purification media. Controlling water quality is an important application of porous films designed to prevent certain molecules and particulates from passing through pores, while allowing water to pass freely. Improving the quality of highly contaminated water is a challenge.

A realistic model of the filtration process at the atomic scale could assist in designing filters that take advantage of the properties of modern exotic materals. While much is known about macroscale phenomological models of filtration, these models typically are not predictive. We are developing a computational model that can take into account the molecular and mesoscale properties of the pores and the particles. The model allows study of diffusing particles in a pore. The particle is allow to interact with the walls of the pore where it may be absorbed. Finally, to gain insight into the process of diffusion in a pore and to verify assumptions of the model we use video microscopy to observe particles diffusing in narrow glass capillaries. (Received February 04, 2014)

1100-70-137 **Jonathan Tran** (jonathan.tran@ttu.edu), 910 East Slaton Road, Lubbock, TX 79404, and **John Calhoun*** (john.m.calhoun@ttu.edu), Lubbock, TX 79426. *Zombie Lazrus Research.*

Zombie research involves the modeling and tracking of an illness which is not well understood. By having a robust design we can use and share the Lazarus program to research all kinds of diseases, infections, and virus trends that happen in society everyday, such as the spread of zombie infections. Computer simulations are monitored and studied using Mathematics, Statistics, and Biology. The goal is to be able to accurately include key factors such as human resistances, rate of contact, lethality rate, lifespan of any illness, and more while creating a visual understanding about what is happening using charts and graphs. (Received February 05, 2014)

74 ► Mechanics of deformable solids

1100-74-353 **Ram Iyer*** (ram.iyer@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *On a thermodynamically consistent model for hysteresis in magnetostriction including hysteresis, viscoelasticity, and rate-dependent power losses.*

In this talk we will present an extension of the thermodynamically consistent model for hysteresis in smart materials (those that have more than input such as stress and magnetization), which was developed recently Krejci et al., to include viscoelastic dissipation, saturation, and rate-dependent power losses. These phenomena seriously hinder the use of smart actuators made of magnetostrictive materials in precision control applications. We will discuss new existence and uniqueness problems that arise in the area of differential equations coupled with hysteresis operators. (Received February 10, 2014)

76 ► Fluid mechanics

1100-76-11 **Anthony Chun Kit Suen*** (asuen@usc.edu), 3620 S Vermont Ave, Los Angeles, CA 90089. *A blow-up criterion for the 3D compressible magnetohydrodynamics in terms of density.*

We study an initial boundary value problem for the 3D magnetohydrodynamics (MHD) equations of compressible fluids in $\mathbb{R}^3$. We establish a blow-up criterion for the local strong solutions in terms of the density and magnetic field. Namely, if the density is away from vacuum ($\rho = 0$) and the concentration of mass ($\rho = \infty$) and if the magnetic field is bounded above in terms of L^∞-norm, then a local strong solution can be continued globally in time. (Received November 14, 2013)

1100-76-82 **Aleksey S Telyakovskiy*** (alekseyt@unr.edu), Department of Mathematics and Statistics /084, University of Nevada, 1664 N. Virginia St., Reno, NV 89557, **Eden Furtak-Cole**, King Abdullah University of Science and Tech, Saudi Arabia, and **Clay Cooper**, Desert Research Institute, NV. *A power series solution to the porous medium equation.* Preliminary report.

The porous medium equation (PME) is a nonlinear diffusion equation, where the diffusivity is a power-law function of the unknown quantity. In hydrological applications it will be the hydraulic head. We consider the case of one-dimensional reservoir, which is initially dry, and is of semi-infinite extent. For certain classes of boundary conditions it is possible to introduce similarity variables and reduced initial-boundary value problem for PME to a boundary value problem for a nonlinear ordinary differential equation. We show how to construct a solution in the form of a power series for that nonlinear ODE and obtain the recurrence relation for the coefficients of the series. Also we show that series converges. (Received January 30, 2014)

1100-76-176 **Luan T Hoang*** (luan.hoang@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, **Thinh T Kieu** (thinh.kieu@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, and **Tuoc V Phan** (phan@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996. *Derivative estimates for generalized Forchheimer flows.* Preliminary report.

The degenerate parabolic equation of the pressure is studied for generalized Forchheimer (non-Darcy) flows of slightly compressible fluids in porous media. No restriction is imposed on the degree of the Forchheimer polynomial. We estimate the L^∞-norm of the pressure, its gradient and time derivative, with emphasis on large time estimates. We also establish the continuous dependence of the solution on the initial and boundary data, and coefficients of the Forchheimer polynomial. This is joint work with Thinh Kieu and Tuoc Phan. (Received February 07, 2014)

1100-76-208 **Eugenio Aulisa**, **Lidia Bloshanskaya*** (bloshanl@newpaltz.edu), **Akif Ibragimov** and **Yalchin Efendiev**. *Upscaling of Forchheimer flows.*

We propose the upscaling method for the nonlinear Forchheimer flow in heterogeneous porous media. The generalized Forchheimer law is considered for incompressible and slightly-compressible single-phase flows. The resulting system is formulated in terms of a degenerate nonlinear flow equation for the pressure with the nonlinearity depending on the pressure gradient. The coarse scale parameters for the steady state problem are determined so that the volumetric average of velocity of the flow in the domain on fine scale and on coarse scale are close. A flow-based coarsening approach is used, where the equivalent permeability tensor is first evaluated following streamline methods for linear cases, and modified in order to take into account the nonlinear effects. The developed upscaling algorithm for nonlinear steady state problems is effectively used for variety of heterogeneities in the domain of computation. Direct numerical computations for average velocity and productivity index justify the usage of the coarse scale parameters obtained for the special steady state case in the fully transient problem. (Received February 08, 2014)

