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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.

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1135	January 10–13, 2018	San Diego, CA	EXPIRED	Vol 39, No. 1
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1137	April 14–15, 2018	Portland, OR	February 6	Vol 39, No. 2
1138	April 14–15, 2018	Nashville, TN	February 13	Vol 39, No. 2
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1140	June 11–14, 2018	Shanghai, Peoples Rep of China	TBA	NONE
1141	September 29–30, 2018	Newark, DE	July 31	Vol 39, No. 3
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1144	October 27–28, 2018	San Francisco, CA	August 28	Vol 39, No. 4
1145	January 16–19, 2019	Baltimore, MD	TBA	TBA
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1147	March 22–24, 2019	Honolulu, HI	January 22	TBA

ORLANDO, FL, September 23–24, 2017

Abstracts of the 1133rd Meeting.

00 ► General

1133-00-46 **Toaufik SABAR*** (sabarsaw@gmail.com), Residence fedane el kheir, imm 9, nr 2, Bernoussi, Casablanca, Casablanca, Morocco. *Best proximity point for tricyclic mappings in Banach spaces, Convex metric spaces and CAT-k spaces.*

Consider a self mapping T defined on the union of three subsets A;B and C of a metric space; T is to be called a tricyclic mapping if it satisfies T:A $\rightarrow$ B; T:B $\rightarrow$ C and T:C $\rightarrow$ A; in this work; we give a contraction type existence theorem for a best proximity point; as well as a new boundedness result. We first define the best proximity point of a tricyclic mapping and give a simple algorithmto find it. Next, we extend our result to convex metric spaces and CAT(k) spaces, the notion of tricyclic contractions is firstly introduced in our work. (Received July 01, 2017)

1133-00-214 **Xiang-dong Hou***, 4202 E Fowler Ave, Tampa, FL 33620. *Some Applications of the Hasse-Weil Bound.* Preliminary report.

Riemann's hypothesis on function fields over a finite field $\mathbb{F}_q$ implies the Hasse-Weil bound for the number of zeros of an absolutely irreducible polynomial in $\mathbb{F}_q[X, Y]$. The Hasse-Weil bound has widespread applications in the arithmetic of finite fields. In this talk we discuss some recent applications of the Hasse-Weil bound to certain problems on permutation polynomials and the Dickson polynomials. The technical difficulties usually reside in the proof of the absolute irreducibility of the polynomials involved. (Received July 26, 2017)

1133-00-310 **Amir H Assadi**, **Yuan Wang** and **Huijing Gao*** (ghuijing1861@gmail.com), 4701, Sheboygan Ave #223, Madison, WI 53705. *Topological Signal processing.*

Signals are time-sequences of objects that communicate certain encoded pieces of information. Brain activity generates electromagnetic fields that are such signals. Pattern recognition in families of signals and their classification pose significant mathematical challenges. Fourier, Wavelet and other analytic transforms are in studied in-depth, while topological transformation remain unexplored. We propose novel topological transformations

that utilize naturally available geometric information in signals. Through Invariant Theory and Moduli, we provide algorithms for classification and *event detection*.
Suppose a piecewise smooth signal f in R^n is given with q smooth maximal length segments. Then there is ordered sequence Q of q points in the Gassman manifold $G(2,n)$ which is a geometric invariant of f. Further, the network whose vertices are Q and the edges are determined by geodesics joining the vertices determine spectral invariants of f under isometries of R^n.
The $G(2,n) - invariantQ$ is used, then, to establish topological invariants for the signal that are useful in many applications, from robust detection of "special events" in video streams to pattern recognition in brain activation recognition in brain activation signals. (Received August 01, 2017)

03 ► Mathematical logic and foundations

1133-03-26 **Afrah Ahmad Abdou*** (aabdou@kau.edu.sa), Jeddah, 12234, Saudi Arabia. *Common fixed point results for multi-valued mappings with some examples.* Preliminary report.
In this work, we introduce the (CLR)–property for the hybrid pairs of single-valued and multi-valued mappings and give some coincidence and common fixed point theorems for the hybrid pairs of some contractive conditions. Also, we will give some examples to illustrate the main results in this paper. Our results extend and improve some results given by some authors. (Received May 12, 2017)

05 ► Combinatorics

1133-05-17 **Shaohui Zhai**, 1301 E Main St, Murfreesboro, TN 37130, **Dalal Alrowaili*** (daa2v@mtmail.mtsu.edu), 105 4th Ave Apt 108, Murfreesboro, TN 37130, and **Dong Ye** (dong.ye@mtsu.edu), 1301 E Main St, Murfreesboro, TN 37130. *Clar Structures vs Fries Structures in Hexagonal Systems.*
Let H be a cata-condensed benzenoid system. A perfect matching of H is a set of disjoint edges which covers all vertices of H. A resonant set $\mathcal{H}$ of H is a set of hexagons such that there exists a perfect matching M such that the edges of every hexagon in $\mathcal{H}$ alternate between M and $E(G)\backslash M$. The Fries number of H is a maximum size of a resonant set overall and the Clar number of H is a maximum size of the independent resonant set (i.e. all hexagons are disjoint). A pair of hexagonal systems is called a contra-pair if one has a larger Clar number but the other has a larger Fries number. In this paper, we characterize contra-pairs of all cata-condesned hexagonal systems and study the relations between the stability of cata-condensed hexagonal systems and the two topological indices. (Received April 22, 2017)

1133-05-69 **Daniel Irving Bernstein*** (dibernst@ncsu.edu), Department of Mathematics, North Carolina State University, Box 8205, Raleigh, NC 27695. *Tropical Linear Spaces in Phylogenetics.*
One approach to phylogenetic tree reconstruction seeks an ultrametric (i.e. equidistant tree metric) that is l-infinity nearest to a given dissimilarity map. While the l-infinity nearest ultrametric is generally not unique, the set of all l-infinity nearest ultrametrics is a tropical polytope. We give an algorithm to compute a superset of its tropical vertices. Ardila and Klivans showed that the set of all ultrametrics on a finite set of size n is the Bergman fan associated to the matroid underlying the complete graph on n vertices. Therefore, we derive our results in the more general context of Bergman fans of matroids. This generality allows our algorithm to be applied to dissimilarity maps where only a subset of the entries are known. (Received July 10, 2017)

1133-05-74 **Arthur L.B. Yang*** (yang@nankai.edu.cn), Center for Combinatorics, Nankai University, Tianjin, 300071, Peoples Rep of China. *The real-rootedness of Kazhdan-Lusztig polynomials of matroids.* Preliminary report.
In analogy with the classical Kazhdan-Lusztig polynomials in representation theory, Elias, Proudfoot and Wakefield associated to every matroid a polynomial with integer coefficients. They conjectured that the Kazhdan-Lusztig polynomial of a matroid has only non-negative coefficients, and its coefficients form a log-concave sequence with no internal zeros. Gedeon, Proudfoot and Young further conjectured that the Kazhdan-Lusztig polynomial of a matroid has only non-positive real zeros. This talk will address some progress on the real-rootedness of the Kazhdan-Lusztig polynomials for some specific families of matroids, including fan matroids and thagomizer matroids. This talk is based on joint works with Alice Gao, Linyuan Lu, Matthew Xie and Philip Zhang. (Received July 11, 2017)

1133-05-77 **Paul Horn*** (paul.horn@du.edu) and **Lauren Nelsen**. *Edge disjoint rainbow spanning trees in general graphs.*

A beautiful conjecture of Brualdi and Hollingsworth states that if the even ordered complete graph K_{2n} is properly edge colored with $2n-1$ colors, then the resulting graph can be decomposed into n edge disjoint rainbow spanning trees, that is spanning trees where each edge color appears exactly once in each tree. Recently, this conjecture has attracted a lot of attention; a result of the speaker states that one can find $\Omega(n)$ edge disjoint trees in this context with a very recent improvement on the implied constant by Pokrovskiy and Sudakov. In general graphs, a proper edge coloring is not enough to imply the existence of even one such tree. But it is natural to ask what kinds of colorings and conditions on a graph imply the existence of many edge disjoint rainbow spanning trees. In this talk I'll discuss a new result, joint with Lauren Nelsen, in which we use a spectral condition to give a strong result in this direction. (Received July 11, 2017)

1133-05-86 **József Balogh**, **Alexandr Kostochka** and **Xujun Liu*** (xliu150@illinois.edu), 1409 W. Green St., Urbana, IL 61801. *Packing chromatic number of subcubic graphs.*

A *packing k-coloring* of a graph G is a partition of $V(G)$ into sets $V_1, \dots, V_k$ such that for each $1 \le i \le k$ the distance between any two distinct $x, y \in V_i$ is at least $i+1$. The *packing chromatic number*, $\chi_p(G)$, of a graph G is the minimum k such that G has a packing k-coloring. Sloper showed that there are 4-regular graphs with arbitrarily large packing chromatic number. The question whether the packing chromatic number of subcubic graphs is bounded appears in several papers. We answer this question in the negative. Moreover, we show that for every fixed k and $g \ge 2k+2$, almost every n-vertex cubic graph of girth at least g has the packing chromatic number greater than k. (Received July 12, 2017)

1133-05-93 **Seog-Jin Kim*** (skim12@konkuk.ac.kr), Konkuk University, Seoul, South Korea, and **Kenta Ozeki** (ozeki-kenta-xr@ynu.ac.jp), Yokohama National University, Yokohama, Japan. *A note on a Brooks' type theorem for DP-coloring.* Preliminary report.

Dvořák and Postle introduced a *DP-coloring* of a simple graph as a generalization of a list-coloring. They proved a Brooks' type theorem for a DP-coloring, and Bernsheteyn, Kostochka and Pron extended it to a DP-coloring of multigraphs. However, detailed structure when a multigraph does not admit a DP-coloring was not specified. In this note, we make this point clear and give the complete structure. This is also motivated by the relation to signed coloring of signed graphs. This is joint work with Kenta Ozeki. (Received July 13, 2017)

1133-05-106 **Ronald J. Gould*** (rg@mathcs.emory.edu), Dept. Math and Computer Science, Emory University, Atlanta, GA 30322. *Have You Ever Meta-Conjectured?*

A graph is hamiltonian if it contains a spanning cycle and pancyclic if it contains cycles of each length l, $3 \le l \le |V(G)|$. In the early 1970's Bondy made his famed meta-conjecture: Almost any condition that implies a graph is hamiltonian also implies it is pancyclic. There may be a simple family of exceptional graphs.

In this talk we will investigate an extension of Bondy's meta-conjecture, namely: Almost any condition that implies a graph is hamiltonian also implies it is chorded pancyclic (contains a chorded cycle of each length l, $4 \le l \le |V(G)|$.) There may be a simple family of exceptional graphs and small order exceptional graphs.

Supporting results will be discussed. (Received July 15, 2017)

1133-05-120 **Steve Butler*** (butler@iastate.edu), **Ron Graham** and **Catherine Yan**. *Parking on trees.*

Parking functions are assignments of preferences of cars so that all cars entering a one-way street will be able to find a place to park given that they first go to a desired location and then proceed to find the nearest available spot. These have many interesting combinatorial connections.

We can think of this parking function in terms of an (oriented) path graph. The key ingredient being deterministic progression from the initial preferred spot to the exit. Any tree can thus be made to work where we orient all edges to the root (i.e., the exit). We give basic strategies for enumeration of these generalized parking functions, including the use of generating functions and present basic results about such parking functions on caterpillars. (Received July 18, 2017)

1133-05-122 **Tong Li*** (tongli121@163.com), Shandananlu 27, Jinan, Shandong 250100, Peoples Rep of China. *Antimagic orientations of even regular graphs.* Preliminary report.

A **labeling** of a digraph D with m arcs is a bijection from the set of arcs of D to $\{1, \dots, m\}$. A labeling of D is **antimagic** if no two vertices in D have the same vertex-sum, where the vertex-sum of a vertex $u \in V(D)$ for a labeling is the sum of labels of all arcs entering u minus the sum of labels of all arcs leaving u. Motivated by the conjecture of Hartsfield and Ringel from 1990 on antimagic labelings of graphs, Hefetz, Mütze, and Schwartz [On antimagic directed graphs, J Graph Theory 64 (2010) 219–232] initiated the study of antimagic labelings

of digraphs, and conjectured that every connected graph admits an antimagic orientation, where an orientation D of a graph G is **antimagic** if D has an antimagic labeling. It remained unknown whether every disjoint union of cycles admits an antimagic orientation. In this paper, we first answer this question in the positive by proving that every 2-regular graph has an antimagic orientation. We then show that for any integer $d \geq 2$, every connected, $2d$-regular graph has an antimagic orientation. Our technique is new. (Received July 19, 2017)

1133-05-124 **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta,, GA 30303. *Goldberg's Conjecture and Tashkinov Trees.* Preliminary report.

Given a graph G possibly with multiple edges but no loops, denote by Δ the *maximum degree*, μ the *multiplicity*, χ' the *chromatic index* and χ'_f the *fractional chromatic index* of G, respectively. Gupta (1967), Goldberg (1973), Andersen (1977), and Seymour (1979) conjectured that $\chi' = \lceil \chi'_f \rceil$ if $\chi' \geq \Delta + 2$. Inspired by the Tashkinov tree technique, some progress has made toward this conjecture in the last decade. Chen, Gao, Kim, Postle and Shan recently showed that if $\chi' > \Delta + \sqrt[3]{\Delta/2}$ then $\chi' = \lceil \chi'_f \rceil$. The key technic result of their proof states that the number of edges of a special vertex set (elementary set) of a k-critical graph is bounded below by a function of k. Replacing the number of edges by the number of different colors, we obtain a stronger result. We will talk this result and its applications.

This is a joint work with Guangming Jing (Received July 19, 2017)

1133-05-137 **Dan Biebighauser** and **Mark Ellingham*** (mark.ellingham@vanderbilt.edu). *Circuit graphs and relative connectivity.*

Induction arguments for k-connected graphs can be difficult because subgraphs of a k-connected graph are not necessarily k-connected. In 1966 David Barnette found a way to get around this for 3-connected planar graphs. He showed that every 3-connected planar graph has a spanning tree of maximum degree at most 3 by working with a more general class of graphs known as *circuit graphs*, which behave well in induction proofs. Similar ideas have been used in proofs of other results on hamiltonicity, spanning trees, and related concepts. We show how these ideas can be extended in a general way. In particular, if G is a graph and $S \subseteq V(G)$, we can define G to be *k-connected relative to S*, or *(k, S)-connected*, if certain conditions hold. We establish some basic properties of this concept and illustrate how they can be used. (Received July 20, 2017)

1133-05-143 **Carl Yerger*** (cayerger@davidson.edu). *Extensions of Steinberg's conjecture for surfaces.*

Steinberg's conjecture states that every planar graph with no cycles of length four or five is 3-colorable. Recently this conjecture was disproved. However, there are many other interesting questions with this framework. Specifically, we are interested in related questions for graphs embedded on a fixed surface. We will describe results related to the history of this idea.

In this talk, we aim to give baseline results given similar conditions for a graph embeddable on a fixed surface. In particular, we show that if G is drawn in surface Σ with Euler genus g, is 4-critical and has no cycles of length four through ten, then $|V(G)| \leq 2442g + 37$. We also discuss potential improvements to this work. (Received July 21, 2017)

1133-05-144 **Joanna Ellis-Monaghan*** (jellis-monaghan@smcvt.edu), Saint Michael's College, O, Colchester, VT 05439, and **Mark Ellingham**. *Graph embedding and the complexity of the DNA reporter strand problem.*

In 2009, Jonoska, Seeman, and Wu showed that every graph admits a route for a DNA scaffolding strand, that is, a closed walk covering every edge either one or two times, in opposite directions if two times. This corresponds to showing that every graph has an orientable embedding with at least one face that is incident with every edge. In the context of the original application, the desired object is such a closed walk of minimum length. Here we give a very short proof of the original result, but more critically, prove that finding a shortest length solution is NP-Hard, even in the special case of 3-regular, 3-connected, planar graphs. Independent of the motivating application, this problem opens a new direction in the study of graph embeddings, and we suggest several new problems emerging from it. (Received July 21, 2017)

1133-05-145 **Jinko Kanno** and **Songling Shan*** (songling.shan@vanderbilt.edu). *Vizing's 2-factor Conjecture Involving Toughness and Maximum Degree Conditions.* Preliminary report.

Let G be a simple graph, and let $\Delta(G)$ and $\chi'(G)$ denote the maximum degree and chromatic index of G, respectively. Vizing proved that $\chi'(G) = \Delta(G)$ or $\Delta(G) + 1$. Define G to be Δ-critical if $\chi'(G) = \Delta + 1$ and $\chi'(H) < \chi'(G)$ for every proper subgraph H of G. In 1968, Vizing conjectured that if G is a Δ-critical graph, then G has a 2-factor. Let G be an n-vertex Δ-critical graph. It was proved that if $\Delta(G) \geq n/2$, then G has a

2-factor; and that if $\Delta(G) \geq 2n/3 + 13$, then G has a hamiltonian cycle, and thus a 2-factor. It is well known that every 2-tough graph with at least three vertices has a 2-factor. We investigate the existence of a 2-factor in a Δ-critical graph under "moderate" given toughness and maximum degree conditions. In particular, we show that if G is an n-vertex Δ-critical graph with toughness at least $3/2$ and with maximum degree at least $n/3$, then G has a 2-factor. In addition, we develop new techniques in proving the existence of 2-factors in graphs. (Received July 21, 2017)

1133-05-147 **Guoli Ding***, Mathematics Departement, Louisiana State University, Baton Rouge, LA 70803. *Infinite antichains under the induced subgraph relation.* Preliminary report.

A set of graphs is an *antichain* if no member is an induced subgraph of another member. A set of graphs is called an *ideal* if every induced subgraph of a member remains a member. An ideal is a *wqo* if every antichain contained in it is finite.

Let $\mathcal{G}_n$ be the ideal of graphs that do not contain $K_{n,n}$ as a subgraph. Let $\mathcal{S}_m$ be the ideal of graphs G for which there exists a set U of at most m vertices such that every component of $G \backslash U$ is a path. We prove the existence of a function $m = m(n)$ with the following property: for any ideal $\mathcal{G} \subseteq \mathcal{G}_n$, $\mathcal{G}$ is a wqo iff $\mathcal{G} \cap \mathcal{S}_m$ is an wqo. (Received July 22, 2017)

1133-05-159 **Emily Marshall*** (marshalle@arcadia.edu). *Vertex splits and minor-free families of graphs.* Preliminary report.

Splitting a vertex of a graph is a way of reversing the edge contraction operation used in minors. Splitter theorems describe initial families of graphs from which nice families can be generated by repeated vertex splits; Seymour's splitter theorem for 3-connected graphs is one of the best known examples. Such theorems are common tools for generating families of graphs with an excluded minor. In this talk, we discuss minor-free families of graphs generated using splitter theorems. In particular, we describe 4-connected planar DW_6-minor-free graphs. (Received July 23, 2017)

1133-05-160 **Martin Rolek*** (msrolek@wm.edu), Department of Mathematics, College of William & Mary, P.O. Box 8795, Williamsburg, VA 23187-8795, and **Zi-Xia Song**. *Coloring graphs with forbidden minors.*

Hadwiger's conjecture from 1943 states that for every integer $t \geq 1$, every graph either can be t-colored or has a subgraph that can be contracted to the complete graph on $t+1$ vertices. As pointed out by Paul Seymour in his recent survey on Hadwiger's conjecture, proving that graphs with no K_7 minor are 6-colorable is the first case of Hadwiger's conjecture that is still open. It is not known yet whether graphs with no K_7 minor are 7-colorable. Using a Kempe-chain argument along with the fact that an induced path on three vertices is dominating in a graph with independence number two, we first give a very short and computer-free proof of a recent result of Albar and Gonçalves and generalize it to the next step by showing that every graph with no K_t minor is $(2t-6)$-colorable, where $t \in \{7, 8, 9\}$. We then prove that graphs with no K_8^- minor are 9-colorable and graphs with no $K_8^=$ minor are 8-colorable. Finally we prove that if Mader's bound for the extremal function for K_t minors is true, then every graph with no K_t minor is $(2t-6)$-colorable for all $t \geq 6$. This implies our first result. We believe that the Kempe-chain method we have developed in this paper is of independent interest. (Received July 23, 2017)

1133-05-162 **Jie Ma*** (jiema@ustc.edu.cn), No. 96 Jinzhai Road, Hefei, Anhui 230026, Peoples Rep of China. *Stability results on the circumference of a graph.*

We will present some recent stability results on the existence of long cycles in graphs. (Received July 24, 2017)

1133-05-164 **Qijun He*** (qijun@bi.vt.edu), **Christopher Barrett**, **Fenix Huang** and **Christian Reidys**. *From genotypes to phenotypes and back: towards an information theory of DNA.*

In this talk we study an information-theoretic framework rooted in the pairing of genotypes and phenotypes. We view the correlation of these as structural semantics of sequence data that allows for a different interpretation than conventional sequence alignment. This structural semantics could enable us to identify and interpret novel, embedded 'patterns' in DNA and RNA sequences. We compute the partition function of RNA sequences with respect to a fixed RNA secondary structure and connect this computation to a concept of mutual information of a sequence–structure pair for RNA secondary structures. We present a Boltzmann sampler and obtain the a priori probability of specific sequence patterns. We present a detailed analysis for several PDB-structures. We localize specific sequence patterns, contrast the energy spectrum of the Boltzmann sampled sequences versus those sequences that refold into the same structure and derive a criterion to identify native structures. We present multiple sequences in the partition function of a fixed structure, each having nearly the same mutual

information, that are nevertheless poorly aligned. This indicates the possibility of the existence of relevant patterns embedded in the sequences that are not identified using alignments. (Received July 24, 2017)

1133-05-168 **Vladimir Itskov*** (vladimir.itskov@psu.edu), McAllister Building, University Park, PA 16801. *Topological inference of nonlinear rank.* Preliminary report.

The non-linear rank of a matrix is the minimal rank of a matrix that is acted by the group of row-wise nonlinear monotone transformations. Knowing the nonlinear rank is essential in many neuroscience and machine learning contexts, however a practical way of its computation has been unknown. It turns out that nonlinear rank can be efficiently estimated using topological methods.

In this talk I will explain how nonlinear rank relates to the geometry and topology of hyperplane arrangements. I will then describe a method for estimating the nonlinear rank via the computational topology techniques and illustrate its utility by estimating the dimension of the space of smells in a fly olfactory system. (Received July 24, 2017)

1133-05-173 **Jessica McDonald*** (mcdonald@auburn.edu), **Josh Harrelson** and **Gregory J Puleo**. *Edge-colouring planar graphs with precoloured edges.*

In this talk we consider the following question: given a planar graph G and a subgraph H of G that has been (properly) edge-coloured, when can we extend this to an edge-colouring of G? If we hope to get a $(\Delta(G)+t)$-edge-colouring of G, then we certainly need to know that no more than $\Delta(G)+t$ colours were used on $E(H)$. In addition to this, if we don't have $t \geq \Delta(H)$, there are example where extension is not guaranteed. However, given these two assumptions, we show that we can always extend the edge-colouring on H to a $(\Delta(G)+t)$-edge-colouring of G, provided $\Delta(G)$ is large enough (eg. at least $16+\Delta(H)$). (Received July 24, 2017)

1133-05-180 **Lina Li** and **Theodore Molla*** (tnmolla@gmail.com). *Triangle-factors in regular tournaments.* Preliminary report.

A *tournament* is an orientation of the complete graph. We say that a tournament G on n vertices is *regular* if the indegree and outdegree of every vertex is $(n-1)/2$. A *triangle-factor* of G is a collection of $n/3$ vertex-disjoint cyclic triangles. We prove that when n is odd, divisible by 3, and sufficiently large every regular tournament on n vertices contains a triangle-factor. For large tournaments, this resolves a conjecture made independently by Cuckler and Yuster. This result is best possible, because for every n congruent to 3 modulo 18, there exists a tournament on n vertices that does not contain a triangle-factor in which the indegree and outdegree of every vertex is either $(n-3)/2$, $(n-1)/2$, or $(n+1)/2$. We will discuss the proof of this theorem and some related work and conjectures. (Received July 25, 2017)

1133-05-183 **Xingxing Yu***, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *On Hajos' coloring conjecture.*

In the 1905s, Hajos conjectured a possible extension of the Four Color Theorem: Graphs containing no subdivision of K_{k+1} can be k-colored. This conjecture holds for $k \leq 3$, and fails for $k \geq 6$. We will discuss recent work on the case when $k = 4$. (Received July 25, 2017)

1133-05-185 **M. N. Ellingham**, **D. Christopher Stephens*** (chris.stephens@mtsu.edu) and **Xiaoya Zha**. *The genus of the complete tripartite graph.*

In 1969, White conjectured that the orientable genus of the complete tripartite graph $K_{l,m,n}$, where $l \geq m \geq n$, is

$$g(K_{l,m,n}) = \left\lceil \frac{(l-2)(m+n-2)}{4} \right\rceil. \tag{1}$$

In 1976, Stahl and White conjectured that its nonorientable genus is

$$\widetilde{g}(K_{l,m,n}) = \left\lceil \frac{(l-2)(m+n-2)}{2} \right\rceil. \tag{2}$$

The authors settled (2) in 2004, and have now confirmed (1).

In this talk we survey the techniques used in the proof of (2). (Received July 25, 2017)

1133-05-192 **Linyuan Lu*** (lu@math.sc.edu), University of South Carolina, Columbia, SC 29208, and **Zhiyu Wang** (zhiyu@math.sc.edu), University of South Carolina, Columbia, SC 29208. *A note on 1-guardable graphs in the cops and robber game.*

In the cops and robber games played on a simple graph G, Aigner and Fromme's lemma states that one cop can guard a shortest path in the sense that the robber cannot enter this path without getting caught after finite many steps. In this paper, we extend Aigner and Fromme's lemma to cover a larger family of graphs and give metric characterizations of these graphs. In particular, we show that a generalization of block graphs, namely

vertebrate graphs, are 1-guardable. We use this result to give the cop number of some special class of multi-layer generalized Peterson graphs. (Received July 31, 2017)

1133-05-193 **Ilkyoo Choi*** (ilkyoochoi@gmail.com), Hankuk University of Foreign Studies, South Korea, and **Louis Esperet**, Laboratoire G-SCOP, CNRS, France. *Improper coloring of graphs on surfaces.*

A graph G is $(d_1, \dots, d_k)$-colorable if its vertex set can be partitioned into k sets $V_1, \dots, V_k$, such that for each $i \in \{1, \dots, k\}$, the subgraph of G induced by V_i has maximum degree at most d_i. The Four Color Theorem states that every planar graph is $(0, 0, 0, 0)$-colorable, and a classical result of Cowen, Cowen, and Woodall shows that every planar graph is $(2, 2, 2)$-colorable. In this paper, we extend both of these results to graphs on surfaces. Namely, we show that every graph embeddable on a surface of Euler genus $g > 0$ is $(0, 0, 0, 9g - 4)$-colorable and $(2, 2, 9g - 4)$-colorable. We also prove that every triangle-free graph that is embeddable on a surface of Euler genus g is $(0, 0, O(g))$-colorable. This is an extension of Grötzsch's Theorem, which states that triangle-free planar graphs are $(0, 0, 0)$-colorable. Finally, we prove that every graph of girth at least 7 that is embeddable on a surface of Euler genus g is $(0, O(\sqrt{g}))$-colorable. All these results are best possible in several ways as the girth condition is sharp, the constant maximum degrees cannot be improved, and the bounds on the maximum degrees depending on g are tight up to a constant multiplicative factor. (Received July 25, 2017)

1133-05-196 **Gregory J. Puleo***, gjp0007@auburn.edu, and **Douglas B. West**. *The slow-coloring game and the interactive sum choice number of trees.*

The *slow-coloring game* on a graph G is played by two players, Lister and Painter, according to the following rules. All vertices are initially uncolored. Each turn, Lister marks a subset M of uncolored vertices, scores $|M|$ points, and presents the subset to Painter. Painter then gives a color to an independent subset of M. The game continues until all vertices are colored. Lister wishes to maximize his total score, while Painter wishes to minimize it. The *sum-color cost* of G, written $\mathring{s}(G)$, is the score achieved by Lister when both players play optimally.

We give an inductive formula for $\mathring{s}(G)$ when G is a tree, and we discuss the relationship between the sum-color cost of trees and the *interactive sum choice number* of trees, a parameter recently introduced by Bonamy and Meeks. (Received July 25, 2017)

1133-05-227 **Guanghui Wang*** (ghwang@sdu.edu.cn), Shandananlu 27, Jinan, Shandong 250100, Peoples Rep of China. *Splitting graphs and digraphs.* Preliminary report.

There are many interesting results in splitting or decomposing graphs under degree constraints. We will consider this problems in edge-colord graphs and digraphs and introduce some problems and results. (Received July 26, 2017)

1133-05-228 **Geir Agnarsson*** (math.geir@gmail.com), Department of Mathematical Sciences, 4400 University Drive, MS: 3F2, Fairfax, VA 22030. *Extremal finite subgraphs of the grid graph.*

For each $n \in \mathbb{N}$ we discuss and determine the maximum number of edges an induced subgraph of the grid graph $\mathbb{Z}^d$ on n vertices can have. This involves work of Bollobás, Leader and Thomason to name a few. The more elementary the approach is, the more involved the arguments tend to be and vice versa. There seems to be some sort of "Heisenberg's uncertainty principle" going on here between the elementariness of arguments and their shortness/simplicity. In this talk we will try to pinpoint the intricate ideas behind the reasons and explain what really is needed to obtain the results we want. – This work was in part inspired by an undergraduate student in computational biology some years ago. (Received July 26, 2017)

1133-05-235 **Yaping Mao**, **Christopher Melekian*** (ccmeleki@oakland.edu) and **Eddie Cheng**. *The Steiner $(n-3)$-diameter of a graph.*

The notion of Steiner distance, introduced by Chartrand, Oellerman, Tian, and Zou in 1989, is a natural generalization of classical graph distance. Given a connected graph G and a subset S of its vertices, the *Steiner distance* of S , denoted by $d(S)$, is the minimum size of a connected subgraph spanning S. Furthermore, for any k with $2 \leq k \leq |V(G)|$, the *Steiner k-diameter* of G, $sdiam_k(G)$, is the maximum value of the Steiner distance over all vertex subsets of cardinality k. In 2011, Chartrand, Okamoto, and Zhang showed that $k - 1 \leq sdiam_k(G) \leq n - 1$ for a graph on n vertices. In this paper, we characterize the graphs satisfying $sdiam_k(G) = \ell$ for $k = n, n - 1, n - 2, n - 3$ and $k - 1 \leq \ell \leq n - 1$. (Received July 27, 2017)

1133-05-240 **Gregory Churchill***, 4202 East Fowler Ave, CMC 342, Tampa, FL 33620, and **Brendan Nagle**. *An Extension of Hansel's Theorem to Hypergraphs.*

For integers $n \geq k \geq 2$, let V be an n-element set, and let $\binom{V}{k}$ denote the set of all k-element subsets of V. Let $\mathcal{C}$ be a collection of pairs $\{A, B\} \in \mathcal{C}$ of disjoint subsets $A, B \subset V$. We say that $\mathcal{C}$ covers $\binom{V}{k}$ if, for every $K \in \binom{V}{k}$, there exists $\{A, B\} \in \mathcal{C}$ so that $K \subseteq A \dot\cup B$ and $K \cap A \neq \emptyset \neq K \cap B$. When $k = 2$, such a family $\mathcal{C}$ is called a separating system of V, where this concept was introduced by Rényi, and studied by many authors.

Let $h(n, k)$ denote the minimum value of $\sum_{\{A,B\}\in\mathcal{C}}(|A| + |B|)$ over all covers $\mathcal{C}$ of $\binom{V}{k}$. Hansel determined the sharp bounds $\lceil n \log_2 n \rceil \leq h(n, 2) \leq n\lceil \log_2 n \rceil$, and Bollobás and Scott sharpened these bounds to an exact formula for $h(n, 2)$, for all integers $n \geq 2$. Here, we extend these results by determining an exact formula for $h(n, k)$, for all integers $n \geq k \geq 2$. (Received July 27, 2017)

1133-05-262 **Selvi Kara Beyarslan*** (selvi@southalabama.edu), Department of Mathematics and Statistics, 411 University Blvd. North, Mobile, AL 36688, **Tai Huy Ha** (tha@tulane.edu), Department of Mathematics, 6823 St. Charles Ave., New Orleans, LA 70118, and **Augustine O'Keefe** (aokeefe@conncoll.edu), Mathematics Department, 270 Mohegan Avenue Pkwy., New London, CT 06320. *Algebraic properties of toric rings of graphs.*

Let $G = (V, E)$ be a simple graph. We investigate the Cohen-Macaulayness and algebraic invariants, such as the Castelnuovo-Mumford regularity and the projective dimension, of the toric ring $k[G]$ via those of toric rings associated to induced subgraphs of G. (Received July 28, 2017)

1133-05-265 **Xiaofeng Gu***, Department of Mathematics, University of West Georgia, Carrollton, GA 30118. *Edge-disjoint spanning trees and spanning 2-connected subgraphs.*

Motivated by the well known spanning tree packing theorem by Nash-Williams and Tutte, we discover a sufficient partition condition of packing spanning 2-connected subgraphs and spanning trees. As a corollary, it is shown that every $(4k + 2l)$-connected and essentially $(6k + 2l)$-connected graph contains k spanning 2-connected subgraphs and l spanning trees that are pairwise edge-disjoint. Utilizing it, we show that every 6-connected and essentially 8-connected graph G contains a spanning tree T such that $G - E(T)$ is 2-connected. (Received July 28, 2017)

1133-05-304 **Stephen G Hartke**, **Sogol Jahanbekam** and **Brent J Thomas*** (brent.thomas@usu.edu). *The chromatic number of the square of subcubic planar graphs.*

Wegner conjectured in 1977 that the square of every planar graph with maximum degree at most 3 is 7-colorable. We prove this conjecture using the discharging method and computational techniques to verify reducible configurations. (Received July 31, 2017)

1133-05-333 **Shuliang Bai*** (sbai@math.sc.edu), Department of Mathematics LeConte College 1, 1523 Greene Street, University of South Carolina, Columbia, SC 29208, and **Linyuan Lu** (lu@math.sc.edu), Department of Mathematics LeConte College 1, 1523 Greene Street, University of South Carolina, Columbia, SC 29208. *A Bound on the Spectral Radius of Hypergraphs with e Edges.*

For $r \geq 3$, let $f_r \colon [0, \infty) \to [1, \infty)$ be the unique analytic function such that $f_r(\binom{k}{r}) = \binom{k-1}{r-1}$ for any integer $k \geq r - 1$. We prove that the spectral radius of an r-uniform hypergraph H with e edges is at most $f_r(e)$. The equality holds if and only if $e = \binom{k}{r}$ and H is the union of a complete r-uniform hypergraph K_k^r and some possible isolated vertices. This result generalizes the classical Stanley's theorem on graphs. (Received July 31, 2017)

1133-05-337 **Pouria Salehi Nowbandegani*** (pouria.salehi.nowbandegani@vanderbilt.edu), 1326 Stevenson Center Ln, SC 1227I, Nashville, TN 37212, and **Colton Magnant**. *Forbidden properly edge-colored subgraphs that force large highly connected monochromatic subgraphs.*

We consider the connected graphs G that satisfy the following property: If $n \gg m \gg k$ are integers, then any coloring of the edges of K_n, using m colors, containing no properly colored copy of G, contains a monochromatic k-connected subgraph of order at least $n - f(G, k, m)$ where f does not depend on n. If we let $\mathcal{G}$ denote the set of graphs satisfying this statement, we exhibit some infinite families of graphs in $\mathcal{G}$ as well as conjecture that the cycles in $\mathcal{G}$ are precisely those whose lengths are divisible by 3. Our main result is that $C_6 \in \mathcal{G}$. (Received August 01, 2017)

1133-05-343 **Gexin Yu*** (gyu@wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA , and **Xia Zhang**, Shangdong Normal University. *Packing of graphs without certain even cycles.* Preliminary report.