1100-76-253 **Juraj Foldes**, **Nathan Glatt-Holtz** and **Geordie Richards*** (g.richards@rochester.edu), 915 Hylan Building, University of Rochester, Rochester, NY 14627, and **Enrique Thomann**. *Ergodic and mixing properties of the Boussinesq equations with a degenerate random forcing.*

The Boussinesq equations play an important role in the analysis of buoyancy driven fluid convection problems. We will discuss the existence, uniqueness and attraction properties of an ergodic invariant measure for the Boussinesq equations in the presence of a degenerate stochastic forcing acting only in the temperature equation and only at the largest spatial scales. The central challenge is to establish time-asymptotic smoothing properties

of the Markovian dynamics corresponding to this system. Towards this aim we encounter a Lie bracket structure in the associated vector fields with a complicated dependence on solutions. This leads us to develop a novel Hörmander-type condition for infinite-dimensional systems. Demonstrating the sufficiency of this condition requires new techniques for the spectral analysis of the Malliavin covariance matrix. (Received February 09, 2014)

1100-76-271 **A Biswas*** (abiswas@umbc.edu), 1000 Hilltop Circle, Baltimore, MD 21250, and **V. Martinez** and **P Silva**. *Gevrey regularity for quasi-geostrophic equations with applications to decay in* $\mathbb{R}^2$. Preliminary report.

Foias and Temam introduced an effective approach to estimate space analyticity radius of solutions to Navier-Stokes equations via the use of Gevrey norms. Since then, this has become a standard tool for studying analyticity. We extend this approach to a class of dissipative equations, including critical and super-critical quasi-geostrophic equations, where the dissipation operator is a fractional Laplacian. This necessitates the use of sub-analytic Gevrey classes and "generalized" Gevrey norms and development of certain commutator estimates in Gevrey classes to exploit the cancellation properties of the equation. This is achieved via the Littlewood-Paley decomposition and the Bony paraproduct formula. Though not essential for applications to the the Navier-Stokes equations, such commutator estimates become crucial for the critical and supercritical quasigeostrophic equations. Applications include large time decay of higher order derivatives. (Received February 09, 2014)

1100-76-285 **Eleftherios Gkioulekas*** (drlf@hushmail.com), University of Texas-Pan American, Department of Mathematics, 1201 West University Drive, Edinburg, TX 78539-2999.
Energy and potential enstrophy flux constraints in quasi-geostrophic models.

We investigate an inequality constraining the energy and potential enstrophy flux spectra in two-layer and multi-layer quasi-geostrophic models. Its physical significance is that it can diagnose whether any given multi-layer model that allows co-existing downscale cascades of energy and potential enstrophy can allow the downscale energy flux to become large enough to yield a mixed energy spectrum where the dominant k^{-3} scaling is overtaken by a subdominant $k^{-5/3}$ contribution beyond a transition wavenumber k_t situated in the inertial range. The validity of the flux inequality implies that this scaling transition cannot occur within the inertial range, whereas a violation of the flux inequality beyond some wavenumber k_t implies the existence of a scaling transition near that wavenumber. This flux inequality holds unconditionally in two-dimensional Navier-Stokes turbulence, however, it is far from obvious that it continues to hold in multi-layer quasi-geostrophic models, because the dissipation rate spectra for energy and potential enstrophy no longer relate in a trivial way, as in two-dimensional Navier-Stokes. (Received February 10, 2014)

1100-76-306 **Ciprian Foias**, **Michael Jolly*** (msjolly@indiana.edu), **Yong Yang** and **Bingsheng Zhang**. *Computations regarding the global attractor of the 2D Navier-Stokes equations.* Preliminary report.

We present results from a computational search for a nonzero force for which zero is in the global attractor of the 2D Navier-Stokes equations. This is carried out in part by means of Shur's solution to the Caratheodory problem of interpolating a bounded, analytic function on the unit disk in the complex plane. (Received February 10, 2014)

1100-76-367 **Adam Larios*** (alarios@math.tamu.edu), 1212 A Webhollow Cir., Bryan, TX 77801, and **Ciprian Foias**. *The Semi-Dissipative Boussinesq Equations: Global Well-Posedness and a Generalized Attractor.*

The large-time behavior of a dissipative system can often be understood by studying its global attractor, which can contain deep information about its underlying structure. I will show that the notion of attractor can be extended to the Boussinesq system with only partial dissipation. We will see that this generalized attractor not only has a rich structure, but also encodes a wealth of turbulent phenomena in a single object. (Received February 10, 2014)

80 ► Classical thermodynamics, heat transfer

1100-80-277 **Dinesh B. Ekanayake*** (db-ekanayake@wiu.edu). *A model for temperature dynamics of an inductively heated shape memory polymer.*