Two n-vertex graphs G_1 and G_2 pack if there exist injective mappings of their vertex sets into $[n]$, such that the images of the edge sets are disjoint. In the 1970s, Bollobás and Eldridge, and independently Catlin, conjectured that if $(\Delta_1+1)(\Delta_2+1) \leq n+1$, then G_1 and G_2 pack, where Δ_1, Δ_2 are the maximum degrees of G_1, G_2, respectively. Towards this conjecture, we show that for each integer $k \geq 2$, if neither of G_1, G_2 contains a 4-cycle nor an even cycle with length between $2k$ and $4k$, and $n > \max\{\Delta_1\Delta_2 + 0.5(\Delta_1+\Delta_2),\ (3k-4.5)(\Delta_1^{1+\frac{1}{k}} + \Delta_2^{1+\frac{1}{k}}) + (6k-5)(\Delta_1+\Delta_2)\}$, then G_1 and G_2 pack. As a corollary, the BEC conjecture is true for graphs without 4-, 6-, 8-cycles and $\Delta_i \geq 330$, $i = 1, 2$, which slightly improves a result by Batenburg and Kang. (Received August 01, 2017)

1133-05-355 **Sean English**, **Jessica Fuller**, **Nathan Graber*** (nathan.graber@ucdenver.edu), **Pamela Kirkpatrick**, **Abhishek Methuku** and **Eric Sullivan**. *Berge-Saturation of Paths and K_3 in k-uniform hypergraphs.*

Let H be a hypergraph, and G be a simple graph on the same vertex set. We say H is *Berge-G* if there exists a bijection $f : E(G) \to E(H)$ such that for each $e \in E(G)$, we have $e \subset f(e)$. If there exists a subhypergraph of H that is Berge-G we say that H contains G, otherwise H is said to be *G-free*. A hypergraph, H is *Berge-G-saturated* if H does not contain G but $H + e$ contains G for every $e \notin E(H)$. The *Berge-saturation number*, denoted B-sat(H, G), is the minimum number of edges in a hypergraph H such that H is G-saturated.

In this talk we will discuss the Berge-saturation number for several classes of graphs and draw comparisons between Berge-saturation and saturation in the traditional graph sense. (Received August 01, 2017)

06 ► Order, lattices, ordered algebraic structures

1133-06-29 **Jinlu Li*** (jli@shawnee.edu), 940 Second St., Portsmouth, OH 45662. *Fixed Point Theorems on Partially Ordered Banach Spaces and Applications.* Preliminary report.

In 1955, Tarski proved the first fixed point theorem on chain-complete lattice for single-valued mappings that initiated a new custom in fixed point theory, in which there are some ordering relations on the underlying spaces, such as, preorder, partial order, or lattice. The underlying spaces are not required to be equipped with a topological structure. To guarantee the existence of fixed points, the considered mappings should satisfy some order-monotonic conditions and it is unnecessary for them to have any continuity property. Some fixed point theorems have been obtained on partially ordered Banach spaces, in which, the continuity of the considered mappings may not be required. When we solve some problems on partially ordered Banach spaces, the ordering structures will provide new powerful tools. The fixed point theorems on posets and on partially ordered Banach spaces have been applied in game theory, economic theory with incomplete utilities and in solving integral equations, vector variational inequalities, ordered variational inequalities, and ordered Nesh equilibrium problems. (Received May 29, 2017)

1133-06-32 **Jean S. Joseph*** (jjose107@fau.edu). *Completion of a Linearly Ordered Set.*

We will present properties that characterize a completion of an arbitrary linearly ordered set and will construct a completion of any linearly ordered set which has these properties. We then will show that any two completions of a linearly ordered set are order isomorphic. Our approach is constructive. (Received June 06, 2017)

11 ► Number theory

1133-11-179 **Alvaro Lozano-Robledo*** (alvaro.lozano-robledo@uconn.edu), University of Connecticut, **Harris B. Daniels** (hdaniels@amherst.edu), Amherst College, and **Erik Wallace** (erik.wallace@uconn.edu), University of Connecticut. *Bounds for the Mordell-Weil rank of certain families of jacobians of hyperelliptic curves defined over Q.*

In this talk, we will discuss a project that extends work of Lehmer, Shanks, and Washington on cyclic extensions, and elliptic curves associated to the "simplest cubic fields". In particular, if $p \geq 3$ is a Sophie Germain prime (so $q = 2p+1$ is also prime), we will describe a family of hyperelliptic curves $C : y^2 = f(x)$, with $f(x)$ of degree p and defined over $\mathbb{Q}$, such that the rank of the Mordell-Weil group of the jacobian $J/\mathbb{Q}$ of C is bounded by the genus of C and the 2-rank of the class group of the (cyclic) field defined by $f(x)$. This is joint work with Harris Daniels (Amherst) and Erik Wallace (UConn). (Received July 24, 2017)

1133-11-194 **Jennifer S. Balakrishnan**, **Sorina Ionica**, **Kristin Lauter** and **Christelle Vincent***, Department of Mathematics and Statistics, 16 Colchester Avenue, Burlington, VT 05401. *Constructing hyperelliptic curves of genus 3 whose Jacobians have CM.*

For cryptographic applications, it is convenient to, given a CM field, be able to construct an abelian variety with complex multiplication by an order in the ring of integers of that field.

It is currently well-understood how to do this in dimension 1, and a lot of progress has been done in dimension 2. We discuss here the challenges of constructing an abelian threefold with complex multiplication by the ring of integers of a sextic CM field and the work that has been done recently in this direction. (Received July 25, 2017)

1133-11-244 **Harris B. Daniels*** (hdaniels@amherst.edu), 31 Quadrangle Amherst, Amherst, MA 01002. *Torsion subgroups of rational elliptic curves over infinite extensions of* $\mathbf{Q}$.

Let $E/\mathbf{Q}$ be an elliptic curve. In this talk we consider the question of what torsion subgroups can occur when we base extend E to some infinite field extensions $K/\mathbf{Q}$. For example, if K is the compositum of all cubic extensions of $\mathbf{Q}$, we show that the torsion subgroup of $E(K)$ is finite and determine 20 possibilities for its structure. This work is partially joint with Álvaro Lozano-Robledo, Filip Najman, and Andrew Sutherland (Received July 27, 2017)

1133-11-316 **Abbey Bourdon*** (bourdoam@wfu.edu) and **Pete L. Clark**. *Degrees of CM Points on* $X_1(M, N)$.

Let M and N be positive integers such that M divides N. The non-cuspidal points of $X_1(M, N)$ correspond to isomorphism classes of triples (E, P, Q), where E is an elliptic curve and the points P and Q generate a subgroup isomorphic to $\mathbb{Z}/M\mathbb{Z} \times \mathbb{Z}/N\mathbb{Z}$. If E has complex multiplication by an order in the imaginary quadratic field K, we say (E, P, Q) is a K-CM point. In this talk, I will give a complete classification of the degrees K-CM points on $X_1(M, N)_{/K}$, where K is any imaginary quadratic field. (Received July 31, 2017)

13 ► Commutative rings and algebras

1133-13-91 **Eloísa Grifo***, eloisa.grifo@virginia.edu. *A stable version of Harbourne's Conjecture.* Preliminary report.

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

1133-13-112 **Mohsen Gheibi***, University of Nebraska-Lincoln, Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588-0130, and **Ryo Takahashi** (takahashi@math.nagoya-u.ac.jp), Graduate School of Mathematics, Nagoya University, Nagoya, 464-8602, Japan. *Totally reflexive modules and Poincaré series.*

In this talk, we describe the Bass series of a Cohen-Macaulay local ring R that admits a specific totally reflexive module. More precisely, we show that the Bass series of R is rational. We also give a description of the Poincaré series of k by using the Poincaré series of the totally reflexive module. (Received July 17, 2017)

1133-13-125 **Andrew R Kustin** and **Adela Vraciu*** (vraciu@math.sc.edu). *Examples of test modules.*

Let (R, m, k) be a local Noetherian ring. An R-module M is called a test module if $\operatorname{Tor}_i^R(M, N) = 0$ for all $i \geq 1$ implies that N is free. The residue class field, k, is a well-known example of test module. We focus on the case when R is an Artinian quotient of a polynomial ring by equations of high degree, and give other examples of test modules. As an application, we describe a class of rings that do not admit non-free totally reflexive modules. (Received July 19, 2017)

1133-13-150 **Luigi Ferraro*** (ferrarl@wfu.edu). *Modules of infinite regularity over graded commutative rings.*

It is proved that if a graded, commutative algebra R over a field k is not Koszul then, denoting by $\mathfrak{m}$ the maximal homogeneous ideal, the nonzero modules of the form $\mathfrak{m}M$ have infinite Castelnuovo-Mumford regularity. It is also proved that over complete intersections which are not Koszul, a nonzero direct summand of a syzygy of k

has infinite regularity. We also relate the vanishing of the graded deviations of R to having a nonzero direct summand of a syzygy of k of finite regularity. (Received July 22, 2017)

1133-13-170 **Saeed Nasseh**, **Sean Sather-Wagstaff*** (ssather@clemson.edu), **Ryo Takahashi** and **Keller VandeBogert**. *Almost Gorenstein Fiber Product Rings.* Preliminary report.

Let $(S, \mathfrak{m}_S, k)$ and $(T, \mathfrak{m}_T, k)$ be local rings that are not fields. Work of Lescot shows that the fiber product $R = S \times_k T$ is Gorenstein if and only if S and T are 1-dimensional regular local rings, in which case R is a 1-dimensional hypersurface. We shall discuss the related question of characterizing *almost* Gorenstein fiber products, in the sense of Goto-Matsuoka-Phuong and Goto-Takahashi-Taniguchi. (Received July 24, 2017)

1133-13-260 **Ananthnarayan Hariharan*** (ananth@math.iitb.ac.in), **Neeraj Kumar** and **Vivek Mukundan**. *Koszulness of certain diagonal subalgebras.* Preliminary report.

Given a bigraded algebra R, the diagonal subalgebra $R_{(c,e)}$ is Koszul for large values c and e. Conca, Herzog, Trung, and Valla give explicit lower bounds on c and e for Koszulness, when R is the Rees algebra of an ideal generated by a regular sequence. We do the same for other classes of ideals by studying residual intersections. This is joint work with Neeraj Kumar and Vivek Mukundan. (Received July 28, 2017)

1133-13-290 **Ashley K Wheeler***, James Madison University, Department of Mathematics & Statistics, Roop Hall 305, MSC 1911, Harrisonburg, VA 22807. *Positroidal components of principal minor schemes.*

A *positroid variety* is a special class of matroid variety whose defining matroid's independent sets consist of consecutive elements from the ground set. For an algebraically closed field K, let $\mathfrak{B}_{n,r,t} \subset \mathbb{A}_K^{n^2}$ denote the locally closed set of $n \times n$ rank r matrices whose size t principal minors vanish. We show the irreducible components of $\mathfrak{B}_{n,n-2,n-2}$ are positroidal. It follows, from a theorem of Knutson, Lam, and Speyer, that $\mathfrak{B}_{n,n-2,n-2}$ is normal, Cohen-Macaulay, has rational singularities, and its components' defining ideals are given by Plücker coordinates. (Received July 30, 2017)

1133-13-291 **Jaree Hudson*** (jmhudson@math.sc.edu). *Generators for Defining Ideals of Special Fiber Rings.*

We discuss a generating set for the ideal defining the special fiber ring of certain Artinian Gorenstein algebras. We approach this problem from the point of view of Macaulay inverse systems. (Received July 30, 2017)

1133-13-312 **Katie Ansaldi*** (ansaldik@wabash.edu), 301 W. Wabash Avenue, Crawfordsville, IN 47933, and **Kuei-Nuan Lin** and **Yi-Huang Shen**. *Generalized Newton Complementary Duals of Monomial Ideals.*

We define the generalized Newton complementary dual of a monomial ideal in a polynomial ring over a field. We show good properties of such duals including linear quotients and isomorphisms between the special fiber rings. This generalizes the Newton complementary dual that was first introduced by Costa and Simis. We construct the cellular free resolutions of duals of strongly stable ideals generated in the same degree. When the base ideal is generated in degree two, we provide an explicit description of cellular free resolution of the dual of a compatible generalized stable ideal. (Received July 31, 2017)

1133-13-319 **Alexander York*** (a.york@ucf.edu). *Linkage and Perfect Modules.*

There have been many attempts to extend the concept of ideal linkage to modules. Martsinkovsky and Strooker define linkage using a projective presentation of the module under study. One takes a projective presentation of an R-module M

$$P_1 \to P_0 \to M \to 0$$

and takes its dual to get

$$0 \to M^* \to P_0^* \to N \to 0.$$

One then says that M and N are directly linked. One downfall of this method is that it only allows one to study linkage in the confines of grade zero.

Nagel extended this by using different classes of modules to present the ones under study. This allows one to define linkage in higher grades, particularly in the grade of the module under question. Of note is the use of quasi-Gorenstein modules to define linkage. First we take a sequence

$$0 \to L \to C \to M \to 0$$

where C is quasi-Gorenstein and both the dimension and grade of C is the same as that of M, say c. Taking a dual of this sequence yields

$$0 \to \operatorname{Ext}^c_R(M,R) \to \operatorname{Ext}^c_R(C,R) \to N \to 0$$

and we say that M and N are directly linked by C. Using this definition we can extend results proved by Martsinkovsky and Strooker to higher grade by the use of perfect modules. (Received July 31, 2017)

1133-13-375 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu), **Oana Veliche** and **Jerzy Weyman**. *The licci property of grade 3 perfect ideals.*

Let R be a regular local ring. All perfect ideals $I \subset R$ of codimension 2 are linked to a complete intersection ideal, they are *licci*. On the other and, generic ideals of codimension 4 are not licci. We provide evidence in support of our conjecture that a perfect ideal of codimension 3 is licci if the free resolution of Q/I over R has certain "Dynkin" format. Here, the connection to Dynkin diagrams comes through Weyman's theory of generic resolutions. (Received August 02, 2017)

14 ► Algebraic geometry

1133-14-6 **T. Shaska*** (shaska@oakland.edu), Rochester, MI. *From hyperelliptic to superelliptic curves.* Preliminary report.

Hyperelliptic curves are the family of curves better understood among all curves of genus $g \geq 2$. In this talk, we will explore what aspects of the theory of hyperelliptic curves can be extended to superelliptic curves. We will consider both the viewpoint of algebraic geometry and number theory. In particular, we will focus on automorphisms, equations of curves over field of moduli , integral minimal models, etc. (Received February 22, 2017)

1133-14-41 **Changho Keem*** (ckeem1@gmail.com), Department of Mathematics, College of Natural Sciences, Seoul National University, Seoul, 151-742, South Korea, and **Yun-Hwan Kim** (yunttang@snu.ac.kr), Department of Mathematics, College of Natural Sciences, Seoul National University, Seoul, 151-742, South Korea. *Irreducibility of the Hilbert scheme of smooth curves in $\mathbb{P}^4$ of degree $g+2$ and genus g.*

We denote by $\mathcal{H}_{d,g,r}$ the Hilbert scheme of smooth curves, which is the union of components whose general point corresponds to a smooth irreducible and non-degenerate curve of degree d and genus g in $\mathbb{P}^r$. In this paper, we show that any non-empty $\mathcal{H}_{g+2,g,4}$ is irreducible, generically smooth and has the expected dimension $4g+11$ without any restriction on the genus g. (Received July 26, 2017)

1133-14-71 **Yiqiang Li*** (yiqiang@buffalo.edu), 244 Mathematics Building, State University of New York at Buffalo, Buffalo, NY 14051. *σ-Quiver varieties and symmetric pairs.*

Nakajima varieties provide a geometric setting for representation theory of Kac-Moody algebras and singularity theory related to general linear groups. A key feature in Nakajima varieties is that they are locally of type A. In this talk, I'll present a new class of quiver varieties, called σ-quiver varieties, which incorporates geometry of classical type. I'll then discuss its connections with singularity theory related to classical groups and a construction of symmetric pairs via Maulik-Okounkov's stable envelope.

This is a work in progress. (Received July 11, 2017)

1133-14-80 **Timothy J. Ford*** (ford@fau.edu), Department of Mathematics, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431. *A Family of Nonnormal Double Planes Associated to Hyperelliptic Curves.* Preliminary report.

Preliminary report. Let C be the affine hyperelliptic curve defined by $y^2 = g(x)$, where $g(x)$ is a polynomial of degree at least three over a field k. Starting with an example that originally appeared in an article by the author and F. DeMeyer, a nonnormal rational affine double plane $X \to \mathbb{A}^2_k$ is constructed together with a one-to-one homomorphism from the subgroup of torsion elements in the Picard group of C to the Brauer group of X. This construction is generalized to the situation where C is an arbitrary affine variety. (Received July 12, 2017)

1133-14-152 **James Phillips*** (jp5ay@virginia.edu). *Covers of elliptic curves and good reduction.*

Raynaud gave a criterion for a branched G-cover of curves defined over a mixed-characteristic discretely valued field K with residue characteristic p to have good reduction in the case of either a three-point cover of $\mathbb{P}^1$ or a one-point cover of an elliptic curve. Specifically, such a cover has potentially good reduction whenever G has a Sylow p-subgroup of order p and the absolute ramification index of K is less than the number of conjugacy

classes of order p in G. In the case of an elliptic curve, we generalize this to the case in which G has an arbitrarily large cyclic Sylow p-subgroup. (Received July 22, 2017)

1133-14-190 **Renzo Cavalieri** and **Nicola Tarasca*** (nicola.tarasca@icloud.com). *Loci of genus two curves with marked Weierstrass points.* Preliminary report.

This project deals with the geometry and combinatorics of moduli spaces of curves. The locus of curves of genus two with n marked Weiestrass points has codimension n inside the moduli space of genus two, n-pointed curves, for $1 \leq n \leq 6$. We produce an explicit formula for the classes of these loci. The formula is expressed using a generating function over stable graphs indexing the boundary strata of moduli spaces of pointed stable curves. (Received July 25, 2017)

1133-14-204 **Renee Hyunjeong Bell*** (rhbell@math.mit.edu), MIT Department of Mathematics, 32 Vassar St., Bldg. 2-239A, Cambridge, MA 02139. *Local-to-Global Principles for Galois Covers of Curves in Characteristic p.*

Given a Galois cover of curves $X \to Y$ with Galois group G which is totally ramified at a point x and unramified elsewhere, restriction to the punctured formal neighborhood of x induces a Galois extension of Laurent series rings $k((u))/k((t))$. If we fix a base curve Y, we can ask when a Galois extension of Laurent series rings comes from a global cover of Y in this way. Harbater proved that over a separably closed field, this local-to-global principle holds for any base curve if G is a p-group, and gave a condition for the uniqueness of such an extension. Using a generalization of Artin-Schreier theory to non-abelian p-groups, we characterize the curves Y for which this lifting property holds and when it is unique, but over a more general ground field. (Received July 25, 2017)

1133-14-252 **Isabel Vogt*** (ivogt@mit.edu). *Interpolation problems for curves in projective space.*

In this talk we will discuss the following question: When does there exist a curve of degree d and genus g passing through n general points in $\mathbb{P}^r$? We will focus primarily on what is known in the case of space curves ($r = 3$). (Received July 27, 2017)

1133-14-288 **Bradley Weaver*** (brw4sz@virginia.edu), 141 Cabell Drive, Charlottesville, VA 22904. *The Local Lifting Problem for D_4.*

For a prime p, a cyclic-by-p group G and a G-extension $L|K$ of complete discrete valuation fields of characteristic p with algebraically closed residue field, the local lifting problem asks whether the extension $L|K$ lifts to characteristic zero. In this talk we shall motivate the local lifting problem (via the global lifting problem for curves), and discuss briefly why all G-extensions $L|K$ with $G = D_4$ (the dihedral group with eight elements) satisfy the local lifting problem for $p = 2$. (Received July 30, 2017)

1133-14-306 **Emre Sen*** (sen.e@husky.neu.edu), Boston, MA 02170. *Singularities of dual varieties associated to exterior representations.*

For a given irreducible projective variety X, the closure of the set of all hyperplanes containing tangents to X is the projectively dual variety X^*. We study the singular locus of projectively dual varieties of certain Segre-Plücker embeddings. We give a complete classification of the irreducible components of the singular locus of several representation classes. Basically, they admit two types of singularities: cusp type and node type which are degeneracies of a certain Hessian matrix, and the closure of the set of tangent planes having more than one critical point respectively. In particular, our results include a description of singularities of dual Grassmannian varieties. (Received July 31, 2017)

1133-14-329 **A R Stout***, 199 Chambers Street, room N599, Mathematics Department, New York, NY 10007. *The auto-Igusa zeta function of a plane curve singularity is rational.*

Associated to an algebraic germ (X, p) is the completed local ring $(R, \mathfrak{m})$ together with the sequence of Artin rings $R_n = R/\mathfrak{m}^n$. We study algebra endormorphisms of R_n, which are parameterized by a variety A_n we term the auto-arc space of (X, p) at level n. The motivic generating series $\zeta_{(X,p)}$ for the sequence of spaces A_n is termed the auto-Igusa zeta function and was introduced into the literature by H. Schoutens. In the case of plane curves, we show that the difference between $\zeta_{(X,p)}$ and the motivic Igusa zeta function (the generating series extensively studied by J. Denef, F. Loeser, et. al.) is a polynomial over the Grothendieck ring of varieties. This implies that $\zeta_{(X,p)}$ is rational. (Received July 31, 2017)

1133-14-331 **Łucja Farnik**, **Francesco Galuppi**, **Luca Sodomaco** and **Bill Trok*** (william.trok@uky.edu). *Combinatorics and Unexpected Curves in the Projective Plane.* Preliminary report.

Let $I(Z)$ be the ideal of a collection of points Z contained in $\mathbb{P}^2$, the projective plane. We say that Z has an unexpected curve of degree d if for a general point $Q \in \mathbb{P}^2$, and some integer m, the dimension of the ideal $I(Z) \cap I(Q)^m$ in degree d is not the expected dimension, that is $\dim[I(Z) \cap I(Q)^m]_d > \max\{0, \dim[I(Z)]_d - \binom{m+1}{2}\}$. We discuss some ongoing work involving the structure of the collections of points Z which admit unexpected curves. We'll mention why we expect high amounts of symmetry of the points in Z, with special attention paid to the case where Z consists of 9 points. Additionally, we'll look at a new technique for proving a given configuration admits an unexpected curve. (Received July 31, 2017)

1133-14-357 **Jean-François Biasse*** (biasse@usf.edu). *Computing isogenies between elliptic curves and applications to cryptography.*

In this talk, I will present some recent results on the computation of isogenies between elliptic curves over finite fields.

Since the inception of curve-based cryptosystems, the computation of isogenies has been a very important topic in cryptography because of its relevance to point counting the the resolution of the discrete logarithm problem.

A second generation of curve-based cryptosystems is currently emerging. They rely on the hardness of computing isogenies which seems intractable even with quantum computers. I will introduce a key exchange mechanism based on isogenies between supersingular curves, and I will discuss recent work on the analysis of its security. (Received August 01, 2017)

15 ► Linear and multilinear algebra; matrix theory

1133-15-141 **Sk. Safique Ahmad*** (safique@iiti.ac.in), Indian Institute of Technology Indore, Simrol, Khandwa Road, Indore, 453552, India, and **Istkhar Ali** (istkhara@iiti.ac.in), Indian Institute of Technology Indore, Simrol, Khandwa Road, Indore, India. *Sensitivity analysis of matrices over a quaternion division algebra.*

In this work, we present the concept of perturbation bounds for the right eigenvalues of a quaternionic matrix. In particular, the Bauer-Fike type theorem for the right eigenvalues of a diagonalizable quaternionic matrix is derived. In addition, perturbations of a quaternionic matrix are discussed via block diagonal decomposition and Jordan canonical form of a quaternionic matrix. (Received July 20, 2017)

1133-15-199 **Radu Balan*** (rvbalan@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Norms and embeddings of classes of positive semidefinite matrices.* Preliminary report.

In this talk we consider several classes of positive semidefinite matrices. Specifically we consider the properties of bounded rank, unit trace, and their intersection. We analyze two family of metrics, the norm metrics, and the Bures/Hellinger metric. Next we analyze linear embeddings in Euclidean spaces and their bi-Lipschitz properties. (Received July 25, 2017)

1133-15-286 **Mostafa Rahmani*** (mostafa@knights.ucf.edu) and **George Atia** (george.atia@ucf.edu). *Innovation Pursuit: A New Approach to the Subspace Clustering Problem.*

In subspace clustering, a group of data points belonging to a union of subspaces are assigned membership to their respective subspaces. We present a new approach dubbed Innovation Pursuit (iPursuit) to the problem of subspace clustering using a new geometrical idea whereby subspaces are successively identified based on their relative novelties. The proposed approach finds the subspaces consecutively by solving a series of simple linear optimization problems, each searching for some direction of innovation in the span of the data that is potentially orthogonal to all subspaces except for the one to be identified in one step of the algorithm. iPursuit can provably yield exact clustering even when the subspaces have significant intersections. The experiments with both real and synthetic data demonstrate that iPursuit can often outperform the state-of-the-art subspace clustering algorithms, more so for subspaces with significant intersections. The proposed idea for direction search is also integrated with spectral clustering to yield a new variant of spectral clustering based algorithms that mostly outperforms the existing spectral clustering based methods and exhibits superior performance in the challenging face clustering problem. (Received July 29, 2017)

1133-15-366 **Kourosh Modarresi** (modarres@adobe.com), P O Box 19544, Stanford, CA 94309, **Abdurrahman Munir*** (munir@adobe.com), 345 park Av, E12- 032, san Jose, CA , and **Jamie Diner** (diner@adobe.com), 345 Park Av, E12 - 032, San Jose, CA. *A Comprehensive Evaluation of Models for Matrices with Missing Values.*

Matrices are prominent features of machine learning and artificial intelligent domains. AI and machine learning focus on learning from data and the preferred format of the presentation of data for the learning process is structuring data as a matrix. In practice, these matrices have many missing entries which is due, in part, to the sparsity of the data. The sparsity itself is partly the result of the high dimensionality of the observed data. There are many different models that have been used to compute these missing entries of a matrix. In this work, we examine the performance of these models with respect to data features such as type, size, sparsity and the application domain. (Received August 01, 2017)

16 ► Associative rings and algebras

1133-16-59 **Jonathan Kujawa** (kujawa@math.ou.edu) and **Jieru Zhu*** (jieru.zhu-1@ou.edu). *Presenting cyclotomic Schur algebras.*

A classical result states that the action of $\mathfrak{gl}(V)$ and the symmetric group on d letters mutually centralize each other on the d-fold tensor of V. If V admits an action by $\mathbb{Z}/r\mathbb{Z}$, it induces an action of the wreath product of $\mathbb{Z}/r\mathbb{Z}$ and the symmetric group on d letters. A Levi Lie subalgebra $\mathfrak{g}$ of $\mathfrak{gl}(V)$ gives the full centralizer of this action, and we further showed a presentation for the cyclotomic Schur algebra as a quotient of the enveloping algebra of $\mathfrak{g}$. This also provides a PBW type basis and a second presentation with idempotent generators. These results extend to the quantum setting and yield similar presentations and a basis for the the cyclotomic q-Schur algebra. When $r = 2$, they become presentations for the Type B hyperoctahedral Schur algebra defined by Richard Green. (Received July 07, 2017)

1133-16-146 **Van Nguyen**, **Gordana Todorov** and **Shijie Zhu*** (zhu.shi@husky.neu.edu), Department of Mathematics 567 Lake Hall, Northeastern University, 360 Huntington Ave., Boston, MA 02115. *Preprojective algebras of tree type quivers.*

We show the equivalence of several descriptions of preprojective algebras for any tree-type quiver Q. In particular, we construct irreducible morphisms, in the Auslander-Reiten quiver of the transjective component of the bounded derived category of its path algebra kQ, that satisfy what we call the λ-relations, where λ a nonzero element in the field k. When $\lambda = 1$, the relations are known as mesh relations. When $\lambda = -1$, they are known as commutativity relations. Using this technique together with the results given by Baer-Geigle-Lenzing, Crawley-Boevey, Ringel, and others, we show that for any tree-type quiver, several descriptions of its preprojective algebra are equivalent. (Received July 21, 2017)

1133-16-315 **Jonathan Kujawa***, Dept. of Mathematics, University of Oklahoma, Norman, OK 73071. *Realizing the spectrum of tensor categories.*

A central theme of mathematics is the idea that geometry and algebra are two sides of the same coin. A recent incarnation of this philosophy is the spectrum of a tensor category. I'll give an overview of this elegant notion, while giving all the necessary background and plentiful examples. In the end I will discuss joint work with Brian Boe and Daniel Nakano in which we provide an concrete description of the spectrum for several tensor triangulated categories which naturally appear in representation theory. (Received July 31, 2017)

1133-16-367 **Benjiman C. Tharp*** (btharp@math.ou.edu), Quincy, IL 62301. *On the representation theory of the marked Brauer algebra.*

The marked Brauer algebra is a diagram algebra which generalizes the ordinary Brauer algebra and is in Schur-Weyl duality with the type $\mathfrak{p}$ Lie superalgebra. Like the ordinary Brauer algebra, this marked version has a very rich representation theory. We will discuss some of the interesting combinatorics which arise from studying certain representations of the marked Brauer algebra. (Received August 01, 2017)

17 ► Nonassociative rings and algebras

1133-17-99 **Irfan Bagci*** (irfan.bagci@ung.edu), Department of Mathematics, University of North Georgia, Oakwood, GA 30566, and **Lucas Calixto** and **Tiago Macedo**. *Weyl modules and Weyl functors for Lie superalgebras.*

Given an algebraically closed field k of characteristic zero, a Lie superalgebra $\mathfrak{g}$ over k and an associative, commutative k-algebra A with unit, a Lie superalgebra of the form $\mathfrak{g} \otimes_k A$ is known as a map superalgebra. Map superalgebras generalize important classes of Lie superalgebras, such as, loop superalgebras (where $A = \mathbb{C}[t^{\pm 1}]$), and current superalgebras (where $A = \mathbb{C}[t]$). Recently, in joint work with L. Calixto and T. Macedo, we defined Weyl functors, Weyl modules for all map superalgebras where $\mathfrak{g}$ is either $\mathfrak{sl}(n, n)$ with $n \geq 2$, or a finite-dimensional simple Lie superalgebra not of type $\tilde{S}(n)$ or $\mathfrak{q}(n)$. Under certain conditions on the triangular decomposition of these Lie superalgebras we proved that Weyl modules satisfy certain universal and tensor product decomposition properties. We also gave necessary and sufficient conditions Weyl modules to be finite dimensional. Finally, we proved that Weyl functors satisfy interesting homological properties, and show several examples to illustrate the differences between the super and non-super cases. In this talk I will provide a brief summary of these results. (Received July 14, 2017)

1133-17-128 **Gordon Brown*** (gbrown@math.ou.edu) and **Jonathan Kujawa** (kujawa@math.ou.edu). *Webs for type Q Lie superalgebras.* Preliminary report.

Webs are a type of diagram introduced by Kuperberg in the 1990s to describe intertwiners between certain modules over the quantum group $U_q(\mathfrak{sl}_n)$. In 2014, Cautis-Kamnitzer-Morrison completed a program initiated by Kuperberg, obtaining a complete set of relations among such intertwiners in terms of webs. In this talk, I report on joint work with Jonathan Kujawa, in which we do the same for certain modules over the Lie superalgebra $\mathfrak{q}(n)$. (Received July 19, 2017)

1133-17-130 **Nicholas Davidson*** (ndavidson@math.ou.edu). *Categorical Actions and Supercategories.*

Over the last ten years, categorical actions of Kac-Moody algebras (in the sense of Khovanov-Lauda and Rouquier) have played an important role in representation theory. I will discuss my work in extending these ideas to actions of Kac-Moody algebras on *supercategories*, and emphasize how this work sheds light on the combinatorics of category $\mathcal{O}$ for the Lie superalgebra $\mathfrak{q}_n(\mathbb{C})$. (Received July 19, 2017)

1133-17-169 **Houssein El Turkey*** (helturkey@newhaven.edu), 300 Boston Post road, West Haven, CT 06516. *Complexity of simple modules over the Lie superalgebra* $\mathfrak{osp}(k|2)$.

The complexity of a module is the rate of growth of the minimal projective resolution of the module while the z-complexity is the rate of growth of the number of indecomposable summands at each step in the resolution. Let $\mathfrak{g} = \mathfrak{osp}(k|2)$ $(k > 2)$ be the type II orthosymplectic Lie superalgebra of types B or D. In this talk, we present the complexity and the z-complexity of the simple finite-dimensional $\mathfrak{g}$-supermodules. We then give these complexities certain geometric interpretations using support and associated varieties. (Received July 24, 2017)

1133-17-233 **Matthew Ondrus** and **Emilie Wiesner*** (ewiesner@ithaca.edu), Ithaca, NY 14850. *Polynomial subalgebras for the Virasoro algebra and their induced modules.* Preliminary report.