Shape memory polymer (SMP) research has expanded rapidly as new polymers and potential applications are found. SMPs return to their original shape from a deformed shape, induced by an external stimulus. Many SMPs exhibit thermo-responsive shape recovery, whereby changes are triggered by heating beyond a certain transition temperature. Yet, contact heating leads to a nonhomogeneous thermal profile within the polymeric structure, limiting applications of SMPs. Various methods have been considered for heating the polymer when non-contact or homogeneous heating is required, including magnetically inducing the shape transition using polymer-magnetic nanoparticle composites (inductive heating). Such methods are very attractive for homogeneous heating and safely and effectively actuating SMP medical devices in vivo. For development of new and more demanding applications, especially within the medical industry, modeling and simulation of these processes is necessary. However, nonlinear temperature-dependent hysteresis presents significant challenges in modeling the thermal dynamics. The purpose of this research is to discuss the well-posedness of a thermal model for inductively heated SMPs based on a temperature-dependent hysteresis operator. (Received February 09, 2014)

82 ► Statistical mechanics, structure of matter

1100-82-292 **Carl P Dettmann*** (carl.dettmann@bris.ac.uk) and **Edson D Leonel**. *Infinite horizon Lorentz gases with static or pulsating scatterers.*

The Lorentz gas consists of a point particle colliding with an extended array of hard obstacles. It has been studied widely in statistical mechanics and ergodic theory as a deterministic diffusion process. Recent interest has focused on the infinite horizon case, where the scatterers are periodic and it is possible (but of zero measure) for the particle to avoid any collisions. In the two-dimensional static case this leads to logarithmic superdiffusion, and anomalous convergence of the second moment to twice the variance of the limiting normal distribution. Higher dimensions lead to a number of interesting variations. When the scatterers have a time-periodic radius, collisions typically increase the average velocity of the particle. In this case heuristic arguments and numerical simulations show that the infinite horizon enhances the acceleration, despite longer periods without collisions. (Received February 10, 2014)

92 ► Biology and other natural sciences

1100-92-46 **Carrie A Manore*** (cmanore@tulane.edu), **Louis Bergsman** and **James Hyman**. *Modeling the Relative Role of Migrant and Resident Bird Populations on West Nile Virus Transmission.*

West Nile virus (WNV) is a mosquito-borne infectious disease that spreads primarily in birds, although humans are also susceptible and infection can lead to serious complications. We present a hybrid multi-host seasonal model for WNV spread in resident and migrant bird species. We explore differences in host competence and mosquito feeding preference between bird species. When the migrant bird species is a competent host with lower death from disease than the resident species, our analysis shows that the migratory birds play an important role in supplying susceptible hosts and driving the significant seasonal upswings in WNV, even if they don't arrive initially infected. We find that time-dependent parameters such as variation in bird community composition over time, local mosquito dynamics, weather, and relative susceptibility of birds can lead to varying risk between years. (Received January 22, 2014)

1100-92-69 **Margaret-Rose Leung*** (rleung@uw.edu) and **Vrushali Bokil**. *A Vector–Host Model for Coinfection by Barley Yellow Dwarf Virus.*

Barley and cereal yellow dwarf viruses (B/CYDV) are aphid-vectored pathogens that affect diverse host communities, including economically-important crop species. Coinfection of a single host by multiple strains of B/CYDV can result in elevated virulence, incidence, and transmission rates. We develop an ODE model for a single host, two pathogen strains, and n vector species. A single parameter describes the degree of relatedness of the strains and of cross-protection between them. We compute the basic and type reproduction numbers of the model and demonstrate that, although the basic reproduction number describes stability of the disease-free equilibrium, the type reproduction numbers better describe the individual behavior of each strain and the dynamics of coinfection. We then conduct a sensitivity analysis on the components of the endemic equilibrium. Our results indicate that disease transmission rates and vector birth and mortality rates are the most influential parameters on the equilibrium prevalences of infection and coinfection. (Received January 27, 2014)

1100-92-77 **Jemal Mohammed-Awel***, 1500 North Patterson Street, Mathematics and Computer Science Department, Valdosta State University, Valdosta, GA. *The effect of Intermittent Preventive Treatment on antimalarial drug resistance spread in areas with population movement.* Preliminary report.

The use of Intermittent Preventive Treatment in pregnant women (IPTp), children (IPTc) and infant (IPTi) is an increasingly popular preventive strategy aimed at reducing malaria incidence in these vulnerable groups. Studies to understand how this preventive intervention can affect the spread of antimalarial drug resistance are important especially when there is movement between neighboring low and high transmission areas. We expanded a previously published model by O'Meara, Smith and McKenzie to include movement between neighboring high and low transmission areas. Our results suggest that population movement results in resistance spreading fastest in high transmission areas, and that the more complete the antimalarial resistance the faster the resistant parasite will spread through a population. Our results also indicate that the demography of infection in low transmission areas tends to change to reflect the demography of high transmission areas when regions are connected by movement. Overall, our results suggest that in the fight to monitor and control drug resistance, different antimalarial monitoring and management policies are needed when the area in question is an isolated high or low transmission area, or when there is movement between high and low transmission areas. (Received January 29, 2014)

1100-92-125 **Katherine Loraine Ehnis** (kate.ehnis@ttu.edu), 4557 Crosstimber Drive, Plano, TX 75093, **Stacy Philip*** (stacy.philip@ttu.edu), 524 Salisbury Dr., Grand Prairie, TX 75052, and **Carl R. Seaquist**, **Fredrick Ramirez** and **Renato Gonik**. *Listening to the Human Brain.*