We introduce a new family of "polynomial" subalgebras for the Virasoro algebra and determine irreducibility conditions for Virasoro modules induced from one-dimensional modules for these subalgebras. These modules give a new presentation for several module families that have already been studied, as well as generalize them. (Received July 27, 2017)

1133-17-249 **Christopher Leonard*** (ctl3az@virginia.edu). *Graded Super Duality for General Linear Lie Superalgebras.*

Super duality is an equivalence between suitable parabolic BGG categories of general linear Lie (super) algebras at an infinite-rank limit. It was first proved by Cheng and Lam in 2010 and was used by those authors and Wang to first establish the Brundan-Kazhdan-Lusztig conjecture on the characters of irreducible modules over general linear Lie superalgebras. Brundan, Losev, and Webster gave a new proof of this BKL conjecture using uniqueness of tensor product categorifications, and showed that the BGG category $\mathcal{O}$ for a (finite-rank) general linear Lie superalgebra has a unique Koszul graded lift. We adapt the BLW approach to provide a new proof of super duality; moreover we provide a lift to a 'graded super duality' - a graded equivalence of categories. (Received July 27, 2017)

1133-17-263 **Joshua Sussan*** (joshuasussan@gmail.com), CUNY Medgar Evers, 1650 Bedford Avenue, Brooklyn, NY 11225. *Towards categorification of 3-manifold invariants.*

The Jones polynomial of a link could be defined through the representation theory of quantum sl(2). Soon after this link invariant was discovered, the Witten-Reshetikhin-Turaev 3-manifold invariant was constructed using the representation theory of quantum sl(2) at a root of unity.

The categorification program has successfully enhanced the Jones polynomial to a homological link invariant. We will explain some ideas of Khovanov which outline a procedure for categorifying the 3-manifold invariant and some progress in this direction. (Received July 28, 2017)

18 ► Category theory; homological algebra

1133-18-127 **Silvana Bazzoni** (bazzoni@math.unipd.it), Dipartimento di Matematica, Università di Padova, Via Trieste 63, 35121 Padova, Italy, **Sergio Estrada*** (sestrada@um.es), Facultad de Matemáticas, Universidad de Murcia, Campus de Espinardo, 30100 Murcia, Spain, and **Manuel Cortés Izurdiaga** (mizurdiaga@uma.es), Depto. de Didáctica de las Matemáticas, Universidad de Málaga, 29071 Málaga, Spain. *Periodic modules and acyclic complexes.*

We study the behavior of modules M that fit into a short exact sequence $0 \to M \to C \to M \to 0$, where C belongs to a class of modules $\mathcal{C}$, the so-called $\mathcal{C}$-periodic modules. We will combine techniques of hereditary cotorsion pairs and presentation of direct limits to conclude, among other applications, that if M is any module and C is cotorsion, then M will be also cotorsion. This will lead to some meaningful consequences in the category $\mathrm{Ch}(R)$ of unbounded chain complexes and in Gorenstein homological algebra. (Received July 19, 2017)

1133-18-242 **Jonathan Brundan*** (brundan@uoregon.edu). *On the definition of Heisenberg category.* Preliminary report.

I will discuss the definition and significance of the Heisenberg category. In level one, this was introduced by Khovanov, and in higher levels by Mackaay and Savage. The level zero case is the affine oriented Brauer category of Brundan, Comes, Nash and Reynolds. (Received July 27, 2017)

1133-18-280 **James R. Gillespie*** (jgillesp@ramapo.edu), 505 Ramapo Valley Road, Mahwah, NJ 07430. *On Ding injective, Ding projective, and Ding flat modules and complexes.*

We characterize Ding modules and complexes over Ding-Chen rings. We show that over a Ding-Chen ring R, the Ding projective (resp. Ding injective, resp. Ding flat) R-modules coincide with the Gorenstein projective (resp. Gorenstein injective, resp. Gorenstein flat) modules, which in turn are nothing more than modules appearing as a cycle of an exact complex of projective (resp. injective, resp. flat) modules. We prove a similar characterization for chain complexes of R-modules: A complex X is Ding projective (resp. Ding injective, resp. Ding flat) if and only if each component X_n is Ding projective (resp. Ding injective, resp. Ding flat). The proofs are based on generalizations of some recent results of Stovicek and Bravo-Gillespie-Hovey which lead to other interesting corollaries. (Received July 29, 2017)

1133-18-358 **Andrew Maurer*** (andrew.b.maurer@gmail.com), Andrew Maurer, Boyd Graduate Studies Research Center, Department of Mathematics, Athens, GA 30602. *On the Finite Generation of Relative Cohomology for Lie Superalgebras.*

The cohomology ring of a complex Lie superalgebra is oftentimes nonzero in only finitely many degrees, and thus carries very little geometric information. Relative cohomology, on the other hand, can be nonzero in infinitely many degrees meaning certain relative cohomology rings may have positive Krull dimension. The author establishes finitude of this Krull dimension for classical Lie superalgebras relative to even subsuperalgebra. This paves the way for cohomology varieties and support varieties for modules to be defined and studied. The author considers questions of connectedness and realizability, along with specific examples when the cohomology ring is Cohen-Macaulay. (Received August 01, 2017)

20 ► Group theory and generalizations

1133-20-176 **Christopher M Drupieski*** (c.drupieski@depaul.edu) and **Jonathan R Kujawa**. *Some graded analogues of one-parameter subgroups and applications to the cohomology of $GL_{m|n(r)}$.*

In 1997, Suslin, Friedlander, and Bendel showed that the cohomology variety of a height-r infinitesimal group scheme G identifies with the variety of homomorphisms $\nu : \mathbb{G}_{a(r)} \to G$. They called this the 'variety of infinitesimal one-parameter subgroups of height $\leq r$ in G.' In this talk I will discuss joint work with Jonathan Kujawa in which we extend the SFB result to the Frobenius kernels of the general linear supergroup $GL_{m|n}$. This involves introducing a family of infinitesimal supergroup schemes, which we call multiparameter supergroups, that generalize the Frobenius kernels of the additive group scheme. (Received July 24, 2017)

1133-20-189 **Jie Du** and **Brian Parshall*** (bjp8w@virginia.edu), Dept. of Mathematics, University of Virginia, Charlottesville, VA 22903, and **Leonard Scott**. *Local and global methods in representations of Hecke algebras.* Preliminary report.

The q-Schur algebeas of Dipper-James were originally used to study the cross-characteristic representation theory of $GL_n(q)$. For some time, these algebras have been known to be quasi-hereditary, even over the ring $\mathbb{Z}[t, t^{-1}]$ of integral Laurent polynomials. In other types, the use of quasi-hereditary algebras in cross-characteristic theory, while a good starting point, seems too restrictive, if one is seeking a theory for all (even *bad*) characteristics different from the defining characteristic p. This talk will discuss this topic, concentrating on an old conjecture of the authors and new techniques which they have recently developed to apply to these questions. In some sense, some of the methods fit quite nicely with the theme of this special session. (Received July 25, 2017)

1133-20-268 **Christopher Bendel**, **Daniel Nakano**, **Cornelius Pillen** and **Paul Sobaje*** (sobaje@uga.edu), 166 Oak Meadow Dr., Athens, GA 30605. *On tensoring restricted simple G-modules with the Steinberg representation.* Preliminary report.

Let G be a simple algebraic group over an algebraically closed field of characteristic $p > 0$, St the Steinberg module for G, and $L(\lambda)$ a restricted simple G-module. We consider the problem of determining when $St \otimes L(\lambda)$ has a good filtration, a problem with a number of important implications for the representation theory of G. (Received July 28, 2017)

1133-20-285 **Cornelius Pillen*** (pillen@southalabama.edu). *Lifting modules of a finite group of Lie type to its ambient algebraic group.* Preliminary report.

Let G be a simple simply connected algebraic group over an algebraically closed field k of positive characteristic p. Inside G, the set of fixed points of the rth iterate of the Frobenius map form a subgroup, a finite of Lie type group, denoted by $G(p^r)$. We are interested in the following question: Given a $kG(p^r)$-module M, does there always exist a G-module that is isomorphic to M as a $kG(p^r)$-module? A well-known result due to Robert Steinberg says that all the simple modules are obtained via restriction from G to $G(p^r)$. But in general the question has a negative answer. This talk is a survey of known results together with several explicit SL_2 examples. (Received July 29, 2017)

1133-20-298 **Zongzhu Lin*** (zlin@math.ksu.edu), Department of Mathematics, CW 138, Kansas State University, Manhattan, KS 66506. *Generalization of Lusztig's character formula.*

Lusztig constructed a formula for all irreducible representations of a reductive algebraic group G in characteristic p assuming that p is large enough so that the irreducible modules of the same p-restricted highest weights for the algebraic group and the corresponding quantum enveloping algebra at p-th root of unit are the same. Lusztig conjectured character formula in terms of Kazhdan-Lusztig polynomials has highest weights limited in the Jantzen region. In this talk, I will formulate a similar formula for a infinite families of highest weight modules of the algebraic group G in terms of the irreducible modules of the quantum group at p^r-th roots of unit. These infinite family of highest weight modules enjoy many interesting properties and provide an infinite family of bases of the character ring. They are expressed in terms of Kazhden-Lusztig polynomials in terms of Frobenius morphisms on the character ring. (Received July 30, 2017)

1133-20-344 **David J Hemmer*** (dhemmer@math.buffalo.edu), 211 Mathematics Building, Buffalo, NY 14260. *Vanishing and non-vanishing in symmetric group character tables.* Preliminary report.

We discuss some questions related to zeros in the character tables of symmetric and alternating groups. (Received August 01, 2017)

1133-20-373 **Bahran Cihan*** (bahra004@umn.edu), Minneapolis, MN 55403. *Categorifications of induction theorems in finite group representation theory.* Preliminary report.

Artin's induction theorem states that every complex character of a finite group G can be written as a rational linear combination of characters induced from cyclic subgroups. We give a categorification of this theorem and several generalizations of it via a well-studied infinite dimensional G-space. The fact that the space is infinite-dimensional means that the usual notion of Euler characteristic is not defined, but we see that by a certain way of summing a divergent series, the correct rational coefficients arise. (Received August 02, 2017)

22 ► Topological groups, Lie groups

1133-22-351 **Artur Elezi*** (artur.elezi@gmail.com), Department of Mathematics and Statistics, American University, 4400 Mass Ave, NW, Washington, DC 20016, and **Tony Shaska** (shaska@oakland.edu), Department of Mathematics and Statstics, 146 Library Drive, Oakland University, Rochester, MI 48309. *Reduction of Binary Forms via the Hyperbolic Centroid.*

In this paper we introduce a reduction theory of binary forms based on the hyperbolic center of mass. This reduction is different from the one introduced by Julia (1917), but seems to give similar results. (Received August 01, 2017)

28 ► Measure and integration

1133-28-307 **Jason W. Bentley*** (jason.w.bentley@knights.ucf.edu), 4393 Andromeda Loop N, Orlando, FL 32816, and **Piotr Mikusinski** (piotr.mikusinski@ucf.edu), 4393 Andromeda Loop N, Orlando, FL 32816. *Construction of Regular Non-Atomic Strictly-Positive Measures in Locally Compact Non-Atomic Polish Spaces.* Preliminary report.

We present a constructive proof of the existence of a regular non-atomic measure that is positive on all non-empty open sets of a locally compact non-atomic Polish space. We construct a sequence of finitely-additive set functions defined recursively on an ascending sequence of rings of subsets and obtain a measure with the desired properties as the extension of a pre-measure defined as the limit of the sequence of set functions. (Received July 31, 2017)

30 ► Functions of a complex variable

1133-30-40 **Xin Li**, Department of Mathematics, University of Central Florida, 4393 Andromeda Loop N, Orlando, FL 32816, and **Rajitha Ranasinghe***, Department of Mathematics, University of Central Florida, 4393 Andromeda Loop N, Orlando, FL 32816. *A Bernstein-type inequality for the Askey-Wilson operator and related results.*

For $|q| < 1$ and given a function $f(x)$ with $x = \cos\theta$, the Askey-Wilson operator, $\mathcal{D}_q$ on f is defined by

$$(\mathcal{D}_q f)(x) := \frac{\breve{f}(q^{1/2}z) - \breve{f}(q^{-1/2}z)}{(q^{1/2} - q^{-1/2})i\sin\theta},$$

where

$$\breve{f}(z) := f\left(\frac{1}{2}\left(z + \frac{1}{z}\right)\right),\ z = e^{i\theta}.$$

Let P_n be a polynomial of degree n. By applying $\mathcal{D}_q$ on P_n we obtain a Riesz-type interpolation from which we establish a Bernstein-type inequality:

$$|(\mathcal{D}_q P_n)(x)| \le \frac{1}{\sqrt{1-x^2}} \cdot \frac{q^{n/2} - q^{-n/2}}{q^{1/2} - q^{-1/2}} \cdot \max_{\zeta\in[-1,1]} |P_n(\zeta)|,\ x \in (-1,1).$$

As $q \to 1^-$, the above inequality reduces to the classical Bernstein inequality

$$|P_n'(x)| \le \frac{n}{\sqrt{1-x^2}} \cdot \max_{\zeta\in[-1,1]} |P_n(\zeta)|,\ x \in (-1,1),$$

with equality being achieved for $P_n \equiv cT_n$ for some constant c, where $T_n(x) = \cos(n \arccos x)$ is the Chebyshev polynomial of first-kind. Several other related results were also obtained. Our proofs are based on the ideas of G. Szegö and M. Riesz. (Received June 20, 2017)

1133-30-97 **Dmitry Khavinson*** (dkhavins@usf.edu). *Vanishing of reproducing kernels in spaces of analytic functions.*

In most situations we are accustomed to , e.g., Bergman and Hardy spaces in the disk, the reproducing kernels do not vanish. Neither they do if we consider the later spaces with fairly general weights, for example comprised from moduluses of analytic functions. Yet in the "cut-off spaces" formed by polynomials of degree less or equal to n this is not necessarily true. Moreover, almost nothing is known regarding zeros of linear combinations of reproducing kernels at different points, an important question if one tries solving various extremal problems We shall discuss what is known and the numerous compelling open problems that remain. (Received July 14, 2017)

1133-30-119 **G. Brock Williams*** (brock.williams@ttu.edu), Dept of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Construction of Quasiconformal and Discrete Harmonic Functions.*

Circle packings have a 25 year history of providing a means for connecting combinatorial and conformal data. For example, Bowers and Stephenson used the combinatorial information encoded by Brooks's parameterization of quadrilateral interstices to great effect in proving the density of packable surfaces in Teichmüller space.

We will describe the use of these Brooks parameters to study quasiconformal and discrete harmonic mappings. (Received July 18, 2017)

31 ► Potential theory

1133-31-21 **Palle Jorgensen*** (palle-jorgensen@uiowa.edu), Dept Mathematics MLH, University of Iowa, Iowa City, IA. *Spectral theory, transfer operators, and dynamics.*

By "transfer operator" I mean a family of operators which arise in a host of areas of dynamics, ranging from wavelet theory, to measurable dynamics, from fractals to signal analysis, and from Markov operators in discrete as well as continuous settings. The appropriate transfer operators often arise in instances where Hilbert space is not given directly, and in any case, the spectral theory differs from that of more traditional settings, as will be outlined in the talk. (Received May 08, 2017)

1133-31-34 **Deniz Karli*** (deniz.karli@isikun.edu.tr), Isik University, Department of Mathematics, Amf 233, Sile, 34980 Istanbul, Turkey. *Singular Integral Operators by Means of Stable Processes and their Connection to Fractional Derivatives.*

Probability Theory presents tools to study singular integral operators and analitically difficult problems by means of stochastic processes. One such problem is to determine a general class of multipliers and so the bounded operators on function spaces. In this talk we will use a discontinuous process, namely a product of a symmetric stable process and Brownian motion, to show boundedness results of extended versions of classical singular integral operators. We will define Littlewood-Paley operators arising from this process and discuss the corresponding multipliers which are studied in [2]. We will introduce versions of intermediate operators appearing in the Littlewood-Paley Theory and show our recent results in [1]. Finally we will discuss the relation between these new operators and fractional derivative in its integral form.

References

[1] Karli, D. *An Extension of a Boundedness Result for Singular Integral Operators*, Colloquium Mathematicum, **145**, Issue 1, (2016) , 15-33.

[2] Karli, D. *A Multiplier Related to Symmetric Stable Process*, Hacettepe Journal of Mathematics and Statistics, **46**, Issue 2, (2017), 217-228.

(Received June 09, 2017)

1133-31-341 **Johann Brauchart** (j.brauchart@tugraz.at), Institute of Analysis and Number Theory, Graz University of Technology, Kopernikusgasse 24/II, 8010, Graz, Austria, **Peter Dragnev*** (dragnevp@ipfw.edu), Department of Mathematical Sciences, IPFW, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805, **Edward Saff** (edward.b.saff@vanderbilt.edu), Center for Constructive Approximation, Department of Mathematics, Vanderbilt University, Nashville, TN 37240, and **Robert Womersley** (r.womersley@unsw.edu.au), School of Mathematics and Statistics, University of New South Wales, NSW, 2052, Sydney, Australia. *Logarithmic and Riesz Equilibrium for Multiple Sources on the Sphere - the Exceptional Case.*

We consider the minimal discrete and continuous energy problems on the unit sphere $\mathbb{S}^d$ in the Euclidean space $\mathbb{R}^{d+1}$ in the presence of an external field due to finitely many localized charge distributions on $\mathbb{S}^d$, where the energy arises from the Riesz potential $1/r^s$ (r is the Euclidean distance) for the critical Riesz parameter $s = d-2$

if $d \geq 3$ and the logarithmic potential $\log(1/r)$ if $d = 2$. Individually, a localized charge distribution is either a point charge or assumed to be rotationally symmetric. The extremal measure solving the continuous external field problem for weak fields is shown to be the uniform measure on the sphere but restricted to the exterior of spherical caps surrounding the localized charge distributions. The radii are determined by the relative strengths of the generating charges. Furthermore, we show that the minimal energy points solving the related discrete external field problem are confined to this support. For $d - 2 \leq s < d$, we show that for point sources on the sphere, the equilibrium measure has support in the complement of the union of specified spherical caps about the sources. Numerical examples are presented to illustrate our results. (Received August 01, 2017)

34 ► Ordinary differential equations

1133-34-25 **Muhammad N Islam*** (mislam1@udayton.edu), Department of Mathematics, Dayton, OH 45469-2316. *Asymptotic stability of non-unique solutions of differential equations by fixed point theory.* Preliminary report.

We consider an initial value problem of a first order nonlinear differential equation. We assume that this problem can have more than one solution. We study a new type of stability property of these solutions employing fixed point theory. The stability that we studied in this paper is different from the standard Liapunov stability, which is commonly studied by Liapunov's direct method. (Received May 11, 2017)

1133-34-33 **Kuppalapalle Vajravelu*** (kuppalapalle.vajravelu@ucf.edu), Department of Mathematics, University of Central Florida, 4393 Andromeda Loop N, Orlando, FL 32816. *Optimal analytical method for nonlinear differential equations arising in science and engineering.* Preliminary report.

The optimal homotopy analysis method (OHAM) for the solution of a nonlinear differential equation arising in science and engineering will be presented. Also, the method will be used to solve coupled nonlinear differential equations. In order to obtain accurate approximate analytical solutions, multiple auxiliary linear operators will be considered which permit accuracy with relatively few terms. The convergence control parameters will be selected through the construction of an optimal control problem for the minimization of the accumulated residual errors. Furthermore, open questions related to OHAM will be discussed. (Received June 07, 2017)

1133-34-39 **Mangalagama Dewasurendra*** (dewasurendra_m@knights.ucf.edu), Department mathematics, 4000 central florida blvd, orlando, FL 32816, **kuppalapalle Vajravelu** (kuppalapalle.vajravelu@ucf.edu), Department mathematics, 4000 central florida blvd, orlando, FL 32816, and **Matthew Baxter** (mabaxter@fgcu.edu), Department of Mathematics, Fort Myers, FL 33965. *A method of directly defining the inverse mapping for solutions of coupled systems of nonlinear differential equations.* Preliminary report.

The Optimal Homotopy Analysis Method (OHAM) uses the method of perturbation to find analytical solutions to nonlinear differential equations. Recently, Liao introduced a new method for solving a nonlinear differential equation called "Directly Defining inverse Mapping Method (MDDiM)" which is an extension to OHAM. In this talk, we extend his method to study the systems of nonlinear differential equations arising in science and engineering. We optimize square residual errors with respect to pertinent parameters in directly define inverse map and converge control parameter. Errors ranging from 10^{-5} to 10^{-9} are reported with relatively few terms. (Received June 19, 2017)

1133-34-365 **Zhisheng Shuai*** (shuai@ucf.edu), Orlando, FL 32765. *A Graph-Theoretic Approach to Global Lyapunov Functions in Mathematical Biology.* Preliminary report.

The graph-theoretic approach has become a standard method to construct global Lyapunov functions for large-scale differential equation systems. Appropriate graph/network design and reduction is the key in the successful application of the approach. We illustrate these graph/network techniques using various models in the literature. (Received August 01, 2017)

35 ► Partial differential equations

1133-35-36 **Chenchen Mou*** (muchenchen@math.ucla.edu). *Perron's method for nonlocal fully nonlinear equations.*

This talk is concerned with existence of viscosity solutions of non-translation invariant nonlocal fully nonlinear equations. We construct a discontinuous viscosity solution of such nonlocal equation by Perron's method. If the

equation is uniformly elliptic, we prove the discontinuous viscosity solution is Hölder continuous and thus it is a viscosity solution. (Received June 16, 2017)

1133-35-43 **Marius Beceanu*** (mbeceanu@albany.edu), 1400 Washington Ave., ES 110, University at Albany SUNY Math. Dept., Albany, NY 12222, and **Gong Chen** and **Wilhelm Schlag**. *New Strichartz-type estimates for the wave and Klein–Gordon equations.*

I plan to present several new Strichartz-type estimates for the Klein–Gordon and wave equations. These results have been obtained in collaboration with Gong Chen and, separately, Wilhelm Schlag. The title, abstract, and content of this talk are all subject to change. (Received August 01, 2017)

1133-35-48 **Yu Deng*** (yudeng@cims.nyu.edu). *Long-time Strichartz estimates on irrational tori, and applications.*

Rcently, Bourgain-Demeter proved the optimal L^p Strichartz estimate on general tori. It turns out that on generic irrational tori, these estimates can still be improved, in the sense that they are satisfied on long time intervals depending on the frequency. We propose a conjecture on the optimal time length, prove partial results in that direction, and discuss applications to controlling growth of Sobolev norms for NLS. This is joint work with P. Germain and L. Guth. (Received July 02, 2017)

1133-35-50 **Nicola Garofalo**, **Arshak Petrosyan** and **Mariana Smit Vega Garcia*** (marianag@uw.edu). *The singular free boundary in the Signorini problem.*

In this talk I will overview the Signorini problem for a divergence form elliptic operator with Lipschitz coefficients, and I will describe a few methods used to tackle two fundamental questions: what is the optimal regularity of the solution, and what can be said about the singular free boundary in the case of zero thin obstacle. The proofs are based on Weiss and Monneau type monotonicity formulas. This is joint work with Nicola Garofalo and Arshak Petrosyan. (Received July 03, 2017)

1133-35-54 **Kanishka Perera*** (kperera@fit.edu), 150 W University Blvd, Melbourne, FL 32901-6975, and **David Jerison**. *Higher critical points in a free boundary problem.*

We study higher critical points of the variational functional associated with a free boundary problem related to plasma confinement. Existence and regularity of minimizers in elliptic free boundary problems have already been studied extensively. But because the functionals are not smooth, standard variational methods cannot be used directly to prove the existence of higher critical points. Here we find a nontrivial critical point of mountain pass type and prove many of the same estimates known for minimizers, including Lipschitz continuity and nondegeneracy. We then show that the free boundary is smooth in dimension 2 and prove partial regularity in higher dimensions. (Received July 04, 2017)

1133-35-56 **Yiran Wang*** (wangy257@math.washington.edu), University of Washington, Department of Mathematics, BOX 354350, Seattle, WA 98195. *Reducing streaking artifacts in quantitative susceptibility mapping.*

It is well-known that reconstruction algorithms in quantitative susceptibility mapping often contain streaking artifacts. These are non-desirable objects that contaminate the image and the possibility of removing or at least reducing them has a great practical interest. In a work by Seo et al, the cause of the artifacts is identified as propagation of singularities for a wave type operator. In this talk, we analyze such singularities using microlocal techniques and propose some strategies to reduce the artifacts. This is a joint work with B. Palacios and G. Uhlmann. (Received July 06, 2017)

1133-35-84 **Steve Zelditch*** (zelditch@math.northwestern.edu), Evanston, IL 60201, and **John A. Toth**, Montreal, Quebec , Canada. *Geometric control and numbers of nodal points on curves.*

We show that the number of nodal points (zeros) of a sequence S of Laplace eigenfunctions ϕ_j of a real analytic Riemannian manifold (M, g) on a real analytic curve C is bounded above by a constant times the frequency λ_j as long as the curve satisfies a condition we call S-good. Roughly speaking, S-good means that the sequence does not decay too fast when restricted to C. We then give sufficient conditions of a geometric control nature that a hypersurface H be good. When $\dim M = 2$, curves are hypersurfaces and the geometric control condition is sufficient for the upper bound on numbers of nodal points on the curve. Joint work with John Toth. (Received July 12, 2017)

1133-35-85 **John A Toth*** (jtoth@math.mcgill.ca) and **Jeffrey Galkowski**. *Eigenfunction scarring and improvements in L^∞ bounds.*

We study the relationship between L^∞ growth of eigenfunctions and their L^2 concentration as measured by defect measures. In particular, we show that scarring in the sense of concentration of defect measure on certain submanifolds is incompatible with maximal L^∞ growth. In addition, we show that a defect measure which is too diffuse, such as the Liouville measure, is incompatible with maximal eigenfunction growth. (Received July 12, 2017)

1133-35-96 **Connor Mooney*** (connor.mooney@math.ethz.ch). *Finite time blowup for parabolic systems in the plane.*

We will discuss examples of finite time singularity from smooth data for linear and quasilinear uniformly parabolic systems in two dimensions. (Received July 14, 2017)

1133-35-108 **Kazuo Yamazaki*** (kyamazak@ur.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627. *On the Navier-Stokes equations in scaling-invariant spaces in any dimension.*

Whether the solution to the Navier-Stokes equations remains smooth for all time in a three-dimensional space remains a challenging open problem. In 1962 Serrin provided a certain space-time integrability condition for smoothness in a scaling-invariant norms for the weak solution to the Navier-Stokes equations, which is a three-dimensional velocity vector field. We discuss recent developments in the research direction in effort to improve such integrability conditions so that we only have to impose the condition on "only one of the three" velocity vector field components, instead of all of three. The proof crucially relies on a key identity which is a consequence of the divergence-free property, and techniques from anisotropic Littlewood-Paley theory that consists of anisotropic Bernstein's inequality, anisotropic Bony paraproducts and anisotropic Besov and Sobolev spaces. Moreover, except only a very few recent results by the speaker, all such results have been limited to the three-dimensional case; we will also discuss the progress toward extending to dimension such as four and beyond, such as the horizontal Biot-Savard law in higher dimensions. (Received July 16, 2017)

1133-35-121 **Linh V Nguyen*** (lnguyen@uidaho.edu), Department of Mathematics, University of Idaho, 875 Perimeter Dr, Moscow, ID 83843. *Analysis of the Linearized Problem of Quantitative Photoacoustic Tomography.*

Photoacoustic tomography is a coupled physics imaging method. A short pulse of laser light is scanned through the biological object of interest. The photo-elastic expansion induces an acoustic pressure wave propagating throughout the space. Quantitative photoacoustic tomography aim to extract physical parameters of the biological object from the acoustic signals measured on an observation surface. In this talk, we address this problem employing the radiative transfer equation as accurate model for light transport. We discuss several stability and uniqueness results for the linearized inverse problem. (Received July 18, 2017)

1133-35-132 **Rupert L Frank** and **Tianling Jin*** (tianlingjin@ust.hk), Clearwater Bay, Kowloon 000000, Hong Kong, and **Jingang Xiong**. *On the best constants and minimizers for the fractional Sobolev inequality in domains.*

We consider a version of the fractional Sobolev inequality in domains and study whether the best constant in this inequality is attained. For the half-space and a large class of bounded domains we show that a minimizer exists, which is in contrast to the classical Sobolev inequalities in domains. (Received July 19, 2017)

1133-35-138 **Lei Zhang*** (leizhang@ufl.edu), Department of Mathematics, 1400 Stadium Rd, Gainesville, FL 32611. *A priori estimates and degree counting theorems for rank 2 singular Toda systems.*

A Toda system is a second order elliptic system with exponential nonlinear terms defined in two dimensional spaces. It has profound connections with many fields of mathematics and physics and it has sustained extensive investigation for a few decades. In this talk I will report recent discoveries about rank 2 singular Toda systems in my joint works with Lee, Lin, Wei and Yang, using tools in quite a few seemingly little related fields. (Received July 20, 2017)

1133-35-156 **Ugur G. Abdulla***, 150 West University Blvd., Melbourne, FL 32901. *The Wiener Test on the Removability of the Logarithmic Singularity for the Elliptic PDEs with Measurable Coefficients and Its Consequences.*

This paper introduces the notion of *log*-regularity (or *log*-irregularity) of the boundary point ζ (possibly $\zeta = \infty$) of the arbitrary open subset Ω of the Greenian deleted neigborhood of ζ in $\mathbb{R}^2$ concerning second order uniformly

elliptic equations with bounded and measurable coefficients, according as whether the *log*-harmonic measure of ζ is null (or positive). A necessary and sufficient condition for the removability of the logarithmic singularity, that is to say for the existence of a unique solution to the Dirichlet problem in Ω in a class $O(\log|\cdot-\zeta|)$ is established in terms of the Wiener test for the *log*-regularity of ζ. From a topological point of view, the Wiener test at ζ presents the minimal thinness criteria of sets near ζ in minimal fine topology. Precisely, the open set Ω is a deleted neigborhood of ζ in minimal fine topology if and only if ζ is *log*-irregular. From the probabilistic point of view, the Wiener test presents asymptotic law for the *log*-Brownian motion near ζ conditioned on the logarithmic kernel with pole at ζ. (Received July 23, 2017)

1133-35-163 **Rana Parshad*** (rparshad@clarkson.edu), potsdam, NY 13699, **emanuel quansah** (quansaek@outlook.com), springfield, OR 97477, **kelly black** (kjblack@gmail.com), athens, GA , and **matthew beauregard** (beauregama@sfasu.edu), Nacogdoches, TX 75962.
Predator-Prey models, invasive species and biological control.

In this talk I will survey basic predator-prey models, and their formulation leading to three species food chain models where an invasive species is acting as a top predator. There are many such situations in nature, such as the burmese python, which currently functions in the Florida Everglades, as a top predator. I will also talk about the control efforts of such species, and my recent efforts in this direction via the use of differential equation models. In particular, I will introduce the new concept of "ecological damping". (Received July 24, 2017)

1133-35-165 **Ugur G. Abdulla**, **Jian Du** and **Adam L. Prinkey*** (aprinkey2009@my.fit.edu), 150 W. University Blvd., Melbourne, FL 32901. *Evolution of Interfaces for the Nonlinear Double Degenerate Parabolic Equation of Turbulent Filtration with Absorption.*

This paper presents a full classification of the short-time behavior of the interfaces and local solutions to the nonlinear double degenerate reaction-diffusion equation of turbulent filtration with strong absorption

$$u_t = \left(|(u^m)_x|^{p-1}(u^m)_x\right)_x - bu^\beta,\ mp>1,\ \beta>0$$

The interface may expand, shrink or remain stationary, as a result of the competition of the diffusion and reaction terms near the interface, expressed in terms of the parameters $m, p, \beta, \mathrm{sign}b$ and asymptotics of the initial function near its support. In all cases we prove explicit formula for the interface and local solution with accuracy up to constant coefficients. The methods of the proof are based on nonlinear scaling laws, and a barrier technique using special comparison theorems in irregular domains with characteristic boundary curves. Numerical analysis using a weighted essentially nonoscillatory (WENO) scheme is pursued and comparison of numerical and analytical results is presented. (Received July 24, 2017)

1133-35-166 **Mihai H Tohaneanu*** (mihaitohy@gmail.com). *Scattering for the defocusing critical wave equation on Schwarzschild backgrounds.*

We prove global existence, uniqueness and scattering for the defocusing energy-critical wave equation on Schwarzschild spacetimes $\Box_{gS}u = u^5$ with large initial data. The result follows from combining uniform energy bounds and Morawetz-type estimates on backward/forward light cones with Strichartz estimates previously proved by the author and collaborators. (Received July 24, 2017)

1133-35-171 **Chenjie Fan*** (cjfanpku@gmail.com), 70 Pacific Street, Apt 331B, Cambridge, MA 02139. *On focusing mass critical NLS at the regularity of L^2.*

We will explore the dynamic of non-scattering L^2 solution u to the radial mass critical nonlinear Schrödinger equation with mass just above the ground state, and show that there exists a time sequence $\{t_n\}_n$, such that $u(t_n)$ weakly converges to the ground state Q up to scaling and phase transformation. (Received July 24, 2017)

1133-35-182 **Ugur G. Abdulla** (abdulla@fit.edu), 150 W University Blvd, Melbourne, FL 32901, and **Roqia A. Jeli*** (rjeli2011@my.fit.edu), 506 Golden dove AVE NE, Palm Bay, FL 32907. *Evolution of Interfaces for the Nonlinear Parabolic p-Laplacian Type Reaction-Diffusion Equations.*

We present a full classification of the short-time behavior of the interfaces and local solutions to the nonlinear parabolic p-Laplacian type reaction-diffusion equation of non-Newtonian elastic filtration

$$u_t - \left(|u_x|^{p-2}u_x\right)_x + bu^\beta = 0,\ p>1, \beta>0$$

The interface may expand, shrink, or remain stationary as a result of the competition of the diffusion and reaction terms near the interface, expressed in terms of the parameters $p, \beta, sign\ b$, and asymptotic of the initial function near its support. In all cases, we prove the explicit formula for the interface and the local solution with accuracy up to constant coefficients. The methods of the proof are based on nonlinear scaling laws, and a barrier technique using special comparison theorems in irregular domains with characteristic boundary curves.