Ten patient Electroencephalogram (EEG) recordings were selected from a study conducted at a Lubbock hospital. These recordings include 2 normal and 8 abnormal EEGs, which were stripped of personal identifying information. Recent publications indicate that sonification (converting data to sound) allows the human ear to analyze series data and detect irregularities that might otherwise go unnoticed. Since brain rhythms are typically lower than the human hearing range, signal-processing techniques, including but not limited to modulation, Fourier transforms, wavelet analysis, and digital filtering, will be applied to convert EEGs to sound. Our objective is to demonstrate that in addition to traditional visual analysis, auditory acuity may be useful in the analysis of EEGs and aid in the early detection of abnormal EEG activity. The project will be a success if an algorithmic approach to sonification leads to the identification of important features of the EEGs by listening to the transformed signal
(Received February 05, 2014)

1100-92-130 **Belinda Pacheco*** (belinda.pacheco@ttu.edu), 110 Gordon Ba- TTU, Lubbock, TX 79409. *AN ANAYLSIS OF VARIATION OF PIGMENTATION PATTERNS IN THE GENUS CORYDORAS.*

In general, humans lack the ability to categorize objectively without the inclusion of bias. Human bias has been a particularly prevalent problem among biologists in terms of their assignments of formal taxonomic names to species within genera that contain significant variability. Consequently, many species could have possibly been incorrectly categorized or misnamed due to variability that biologists have failed adequately to account for. The overall purpose of this project is to characterize the patterns of variation in pigmentation in highly variable genera using a model organism from which quantification and consequent classification of pigmentation patterns could be attained. Corydoras, a popular and problematic genus of South American catfishes known for their complex pigmentation variation, is being used as a model organism. The problem addressed by this study is being approached using imaging of pigmentation patterns followed by the quantitative and statistical analysis of those images. Catfish images were taken from colored photographs and morphometric methods were used to quantify and characterize patterns of variation. (Received February 05, 2014)

1100-92-134 **Mary P. Hebert*** (mary.hebert@ttu.edu) and **Linda J. S. Allen**. *Plant-vector-virus models with vector aggregation applied to cassava mosaic virus.*

A system of differential equations and a Markov chain are used to model the dynamics of a host plant that can be infected by a virus carried by an insect vector. The models include the effects of vector aggregation implicitly through the transmission term. The basic reproduction number is computed for the deterministic model and the probability of an outbreak in the stochastic model. The model is applied to cassava mosaic virus (CMV), a virus that causes a devastating disease for large crops of cassava in Africa, reducing crop yields and resulting in significant monetary loss. CMV is transmitted by the whitefly vector. (Received February 05, 2014)

1100-92-153 **Luke R Anderson*** (luke.r.anderson@ttu.edu), 4432 Haner Dr, Odessa, TX 79762. *Modeling tumor-CD4+-Cytokine Interactions with Treatment.*

Many cancerous tumors produce recognizable antigens which can incur an antitumor response from an adaptive immune system. Until recently, most cancer immunotherapy studies have focused on the CD8+ CTLs that recognize MHC class 1 molecules and their antigens on tumor cells. Recent studies have shown that cancer cells are beginning to evolve and avoid recognition by CD8+ CTLs. Because of this evolution; focus has begun to shift to CD4+ T cells. Recent studies show that CD4+ Th1 and Th2 cells can act independently of CD8+ CTLs to eradicate tumor cells. A set of three equations were constructed to model the relationship between cancer cells, CD4+ T cells, and two important cytokines (IL-4 and Th2). It has been found that without treatment even a small tumor cannot be eliminated. However, with cytokine treatment it may be possible to shrink, stabilize, or eliminate a tumor depending on its antigenicity. (Received February 06, 2014)

1100-92-164 **Sabrina Deleon*** (s.deleon@ttu.edu), Lubbock, TX 79413. *Uptake, Translocation, and Stress Effects of Carbon Nanotubes in Drought-Induced Corn.* Preliminary report.

Carbon nanotubes are currently one of the most used manufactured nanomaterials. However, these materials are not regulated and there are concerns regarding their safety for the environment and human health. This study was conducted to evaluate uptake of various types of carbon nanotubes in corn under ideal watering and drought conditions. Corn was exposed to either non-functionalized carbon nanotubes (CNTs) or functionalized carbon nanotubes (COOH-CNTs). Corn plants were grown for 21 days in soil with no CNTs/COOH-CNTs or 10 mg/kg of CNTs or COOH-CNTs in a greenhouse with natural day:night conditions. In addition to growing plants under ideal conditions, plants were also grown under conditions simulating a seven-day drought and photosynthesis measurements were taken using a LI-6400XT Portable Photosynthesis System. Following harvest after 50 days, roots, stems, and leaves were dried, grounded, and analyzed using a microwave-induced heating technique to quantify CNT and COOH-CNT concentrations in the corn. Plants analyses are currently ongoing. (Received February 06, 2014)

1100-92-197 **Elissa J Schwartz*** (ejs@wsu.edu), Department of Mathematics, P. O. Box 643113, Washington State University, Pullman, WA 99164-3113, and **Kasia A. Pawelek**, **Karin Harrington**, **Richard Cangelosi** and **Silvia Madrid**. *Immune Control of Equine Infectious Anemia Virus Infection by Cell-Mediated and Humoral Responses.*

Equine Infectious Anemia Virus (EIAV) is a retrovirus that establishes a persistent infection in horses and ponies. The virus is in the same lentivirus subgroup that includes human immunodeficiency virus (HIV). The similarities between these two viruses make the study of the immune response to EIAV relevant to research on HIV. We developed a mathematical model of within-host EIAV infection dynamics that contains both humoral and cell-mediated immune responses. Analysis of the model yields results on thresholds that would be necessary for a combined immune response to successfully control infection. Numerical simulations are presented to illustrate the results. These findings have the potential to lead to immunological control measures for lentiviral infection. (Received February 08, 2014)

1100-92-210 **Curtis Lawrence Wesley*** (curtiswesley@letu.edu), 1711 Tulip Ln, Longview, TX 75601. *A Model of the Spread of West Nile Virus with Varying Mosquito Populations.* Preliminary report.

In this paper, a model for the spread of West Nile Virus is presented that incorporates seasonal weather patterns. Climate change can be a key factor in the increase or decrease of mosquito populations, the main disease vector for West Nile Virus. This can have a huge impact on the spread of disease through the human and bird populations. I develop a human-bird-mosquito SI model with seasonal effects. Numerical simulations are presented and the basic reproduction number is considered for the more basic cases. (Received February 08, 2014)

1100-92-273 **Ronald C Anderson*** (ronald.c.anderson@ieee.org), 3102 4th St, Apt 176, Lubbock, TX 79415. *A Neuronal Network Model of the Turtle Visual System.* Preliminary report.

Understanding interactions among neurons in the brain is a challenging biological and computational endeavor. Tools from mathematical modeling and computer simulation offer excellent prospects for unraveling relationships among these cells in biological networks. This preliminary report presents a synthesis of retina, lateral geniculate, and visual cortex region models into a biologically-inspired simulation of the freshwater turtle visual system. The underlying cellular components of each model are based on the Hodgkin-Huxley equations for neuron action potentials. Using this model, we seek an understanding of how synaptic connectivity within and among the regions may influence visual stimulus perception. A principal conjecture is the lateral geniculate can serve a retinal noise canceling function in the stages of visual processing. (Received February 09, 2014)

1100-92-276 **Amy J. Ekanayake*** (aj-ekanayake@wiu.edu) and **Dinesh B. Ekanayake**. *The combined impact of the Allee effect and seasonality on disease dynamics.*

The Allee effect, together with seasonal migration and breeding, influences dynamics of infectious diseases and can force extinction of species in patchy environments. Analysis can provide useful insight into: the importance of seasonal factors in driving ongoing disease dynamics; the role of the Allee effect on extinction and persistence; the possibility of managing an endangered species; and control of invasive species and disease populations. The Allee effect has been studied together with dispersal in the literature and the results have important implications for predicting the survival of threatened populations. Yet only a few studies have considered the Allee effect under seasonal conditions and dispersal in a multi-patch environment. These dynamics are present for epidemics such as the sylvatic plague among prairie dogs. In this research, we study epidemic population models with the Allee effect under seasonal birth and migration in a patchy environment. We discuss conditions for the existence of a strong Allee effect under the influence of season behavior, conditions for stability of a disease free positive periodic solution, and how the model can be used to evaluate control methods in a wildlife population. (Received February 09, 2014)

1100-92-293 **Vrushali A Bokil*** (bokilv@math.oregonstate.edu), 368 Kidder Hall, Department of Mathematics, Oregon State University, Corvallis, OR 97331-4605, and **Linda J. S. Allen**. *Stochastic Models for Competing Species with a Shared Pathogen.*

We study the dynamics of deterministic and stochastic models for n competing species with a shared pathogen. The deterministic model is a system of ordinary differential equations for n competing species in which a single shared pathogen is transmitted among the n species. There is no immunity from infection, individuals either die or recover and become immediately susceptible, an SIS disease model. Analytical results about pathogen persistence or extinction are summarized for the deterministic model for two and three species and new results about stability of the infection-free state and invasion by one species of a system of n-1 species are obtained. New stochastic models are derived in the form of continuous-time Markov chains and stochastic differential equations. Branching process theory is applied to the continuous-time Markov chain model to estimate probabilities for pathogen extinction or species invasion. Finally, numerical simulations are conducted to explore the effect of disease on two- species competition. These simulations illustrate some of the analytical results and highlight some of the differences in the stochastic and deterministic models. (Received February 10, 2014)

1100-92-316 **Linda J. S. Allen*** (linda.j.allen@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Probability of Disease Outbreaks in Multi-Species, Multi-Patch Models with Applications to Zoonotic Diseases.* Preliminary report.

Approximately 75% of human infectious diseases originate from an animal reservoir, many caused by viruses such as SARS coronavirus, avian influenza viruses, rabies virus, West Nile virus and hantaviruses. Human diseases originating from a nonhuman animal reservoir are referred to as zoonoses and the transmission of infection from an animal reservoir to another species is referred to as a spillover infection. In this presentation, deterministic and stochastic multi-patch models developed for the study of hantavirus in reservoir and spillover populations are used to study the probability of a disease outbreak. A continuous-time Markov chain model approximates the infection dynamics near the disease-free state. Theory from multi-type branching process is then used to estimate the probability of a disease outbreak. Numerical results show the importance of location and population densities to the probability of a disease outbreak. (Received February 10, 2014)

1100-92-342 **Jan Medlock*** (jan.medlock@oregonstate.edu), 106 Dryden Hall, Corvallis, OR 97333. *Optimizing Influenza Vaccine Allocation.*