The results are published in *European Journal of Applied Mathematics, Volume 28, 5(2017).* (Received July 25, 2017)

1133-35-184 **Gigliola Staffilani***, MIT, room 2-251, 77 Massachusetts Avenue, Cambridge, MA 02138.
The old and the new in dispersive and wave equations.

Title: The old and the new in dispersive and wave equations

Abstract: In this talk I will review some recent results for dispersive and wave equations and I will connect them with what we now consider classical theorems. For example I will discuss Strichartz and improved Strichartz estimates for the Schrodinger equation on tori, I will talk about the fact that the Gross Pitaevskii hierarchy has infinitely many conservation laws, and I will show how randomization of initial data is compatible with some null forms that appear in certain geometric wave equation problems. (Received July 25, 2017)

1133-35-186 **Sohrab Mirshams Shahshahani*** (sohrab@math.umass.edu), Amherst, MA 01060.
Geometric wave equations on hyperbolic space.

In this talk I will discuss recent progress on geometric wave equations on the hyperbolic space. To motivate the problem I will begin by describing previous results on the equivariant wave maps on H^2, where, in contrast to the Euclidean problem, there is a 1-parameter family of finite energy harmonic maps, and then explain the various difficulties that arise from considering non-equivariant maps. In the remainder of the talk I will discuss the resolution to some of the new difficulties, including the choice of gauge. (Received July 25, 2017)

1133-35-209 **Hongjie Dong*** (hongjie_dong@brown.edu), 182 George Street, Providence, RI 02912, and **Tianling Jin** and **Hong Zhang**. *Dini type estimates for nonlocal parabolic equations.*

I will present a recent result regarding Dini type estimates for fully nonlinear nonlocal parabolic equations with drift terms, and for linear nonlocal parabolic equations with time-irregular data. No smallness condition on the drift coefficients is imposed when the order of the nonlocal operators is greater or equal to 1. (Received July 26, 2017)

1133-35-223 **Irina Mitrea*** (imitrea@temple.edu), 1805 N Broad Street, Wachman Hall, Department of Mathematics, Temple University, Philadelphia, PA 19122. *Harmonic and Functional Analysis Methods for Elliptic Boundary Value Problems in the Upper Half Space.*

In this talk I will discuss well-posdness results for the Dirichlet problem for second-order, homogeneous, elliptic systems, with constant complex coefficients, in the upper half space, with boundary data from Lebesgue spaces, variable exponent Lebesgue spaces, Lorentz spaces, Zygmund spaces, as well as their weighted versions. A key tool in this analysis is establishing boundedness of the Hardy-Littlewood maximal operator on appropriate Kothe function spaces. This is joint work with Dorina Mitrea, Marius Mitrea, and Jose Maria Martell. (Received July 26, 2017)

1133-35-224 **Benjamin Dodson**, **Jonas Luhrmann*** (luehrmann@math.jhu.edu) and **Dana Mendelson**. *Probabilistic scattering for the 4D energy-critical defocusing nonlinear wave equation.*

We consider the Cauchy problem for the energy-critical defocusing nonlinear wave equation in four space dimensions. It is known that for initial data at energy regularity, the solutions exist globally in time and scatter to free waves. However, the problem is ill-posed for initial data at super-critical regularity, i.e. for regularities below the energy regularity. In this talk we study the super-critical data regime for this Cauchy problem from a probabilistic point of view, using a randomization procedure that is based on a unit-scale decomposition of frequency space. We will present an almost sure global existence and scattering result for randomized radially symmetric initial data of super-critical regularity. The main novelties of our proof are the introduction of an approximate Morawetz estimate to the random data setting and new large deviation estimates for the free wave evolution of randomized radially symmetric data.

This is joint work with Ben Dodson and Dana Mendelson. (Received July 26, 2017)

1133-35-236 **Ugur Abdulla**, **Evan Cosgrove** and **Curtis Earl*** (cearl2013@my.fit.edu), 150 W. University Blvd, Melbourne, FL 32901, and **Jonathan Goldfarb**. *On the Optimal Control of the Stefan Type Parabolic Free Boundary Problems with State Constraints.*

We consider the inverse Stefan type free boundary problem for the general second order parabolic PDE under state constraints in the form of the upper bound for the temperature. This problem arises in bioengineering problem about the laser ablation of the skin. We implement optimal control framework following a variational formulation developed in *U. G. Abdulla, Inverse Problems and Imaging, 7,(2013),307-340 & 10(2016),869-898*, with penalty functional added due to state constraint. We pursue space-time discretization and prove the

convergence of the sequence of discrete optimal control problems to the continuous optimal control both with respect to functional and control. We prove the Frechet differentiability in Besov spaces and derive the formula for the Frechet differential under minimal assumptions on the data. (Received July 27, 2017)

1133-35-238 **Ugur G. Abdulla** and **Lamees Alzaki*** (lalzaki2013@my.fit.edu). *Analysis of Interfaces for the Nonlinear Degenerate Second Order Parabolic Equations Modeling Diffusion-Convection Processes.*

We consider Cauchy problem with compactly supported initial function for the nonlinear degenerate second order parabolic PDE

$$u_t = (u^m)_{xx} + b(u^\gamma)_x,\ m > 1, \gamma > 0, b \in \mathbb{R}$$

modeling diffusion-convection processes arising in fluid or gas flow in a porous media, plasma physics, population dynamics in mathematical biology and other applications. Due to the property of the finite speed of propagation the problem develops interfaces or free boundaries separating the region where solution is positive from the region where it vanishes. We present full classification of the short-time behaviour of the interfaces and local solutions near the interfaces. The interface may expand, shrink, or remain stationary as a result of the competition of the diffusion and convection forces near the interface, expressed in terms of the parameters $m, \gamma, sign\ b$, asymptotics of the initial function near its support, and whether interface is the right or left boundary curve. In all cases, we prove the explicit formula for the interface and the local solution with accuracy up to constant coefficients. The methods of the proof are based on nonlinear scaling laws, and a barrier technique using special comparison theorems in irregular domains with characteristic boundary curves. (Received July 27, 2017)

1133-35-239 **Ugur G. Abdulla** and **Habeeb Aal Rkhais*** (haalrkhais2014@my.fit.edu). *On the Qualitative Theory of the Nonlinear Degenerate Parabolic Equations of the Reaction-Diffusion-Convection Type.*

We apply the methods developed in papers *U.G. Abdulla, J. Diff. Eq., 164, 2000, 321-354; U.G. Abdulla & J.King, SIAM J. Math. Anal., 32, 2(2000), 235-260,* to solve the problem on the initial development and asymptotics of the interfaces and local solutions near the interfaces for the reaction-diffusion-convection equation

$$u_t - (u^m)_{xx} + a(u^\gamma)_x + bu^\beta,\ m > 1, \gamma, \beta > 0, a, b \in \mathbb{R}$$

with compactly supported initial function. Depending on the relative strength of three competing forces such as diffusion, convection, and reaction, the interface may expand, shrink or remain stationary. We pursue full classification of the asymptotics of the interfaces and local solutions in terms of parameters $m, \gamma, \beta, sign\ a, sign\ b$. The methods used are rescaling and blow-up techniques for the identification of the asymptotics of the solution along the class of interface type curves, construction of the barriers and application of the comparison theorem in non-cylindrical domains with characteristic boundary curves. (Received July 27, 2017)

1133-35-243 **Robert Pertsch Gilbert*** (gilbert@udel.edu), Robert Pertsch Gilbert, 112 Briar Lane, Newark, DE 19711, and **Michael Shoushani** (mashous86@gmail.com), Department of Mathematics, University of Western Connecticut, Danbury, CT 06810. *Effective Equations for Poro-elastc Materials.*

We extend known homogenization results for periodic geometries to the case a stationary random, scale-separated microstructure consisting of of linear elastic solid and a viscous Newtonian fluid.. The ratio ε of the macroscopic length scale and a typical size of the microstructural inhomogeneity is the small parameter of the problem. We employ stochastic two-scale convergence in the mean to pass to the limit $\varepsilon \to 0$ in the governing equations. We assume that an elastic medium is randomly fissured with the associated random field being statistically homogeneous, with built-in scale separation. The effective equations are derived using the stochastic two-scale convergence in the mean. We consider also the existence theorem for the effective equations in the time-harmonic domain by using the Gårding inequality. In order to have the requisite formulae we extend the discussion of Carcione to the completely anisotropic case. (Received July 27, 2017)

1133-35-253 **Matthew D Blair*** (blair@math.unm.edu). *Logarithmic improvements in L^p bounds for eigenfunctions at the critical exponent in the presence of nonpositive curvature.*

We consider the problem of determining upper bounds on the growth of L^p norms of eigenfunctions of the Laplacian on a compact Riemannian manifold in the high frequency limit. In particular, we examine the problem of identifying geometric or dynamical conditions on the manifold which yield improvements on the universal L^p bounds of C. Sogge. The emphasis here will be on bounds at the so-called "critical exponent" where one must rule out a spectrum of scenarios for phase space concentration in order to obtain an improvement. We then discuss a recent work with C. Sogge which shows that when the sectional curvatures are nonpositive, then there is a logarithmic type gain in the known L^p bounds at the critical exponent. (Received July 27, 2017)

1133-35-271 **Boris Hanin*** (bhanin@math.tamu.edu) and **Thomas Beck**. *Eigenvalue Spacings and Nodal Sets at Infinity for Radial Perturbations of the Harmonic Oscillator.*

We study properties of the nodal sets of high frequency eigenfunctions and quasimodes for radial perturbations of the Harmonic Oscillator. In particular, we consider nodal sets on spheres of large radius (in the classically forbidden region) for quasimodes with energies lying in intervals around a fixed energy E. For well chosen intervals we show that these nodal sets exhibit quantitatively different behavior compared to those of the unperturbed Harmonic Oscillator. These energy intervals are defined via a careful analysis of the eigenvalue spacings for the per- turbed operator, based on analytic perturbation theory and linearization formulas for Laguerre polynomials. (Received July 28, 2017)

1133-35-275 **Casey Jao*** (cjao@math.berkeley.edu). *Refined Strichartz estimates for the mass-critical quantum harmonic oscillator.*

Sharpened forms of the Strichartz inequality play a pivotal role in the analysis of large data nonlinear Schrödinger equations (and dispersive equations in general) at critical regularity. Such results begin to characterize the linear Schrodinger waves that come close to saturating the standard Strichartz estimate, and the harmonic analysis is especially subtle at L^2 regularity due to an enormous group of noncompact symmetries. Indeed, the recent breakthroughs for the mass-critical NLS ultimately exploit Fourier restriction theory for the paraboloid to construct profile decompositions.

I will discuss generalizations of these refined L^2-critical estimates to some nontranslation-invariant Schrödinger operators, in particular the harmonic oscillator, to which purely Fourier-analytic methods are ill-adapted. (Received July 28, 2017)

1133-35-281 **Abdullah Said Erdogan*** (aserdogan@gmail.com). *Regularization methods for source identification problems in the heat equation.*

In this paper, inverse problems with a space dependent heat source in the one-dimensional heat equation is considered. A simplified Tikhonov regularization method and Lavrentiev regularization method are applied. (Received July 29, 2017)

1133-35-282 **Roberto Triggiani*** (rtrggani@memphis.edu), 160 Ascot Park Common Drive, Memphis, TN 38120. *Fluid-viscoelastic plate interactions: analyticity, spectral analysis, uniform stability.* Preliminary report.

We consider a heat-viscoelastic plate interactions with coupling at the interface between the two media on high boundary conditions of the plate. We show that the resulting coupled system generates a s.c.semigroup of contractions in the natural state space, which moreover is analytic. Furthermore it is uniformly stable. A spectral analysis description is also given (Received July 29, 2017)

1133-35-283 **Irena M Lasiecka*** (lasiecka@memphis.edu), Department of Mathematical Sciences, University of Memphis, Mamphis, TN. *Analysis of a third order in time abstract dynamics arising in the modeling High Frequency Ultrasound (HIFU).*

We consider a third order in time abstract dynamics arising in modeling of High Frequency Ultrasound. Of particular interest is MGT (Moore-Gibson-Thompson) equation which model accounts for a finite speed of propagation of acoustic waves. This phenomenon results from the application of Catteneo Law rather than the Fourrier 's Law in describing heat conduction. The resulting model is a third order in time equation with a heat relaxation parameter . In addition to the heat flux relaxation, molecular relaxation is also accounted for. The latter results in adding memory term with a dynamic relaxation kernel . Questions related to well-posedness and stability of the resulting third order dynamics with a memory are discussed. Sharp stability results will be presented.

In particular, it will be shown that the dynamics can be uniformly stabilized through molecular relaxation only and without any mechanical dissipation. Quantitative description of stability is provided by optimal decay rates for the energy which reflect the rates of decay of molecular relaxation. These results are obtained in collaboration with Philipo Del'Oro, Vittorino Pata and Xiaojun Wang. (Received July 29, 2017)

1133-35-287 **Tariel Kiguradze** (tkigurad@fit.edu) and **Noha Al-Jaber*** (naljaber2013@my.fit.edu), Florida Institute of Technology, 150 W. University Blvd, Melbourne, FL 32901. *Unique Solvability of Ill-posed Periodic Problem for a Higher Order Linear Hyperbolic Equation.*

Abstract. Consider the periodic problem

$$u^{(\mathbf{m})} = p(\mathbf{x})u + q(\mathbf{x}), \qquad (1)$$

$$u(\mathbf{x}+\mathbf{T}_i)=u(\mathbf{x}) \quad (i=1,\dots,n), \quad (2)$$

where $n\geq 2, \mathbf{x}=(x_1,\dots,x_n), \mathbf{T}=(T_1,\dots,T_n), \mathbf{T}_i=(0,\dots,T_i,\dots,0), \mathbf{m}=(m_1,\dots,m_n), \|\mathbf{m}\|=m_1+\ldots+m_n$. If $\mathbf{l}=(l_1,\dots,l_n)\in\mathbb{Z}_+^n$, then by $C_{\mathbf{T}}^{\mathbf{l}}(\mathbb{R}^n)$ denote the space of continuous functions $u:\mathbb{R}^n\to\mathbb{R}$ satisfying (2) and having continuous partial derivatives $u^{(\mathbf{k})}$, $(\mathbf{k}\leq\mathbf{l})$.

Theorem. *Let* $\mathbf{m}=2\mathbf{m}^*$,

$$(-1)^{\|\mathbf{m}^*\|}p(\mathbf{x})\leq 0,$$

$$(-1)^{\|\mathbf{m}^*\|}\int_0^{T_j}p(x_1,\dots,s_j,\dots,x_n)ds_j<0 \quad (j=1,\dots,n),$$

and let $p,q\in C_{\mathbf{T}}^{\mathbf{l}}(\mathbb{R}^n)$. *Then problem* (1), (2) *has a unique* (*weak, if* $\mathbf{l}\prec\mathbf{m}$) *solution* $u\in C_{\mathbf{T}}^{\mathbf{l}}(\mathbb{R}^n)$. (Received July 31, 2017)

1133-35-289 **Ugur G Abdulla** and **Amna Ali.S Abu weden*** (aabuweden2014@my.fit.edu). *Some Free Boundary Problems for the Nonlinear Degenerate Multidimensional Parabolic Equations Modeling Reaction-Diffusion Processes.*

This paper presents a full classification of the short-time behavior of the interface in the Cauchy problem for the nonlinear second order degenerate parabolic PDE

$$u_t-\Delta u^m+bu^\beta=0,\ x\in\mathbb{R}, t>0$$

with nonnegative and radially symmetric initial function u_0 such that

$$supp\ u_0\subset\{|x|<R\},\ u_0\sim C(R-|x|)^\alpha, \quad as\ |x|\to R-0,$$

where $m>1, C, \alpha, \beta>0, b\in\mathbb{R}$. Interface surface $t=\eta(x)$ may shrink, expand or remain stationary depending on the relative strength of the diffusion and reaction terms near the boundary of support, expressed in terms of the parameters $m, \beta, \alpha, sign\ b$ and C. In all cases we prove explicit formula for the interface asymptotics, and local solution near the interface. (Received July 30, 2017)

1133-35-293 **Stanley Snelson***, Department of Mathematical Sciences, Florida Institute of Technology, 150 W. University Blvd, Melbourne, FL 32901. *Asymptotic stability in the variable-speed* ϕ^4 *model: odd perturbations.*

We consider the ϕ^4 model in one space dimension with propagation speeds that are small deviations from a constant function. In the constant-speed case, a stationary solution called the kink is known explicitly, and the recent work of Kowalczyk, Martel, and Muñoz established the asymptotic stability of the kink with respect to odd perturbations in the energy space. We show that a stationary kink solution exists also in the case of non-constant propagation speeds, and extend the asymptotic stability result to our setting. This requires an understanding of the spectrum of the linearization around the variable-speed kink. (Received July 30, 2017)

1133-35-294 **Christopher Henderson** (henderson@math.uchicago.edu) and **Stanley Snelson***, Department of Mathematical Sciences, Florida Institute of Technology, 150 W. University Blvd, Melbourne, FL 32901. C^∞ *smoothing for weak solutions of the inhomogeneous Landau equation.*

We consider the spatially inhomogeneous Landau equation with initial data that is bounded by a Gaussian in the velocity variable. In the case of moderately soft potentials, we show that weak solutions immediately become smooth, and remain smooth as long as the mass, energy, and entropy densities remain under control. For very soft potentials, we obtain the same conclusion with the additional assumption that a sufficiently high moment of the solution in the velocity variable remains bounded. Our proof relies on the iteration of local Schauder-type estimates. Joint work with Christopher Henderson. (Received July 30, 2017)