The emergence of the 2009 H1N1 influenza A strain and delays in production of vaccine against it illustrate the importance of optimizing vaccine allocation. We have developed computational optimization models to determine optimal vaccination strategies with regard to multiple objective functions: e.g. deaths, years of life lost, economic costs. Looking at single objectives, we have found that vaccinating children, who transmit most, is robustly selected as the optimal allocation. I will discuss ongoing extensions to this work to incorporate multiple objectives and uncertainty. (Received February 10, 2014)

1100-92-389 **Gordon Akudibillah*** (akudibig@onid.oregonstate.edu), Environmental Science Dept, Oregon State University, Corvallis, OR 97331, and **Jan Medlock**, Dept. of Biomedical Science, 209 Dryden Hall, Corvallis, OR 97331. *Optimizing HIV Treatment In Resource Limited Settings.* Preliminary report.

Apart from the traditional role of preventing progression from HIV to AIDS antiretroviral drugs have an additional clinical benefit of substantially reducing infectiousness thus making them potentially an important strategy in the fight against AIDS. Recent advances in drug therapy have seen the use of antiretroviral medications as a prophylaxis. Administered either as post-exposure prophylaxis after high-risk exposure or as pre-exposure prophylaxis in those with ongoing HIV exposure. In this study, we constructed a compartmental heterosexual transmission model based on the dynamics of HIV in heterosexual population in Sub-Sahara. The model classifies the male and female populations by risk (low, medium and high) according to their sexual preferences. Data from South Africa was used to parameterize the model. For a finite amount of drugs we implemented a numerical optimization algorithm to find optimal allocation of the drugs amongst risk groups that minimizes objective functions such as Total Number of Deaths and Total Number of Infections. Preliminary results suggest that, the priority should be given to the high-risk females during drug allocations to minimize the number of deaths or infection per year. (Received February 11, 2014)

93 ► Systems theory; control

1100-93-103 **Bernard Friedland*** (bf@njit.edu), Dept of Electrical and Computer Engineering, Newark, NJ 07102. *On Definition of Bandwidth and Response Time in Linear Dynamic Systems.* Preliminary report.

Centroidal definitions of bandwidth W and response time T of a linear system are proposed. For a linear, time-invariant system characterized by ordinary differential equations, $\dot{x} = Ax + Bu,\ y = Cx$ these are easily calculated in terms of the matrices A, B, and C and by solution of Lyapunov equations. These definitions comport well with intuitive definitions for low order systems, as demonstrated by several examples. (Received February 03, 2014)

1100-93-116 **John Davis*** (john_m_davis@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798, **Ian Gravagne** (ian_gravagne@baylor.edu), Dept of Electrical & Computer Engineering, Baylor University, Waco, TX 76798, **Geoffrey Eisenbarth** (geoffrey_eisenbarth@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798, and **Dylan Poulsen** (dylan_poulsen@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798. *Time Scales Modeling Done Right: Discretizing onto a Time Scale.* Preliminary report.

When studying real world applications from a time scales approach, it is crucial to model the underlying phenomena with dynamic equations which preserve the original dynamics. Failure to do so usually results in dynamic equations models that are artificial and inaccurate. In this talk, we will discuss, for example, how to map continuous models such as $\dot{x}(t) = Ax(t)$, $t \in \mathbb{R}$, to a dynamic equation $\xi^{\Delta}(\tau) = \mathcal{A}\xi(\tau)$, $\tau \in \mathbb{T}$, where $\mathbb{T}$ is a time scale, in such a way that solutions of the latter preserve the dynamics of the former. Finally, we discuss some real world applications where doing so not only allows new progress on the application but also leads to interesting mathematical questions that would not have arisen otherwise. (Received February 04, 2014)

1100-93-148 **Dylan Poulsen*** (dylan_poulsen@baylor.edu), TX, and **John M Davis** and **Ian A Gravagne**. *Stability of Markov Chains: A Time Scales Viewpoint with Applications to Control.*

We present a version of Lyapunov theory for discrete time scales where the distances between time scale points are independent random variables.

In the case of quadratic Lyapunov functions for the LTI case, our results improve the requirement that $\mathrm{spec}(A) \subset \mathcal{H}_{\min}$, the smallest Hilger circle. Through this analysis, we encounter an interesting geometric relationship between the regions of almost sure exponential stability and mean-square stability. Specifically, the region of stochastic Lyapunov stability is the osculating circle to the region of almost sure exponential stability.

Our approach also allows us to consider a special class of LTV problems where the dependence on time is only through the distance between adjacent time scale points. As an application of these results, we consider observer-based state feedback where the time between sampling points is not known *a priori*, but has known statistical properties. In particular, we assume that the distance between sampling points is an independent sequence of random variables with known mean and variance. (Received February 06, 2014)

1100-93-185 **Ian Gravagne*** (ian_gravagne@baylor.edu), Ian Gravagne, 1 Bear Place 97356, Waco, TX 76798, and **John M. Davis**, **Matthew Mosley** and **Dylan Poulsen**. *Application of an Observer in a Linear Feedback Controller on a Stochastic Graininess Time Scale.* Preliminary report.

In practice, feedback controllers for linear or linearizeable systems sometimes cannot directly measure certain system states that are necessary for stable, high-performance control. In these cases, an observer may be useful for estimating the unmeasurable states.

Previously, it was known that system states could be reconstructed from past outputs for systems operating on a stochastic, discrete time domain; however, this result was not good enough to support real-time feedback control. Recently, co-author D. Poulsen proposed a novel observer configuration that can stabilize a state-feedback controller operating on a stochastic time domain.

This talk explores the application of the Stochastic Time Scale Observer to a state feedback problem through computer simulation. The theory is briefly developed, and then various cases are discussed as the simulator is coded to include more and more "real-world" effects that are not captured in the theory such as communications delays, dropped packets, noisy sensor readings and quantization errors. It will be shown the the proposed observer is quite robust to these effects for the system of interest, and able to stabilize the closed-loop system dynamics with knowledge only of the time scale graininess statistics. (Received February 07, 2014)

1100-93-246 **Wenzhen Fan*** (wenzhen.fan@ttu.edu) and **Clyde Martin** (clyde.f.martin@ttu.edu). *Smoothing splines on the manifold of lines in $\mathbb{R}^2$.*

Manifolds of lines in $\mathbb{R}^n$ have played a role in the theory of linear systems and the theory of the shape analysis.More recently they have become an important tool in statistics.In this paper, smoothing splines on the manifold of lines in $\mathbb{R}^2$ are constructed using natural metric on the manifold of lines in $\mathbb{R}^2$.This method uses a particular representation of the manifold of lines in $\mathbb{R}^2$ and does very well in terms of the cost function. (Received February 09, 2014)

1100-93-324 **Jennifer Emerson**, **Wenzhen Fan** and **Clyde F. Martin*** (clyde.f.martin@ttu.edu), Department of Mathematics and Statistics, 1400 Boston Ave, Lubbock, TX 79409. *Smoothing Splines for the Sphere.*

Data involving the movement of the head and eye can be thought of as coming from measurement on the sphere. In this talk we show that we can construct satisfactory smoothing splines on the sphere using either projections or the distance between lines treating the sphere as a double cover of projctive space. (Received February 10, 2014)

1100-93-331 **Matthias Kawski*** (kawski@asu.edu), School of Mathematical & Statistical Sciences, Arizona State University, Tempe, AZ 85287. *Hopf algebras and linear functionals in nonlinear control.* Preliminary report.

Agrachev's chronological calculus, a well-established powerful tool for the analysis on nonlinear control systems, considers controls and their associated flows as linear operators on the algebra of output functions. We demonstrate how the underlying combinatorial Hopf algebra structures provide insights into the geometry of nonlinear control systems and how they lead to more efficient algorithms, e.g., for path planning. The main focus is on translating combinatorial algebraic objects to dynamic and analytic objects, with special attention to the role of the observation algebra. (Received February 10, 2014)

1100-93-347 **Takafumi Oki*** (takafumi.oki@ttu.edu), 303 Detroit Ave, Savoy 205, Lubbock, TX 79415. *Feedback Stabilization of Rotational Dynamical Systems on $SO(3)$.*

In this talk, we discusses feedback stabilization problems for a class of Rotational Dynamical Systems on **SO(3)** characterized by **Tait-Bryan parametrization**. This dynamical system is used to describe human head movement from the point of view of stabilizing an equilibrium point of the dynamical system. We propose a damping type control law which minimizes certain type of meaningful cost functionals on the generalized torque input. (Received February 10, 2014)

1100-93-388 **G. B. Eisenbarth*** (geoffrey_eisenbarth@baylor.edu), **J. M. Davis** and **I. A. Gravagne**. *Singular Value Conditions for System Stability on Disconnected Time Scales.*

Linear switched systems comprise a convenient class of linear systems whose stability in general is difficult to analyze: those whose dynamics depend on time. While there are numerous papers discussing the stability of switched systems evolving over $\mathbb{R}$ and $\mathbb{Z}$, fairly little has been done in the context of time scale domains.

In this talk, we discuss some recent developments which yield sufficient conditions for global stability of a switched system via the existence of common quadratic Lyapunov functions (CQLFs). While the majority of the literature concerning CQLFs analyzes particular classes of switched systems and their inter-related properties (i.e., normal, pairwise commuting, simultaneously diagonalizable/triangularizable systems), the theorems presented in this talk diverge from the usual and imply the existence of a CQLF on a system by system basis. (Received February 11, 2014)

94 ► Information and communication, circuits

1100-94-25 **Joseph D Lakey*** (jlakey@nmsu.edu), Department of Mathematical Sciences, NMSU, Las Cruces, NM 88003-8001. *Time localized bandpass projections and an application to EEG.* Preliminary report.

A new time localized projection onto a subspace of band limited signals is presented and used to provide a definition of phase for a certain time-frequency localized signal component. This phase is then used to define a phase locking metric and applied to the study of EEG signals. Phase locking has been studied in the context of EEG signals for over 15 years. We compare the performance of our phase locking metric qualitatively with previously proposed metrics in this context. (Received January 13, 2014)

1100-94-269 **Ruben Rivera*** (ruben_m_rivera@nnmc.edu), **John Auxier**, **Ajit Hira**, **Susan Nsaba** and **Danelle Jaramillo**. *A Variant on Hashed-MQV Approach to Diffie Hellman Protocol.*

We present some results of our research on cryptography by delineating aspects of a novel approach to the Diffie-Hellman (DH) problem. Many researchers favor the MQV protocol of Law, Menezes, Qu, Solinas and Vanstone because of its greater efficiency among the commonly known authenticated Diffie-Hellman protocols The MQV is specifically designed to achieve a remarkable list of security properties, including resistance to active man-in the-middle attacks. Recently, Hugo Krawczyk invented a Hashed MQV (HMQV) protocol, which involves the hashing of the party's own DH value and the peer's identity. HMQV is designed to overcome the security shortcomings of MQV, while preserving the efficient performance of MQV. Our protocol uses double hashing of the DH value and of the peer's identity. We expect to adapt our protocol to the Twin DH problem of Cash, Klitz and Shoup. Such studies have obvious applications in communication systems. (Received February 09, 2014)

1100-94-294 **Carl P Dettmann*** (carl.dettmann@bris.ac.uk). *From random geometric graphs to wireless networks.*

Random geometric graphs, consisting of a random point process together with links between pairs of points separated by distance less than a cut-off, were introduced by E. N. Gilbert in 1961. They have been widely studied by both probabilists and engineers. For the latter, they are a convenient model of ad-hoc networks, where wireless device locations are not specified in advance, and pass messages via a sequence of links rather than a central router. However there is still some distance between theory and applications. For example, recent analytical and numerical results have highlighted that deterministic and probabilistic connection models (the latter where links occur with a probability depending on distance) have qualitatively different behaviors. Also, practical networks exhibit a dependence on the confining geometry which is rather different from the widely considered limit of infinite system size. (Received February 10, 2014)

97 ► Mathematics education

1100-97-33 **Bettye Grigsby*** (grigsbyb@uhcl.edu), 2700 Bay Area Boulevard, Houston, TX 77058, **Winona Vesey** (vesey@uhcl.edu), 2700 Bay Area Boulevard, Houston, TX 77058, and **Gary Schumacher** (schumacher@uhcl.edu), 2700 Bay Area Boulevard, Houston, TX 77058. *Learning Environments and Instructional Strategies that Promote African American Males' Learning in Mathematics.*

The purpose of this research was to determine what learning environments and instructional strategies contribute to African American male success in mathematics classrooms. A mixed-methods research design was utilized. The research findings indicated: a gap between teacher and student perception of expectations; African American male students indicated they would like to participate in more group activities; and some students feel they are not treated with respect and teachers do not care for them. (Received January 17, 2014)

1100-97-34 **Bryan Nankervis*** (bn10@txstate.edu). *Gender Inequities in University Admissions and Scholarships in Texas Due to the Differential Validity of the SAT.*

Previous research has documented sex differences in mathematical skills and abilities across various content areas and suggests these differences are a result of a complex mix of biological, sociological, and psychological factors. Consequently, males significantly outscore females on the SAT I quantitative section, which is designed to predict first-year college success in mathematics. This paper, however, demonstrates that gender gaps in performance on the SAT I have little to do with college readiness, but rather are due to the misaligned content of the instrument as well as the environment in which the exam is administered. Specific examples of gender inequity resulting from criteria based on SAT scores for admissions and scholarships at four-year institutions in Texas are addressed. This analysis informs research on access to post-secondary education and has far-reaching implications for the design and administration of standardized mathematics tests such as the SAT I, which is used for determining admission to many colleges as well as the awarding of scholarships. (Received January 17, 2014)

1100-97-84 **Richard J. Sinclair*** (sinclair@unt.edu), 1155 Union Circle 305309, University of North Texas, Denton, TX 76203-5017. *An Option for Accelerated Mathematics Education.*

The Texas Academy of Mathematics and Science at the University of North Texas is a college-based program that allows students to complete concurrently the last two years of high school and the first two years of college. The academy's goal is to create "young scientists and engineers" by a focus on rigorous STEM courses and participation in state-of-the-art research. Students take a two-year curriculum of science courses, balanced with humanities and electives. About one-half of the applicants are female. Because of the configuration of the dormitory, the student body is 44% female. The average math SAT (10th grade) for admitted females is 662, and males 697. Minorities represent about 12% of the student population. Typically, females perform better in the required math classes (Precalculus through Calculus II) than the male students, and about equally in Calculus-based Physics. However, males are seven times more likely to select more advanced math courses as electives (Calculus III, or above), than females. While more girls at TAMS are declaring math or engineering majors over time, Biology and Pre-Medicine are the most popular directions despite excellent mathematics ability and performance. (Received January 30, 2014)

1100-97-97 **Carlos A. LopezLeiva*** (callopez@unm.edu), MSC 05 3040, College of Education, LLSS Department, 1 University of New Mexico, Albuquerque, NM 87131-001. *Leadership Spaces for Latina Mothers: Working Program Structures to Work with Bilingual Families in Mathematics.*

This presentation addresses the work developed with a group of Latina mothers in a mathematics afterschool program for a period of three and a half years. The analysis of the productive patterns of interaction of this group of mothers with a group of bilingual students and their facilitators demonstrates that the program's participation and activity structure closely determined the quality of the mothers' participation. A narrative of sequential arrangements will be shared with the audience in order to show how our different intentional attempts to alter the structure of the program was parallel to the process of understanding how to successfully capitalize on mothers' leadership roles and knowledge during intergenerational and bilingual mathematical activity. Key social processes—acknowledging mothers as facilitators, focusing on communication rather than on a specific language, and supporting mathematics performance through social interactions—that opened up a space for Latina mothers' leadership and dynamic participation during bilingual mathematical activity will be presented and discussed during the presentation. (Received February 01, 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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