1133-35-308 **Zakaria El Allali*** (elallali@hotmail.com), El Allali Zakaria, Atlanta, GA 30332-0365, **Said Taarabti** (taarabti@gmail.com), Said Taarabti, Nador, Nador, Morocco, and **Khalil Ben Haddouch** (ayasch1@hotmail.com), Khalil Bemhaddouch, Nador, Nador, Morocco. *Eigenvalue problems for* $p(x)-$ *Kirchhoff-type equations with Neumann boundary conditions.*

This paper is concerned with the existence of nontrivial weak solutions for a $p(x)-$ Kirchhoff-type problem of the following form

$$\begin{cases} -M\left(\int_\Omega \frac{1}{p(x)}|\Delta u|^{p(x)}dx\right)\Delta_{p(x)}^2 u=\lambda V(x)|u|^{q(x)-2}u & \text{in } \Omega,\\ \frac{\partial u}{\partial\nu}=\frac{\partial}{\partial\nu}(|\Delta u|^{p(x)-2}\Delta u)=0 & \text{on } \partial\Omega. \end{cases} \quad (1)$$

By using the Mountain Pass Theorem of Ambrosetti and Rabinowitz, Ekeland's Variational principle and the theory of the variable exponent Sobolev spaces, we show the existence of the weak solutions. (Received July 31, 2017)

1133-35-309 **Kamran Sadiq*** (kamran.sadiq@ricam.oeaw.ac.at), Altenbergerstrasse 69, 4040 Linz, Austria. *Quantitative Photoacoustic Imaging in the Acoustic Regime.*

While in standard photoacoustic imaging the propagation of sound waves is modeled by the standard wave equation, our approach is based on a generalized wave equation with variable sound speed and material density, respectively. We present an approach for photoacoustic imaging, which in addition to recovering of the absorption density parameter, the imaging parameter of standard photoacoustics, also allows to reconstruct the spatially varying sound speed and density, respectively, of the medium. We provide analytical reconstruction formulas for all three parameters based in a linearized model based on single plane illumination microscopy (SPIM) techniques. (Received July 31, 2017)

1133-35-311 **Cristian Gavrus*** (cristian@berkeley.edu), Berkeley, CA 94704. *Global well-posedness for the energy critical Massive Maxwell-Klein-Gordon equation with small data.*

We discuss the global well-posedness and modified scattering for the massive Maxwell-Klein-Gordon equation in the Coulomb gauge on R^{1+d} ($d \geq 4$) for data with small critical Sobolev norm. This extends to positive mass $m^2 > 0$ the results of Krieger-Sterbenz-Tataru ($d = 4, 5$) and Rodnianski-Tao ($d \geq 6$), who considered the case $m = 0$. (Received July 31, 2017)

1133-35-325 **Boyan Sirakov*** (bsirakov@mat.puc-rio.br). *Optimal boundary half-Harnack estimates and a priori bounds for elliptic differential inequalities.*

We prove optimal boundary versions of some basic estimates from the regularity theory of uniformly elliptic PDE, such as growth lemmas and half-Harnack inequalities, and show how such estimates can be used to obtain new and optimal a priori bounds for positive sub- and super-solutions of a class of elliptic equations, both in divergence and in non-divergence form, involving a superlinear nonlinearity. One application is the multiplicity of solutions of the Dirichlet problem for a general class of elliptic operators with natural growth in the gradient, that is, in which the first and the second order terms have the same scaling with respect to dilations. (Received July 31, 2017)

1133-35-340 **Chi Hin Chan** and **Magdalena Czubak*** (magda.czubak@colorado.edu), University of Colorado Boulder, Department of Mathematics, Campus Box 395, Boulder, CO 80309. *The antithesis to the Stokes paradox on the hyperbolic plane.*

Stokes proposed the Stokes equation as a model for the fluid flow in the low Reynolds' regime. However, when there is a long cylinder moving slowly in the direction perpendicular to the axis of the cylinder, there is no nontrivial solution. This lack of the nontrivial solution is called the Stokes paradox. We show there is no Stokes paradox in the hyperbolic plane. Moreover, we construct a nontrivial solution to the steady Navier-Stokes in the exterior domain on the hyperbolic plane. Existence of such a solution in the Euclidean setting is open. (Received August 01, 2017)

1133-35-346 **Yaiza Canzani***, 305 Phillips Hall CB #3250, Chapel Hill, NC 27599, and **Jeffrey Galkowski** and **John Toth**. *Averages of Laplace eigenfunctions over curves.*

In this talk we will discuss conditions on a sequence of Laplace eigenfunctions so that their averages over a given closed curve go to zero as their eigenvalues grow to infinity. We will also discuss the averages of the normal derivatives of the eigenfunctions along the curve. Everything will be done on smooth compact manifolds without boundary. The conditions needed to address these problems are on the defect measure associated to the sequence of eigenfunctions and on how this defect measure behaves near the given curve. (Received August 01, 2017)

1133-35-353 **Maria Alessandra Ragusa*** (maragusa@dmi.unict.it), Department of Mathematics and Informatics, University of Catania, Cittadella universitaria, Viale A. Doria No.6, 95125 Catania, Italy. *New regularity properties of minimizers of some variational integrals*

We present some problems studied in cooperation with Professor Atsushi Tachikawa. We treat regularity results for minimizers

$$u(x) : \Omega \subset R^m \to R^n$$

of quadratic and non quadratic growth functional

$$\int_\Omega A(x, u, Du)dx.$$

About the dependence on the variable x, it is assumed only that $A(\cdot, u, p)$ is in the vanishing mean oscillation class, as a function of x. Namely, the continuity of $A(x, u, p)$ with respect to x is not assumed. This is a placeholder abstract. To be changed in a couple of days (Received August 01, 2017)

1133-35-377 **Yuanwei Qi*** (yuanwei.qi@ucf.edu), Orlando, FL 32765, and **Xinfu Chen** and **Guirong Liu**. *Minimum Speed of Traveling Waves to Non-monotone Systems*

In this talk, I shall present some new results which shows that traveling wave solutions to a class of systems of reaction-diffusion equations have a minimum speed. This settles a long outstanding open question.
(Received August 02, 2017)

37 ► Dynamical systems and ergodic theory

1133-37-66 **Yunping Jiang*** (yunping.jiang@qc.cuny.edu), Department of Mathematics, Queens College of CUNY, 65-30 Kissena Blvd, Flushing, NY 11358. *Higher Order Oscillating Sequences, Affine Distal Flows on the d-Torus, and Sarnak's Conjecture.* Preliminary report.

In this paper, we give two precise definitions of a higher order oscillating sequence and show the importance of this concept in the study of Sarnak's conjecture. We prove that any higher order oscillating sequence of order d is linearly disjoint from all affine distal flows on the d-torus for all $d \geq 2$. One consequence of this result is that any higher order oscillating sequence of order 2 is linearly disjoint from all affine flows on the 2-torus with zero topological entropy. In particular, this confirms Sarnak's conjecture for all affine flows on the 2-torus with zero topological entropy and for all affine distal flows on the d-torus for all $d \geq 2$. (Received July 09, 2017)

1133-37-67 **Daniel Ingebretson***, UIC Dept. of Math, Stat, and Comp. Sci., 322 Science and Engineering Offices (M/C 249), 851 S Morgan St., Chicago, IL 60607. *Hausdorff dimension of Kuperberg minimal sets.*

Seifert's conjecture was answered negatively in 1994 by Kuperberg who constructed a smooth aperiodic flow on a three-manifold. This construction was later found to contain a nontrivial minimal set with a complicated topology. The minimal set is embedded as a surface lamination with a Cantor transversal of Lebesgue measure zero. In this talk we will discuss the pseudogroup dynamics on the transversal, the induced symbolic dynamics, and the Hausdorff dimension of the Cantor set. (Received July 10, 2017)

1133-37-68 **Scott Kaschner*** (skaschne@butler.edu), Butler University, Jordan Hall, Room 270, 4600 Sunset Ave., Indianapolis, IN 46208, and **Roland Roeder**, 402 N Blackford Rd. LD270, Indianapolis, IN 46202. *Dynamical degrees and the projective heat map.*

In a recent monograph, Schwartz provided a nearly complete description of the dynamics of the projective heat map H, a rational map of two dimensional Euclidean space that maps any pentagon P to the pentagon whose vertices are the projective midpoints of the edges of P. We place Schwartz's work on the real dynamics of H into the complex perspective by computing its first dynamical degree and presenting some corollaries about the dynamics of H. (Received July 10, 2017)

1133-37-76 **Christian P Wolf*** (cwolf@ccny.cuny.edu). *On the computability of rotation sets and their entropies.*

Given a continuous dynamical system $f : X \to X$ on a compact metric space X and an m-dimensional continuous potential $\Phi : X \to R^m$, the (generalized) rotation set $R(\Phi)$ is defined as the set of all μ-integrals of Φ, where μ runs over all invariant probability measures. Analogous to the classical topological entropy, one can associate the localized entropy $H(w)$ to each $w \in R(\Phi)$. In this talk, we study the computability of rotation sets and localized entropy functions by deriving conditions that imply their computability. We then apply our results to study to the case of subshifts of finite type. We prove that $R(\Phi)$ is computable and that $H(w)$ is computable in the interior of the rotation set. Finally, we construct an explicit example that shows that, in general, H is not continuous on the boundary of the rotation set, when considered as a function of Φ and w. This suggests that, in general, H is not computable at the boundary of rotation sets. This is joint work with Michael Burr and Martin Schmoll. (Received July 11, 2017)

1133-37-94 **Alexander J Mitchell*** (almitch1@wsc.edu), 1111 Main St., Wayne State College, Carhart Science Building, Wayne, NE 68787. *Existence of the Mandelbrot set in the Parameter Planes of Certain Rational Functions.*

In this paper we study rational functions of the form $R_{n,a,c}(z) = z^n + \dfrac{a}{z^n} + c$ and situations where certain parameters are fixed while others vary. We show that for certain cases, the parameter plane contains homeomorphic copies of the Mandelbrot set.

We use techniques first introduced by Douady and Hubbard that were then refined by Robert Devaney. These techniques involve polynomial-like maps of degree two. (Received July 14, 2017)

1133-37-116 **Eduardo Dueñez*** (eduenez@spelman.edu), Mathematics Department, Spelman College, Atlanta, GA 30314, and **José Iovino** (jose.iovino@utsa.edu), Mathematics Department, The University of Texas at San Antonio, San Antonio, TX 78249. *Mean convergence of polynomial ergodic averages and continuous logic.* Preliminary report.

We provide a "soft" proof of the mean convergence of averages under a polynomial abelian group action on a Hilbert space (a special case of current results due to Tao, Host-Kra and Walsh). We use the formalism of continuous logic via Henson structures, and introduce a suitable class of structures consisting of a Hilbert space $\mathcal{H}$ endowed with a polynomial action of an (abelian) group G by unitary automorphisms of $\mathcal{H}$. For fixed G (plus a notion of "averaging over G" as given by a fixed Følner net $\{G_j\}$ therein) we show, roughly speaking, that the class of all structures $(\mathcal{H}, G, \{G_j\}, f)$ such that $f : G \to \mathrm{U}(\mathcal{H})$ is a Leibman polynomial of degree at most d is axiomatizable in a suitable Henson language. As a by-product of the compactness of the Henson logic, the theorem is refined *gratis* to a statement about uniformly metastable convergence (in Tao's sense). Our approach owes much to Tao's outline of a nonstandard analysis proof of Walsh's Theorem. (Received July 18, 2017)

1133-37-123 **Chris Bose*** (cbose@uvic.ca), Department of Mathematics and Statistics, University of Victoria, PO Box 1700 STN CSC, Victoria, BC V8W2Y2, Canada, and **Wael Bahsoun** and **Marks Ruziboev**. *Random Young towers and quenched decay of correlation for slowly mixing systems.* Preliminary report.

Statistical properties for random dynamical systems come in two categories: annealed, where the statistics are averaged over the randomizing states or quenched, where the property holds for (almost every) realization of the random system. We will briefly compare these two classifications, and then derived quenched correlation estimates for random application of intermittent maps via construction of a family of random Young towers. (Received July 19, 2017)

1133-37-157 **Muhammad U. Abdulla***, 150 West University Blvd., Melbourne, FL 32901, **Ugur G. Abdulla**, 150 West University Blvd., Melbourne, FL 32901, **Naveed H. Iqbal**, 150 West University Blvd., Melbourne, FL 32901, and **Jake Barrett**, 150 West University Blvd., Melbourne, FL 32901. *Minimal Orbits, Sharkovski Ordering and Universality in Chaos.*

We prove the outstanding conjecture on the number of third minimal odd periodic orbits of continuous endomorphisms on the real line. In a recent paper *Abdulla et al., International Journal of Bifurcation and Chaos,* **27***, 5, 2017* it is proved that there are $4k-3$ types of second minimal $2k+1$-orbits, $k \geq 3$, each characterized with unique cyclic permutations and directed graphs of transitions with accuracy up to inverses. In this paper, we prove that there are $8k^2+32k-110$ types of third minimal $2k+1$ periodic orbits, $k \geq 4$, each characterized with unique cyclic permutations and digraphs with accuracy up to inverses. The primary application of this result is to the problem of identifying and classifying the distribution of superstable periodic windows within the chaotic regime of bifurcation diagrams of the one-parameter family of unimodal maps. It was revealed in the referred featured article that by fixing the maximum number of appearances of periodic windows, a universal pattern of distribution arises. In particular, the second (or third) appearance of all orbits in the bifurcation diagrams were always a second (or third) minimal orbit, with both a Type 1 cyclic permutation (and respective digraph), and a unimodal topological structure. (Received July 23, 2017)

1133-37-215 **Mrinal K Roychowdhury*** (mrinal.roychowdhury@utrgv.edu), 1201 West University Drive, Edinburg, TX 78539. *An overview of the quantization for mixed distributions.*

The basic goal of quantization for probability distribution is to reduce the number of values, which is typically uncountable, describing a probability distribution to some finite set and thus approximation of a continuous probability distribution by a discrete distribution. Mixed distributions are an exciting new area for optimal quantization. Recently, in the paper "An overview of the quantization for mixed distributions", available in arXiv, I have determined the optimal sets of n-means, the nth quantization error, and the quantization dimensions of different mixed distributions. Besides, I have discussed whether the quantization coefficients for the mixed distributions exist. The results in this paper will give a motivation and insight into more general problems in quantization of mixed distributions. I will talk about it. (Received July 26, 2017)

1133-37-218 **Daniel A Cristofaro-Gardiner*** (dcristof@ucsc.edu), **Michael Hutchings** and **Daniel Pomerleano**. *Two or infinity.*

I will present recent joint work showing that for any nondegenerate contact form on a closed three-manifold, the associated Reeb vector field has either two or infinitely many distinct embedded closed orbits as long as the associated contact structure has torsion Chern class. A key ingredient in the proof is an identity relating the lengths of certain sets of Reeb orbits to the volume of the three-manifold. (Received July 26, 2017)

1133-37-241 **C. Carroll*** (c-carroll@tamuk.edu). *Hyperbolic automorphisms of the 2-torus with a common topological entropy.*

This talk concerns the nature and number of conjugacy classes determined by hyperbolic automorphisms of the 2-torus with a given topological entropy $\log|\lambda|$. We rely on a natural identification between canonical conjugacy representatives and selected ordered factorizations of integer values of the minimal polynomial of λ, as well as standard results from number theory. (Received July 27, 2017)

1133-37-266 **Joel W. Fish*** (joel.fish@umb.edu), 20 Crosby Road, Newton, MA 02467, and **Helmut Hofer**. *Feral pseudoholomorphic curves and minimal subsets.* Preliminary report.

I will discuss some current joint work with Helmut Hofer, in which we define and establish properties of a new class of pseudoholomorhic curves (feral J-curves) to study certain divergence free flows in dimension three. In particular, we show that if H is a smooth, proper, Hamiltonian in $\mathbb{R}^4$, then no energy level of H is minimal. That is, the flow of the associated Hamiltonian vector field has a trajectory which is not dense. (Received July 28, 2017)

1133-37-273 **Doğan Çömez*** (dogan.comez@ndsu.edu), Minard Hall 408 E24, Fargo, ND 58108, and **Mrinal K Roychowdhury** (mrinal.roychowdhury@utgrv.edu), 1201 West University Dr., Edinburg, TX 78539. *Quantization for the condensation system associated with inhomogeneous self-similar measures.*

A condensation system is a triple $(\{S_i\}_{i=1}^n, \overrightarrow{p}, \nu)$, where each $S_i : \mathbb{R}^d \to \mathbb{R}^d$ is a contraction, $\overrightarrow{p} = (p_1, \ldots, p_n)$ is a probability vector, and ν is a probability measure on $\mathbb{R}^d$ with compact support. Let P be an inhomogeneous self-similar measure associated with this system. Such a measure is of the form

$$P = \sum_{i=1}^{n} p_i P \circ S_i^{-1} + \nu,$$

and has a unique compact support. Various properties of these measures, such as L_p-spectra and Renyi dimensions, have been studied recently. In this talk will focus on the optimal sets of n-means and n-th quantization error for a measure of this type. Furthermore, we will show that the quantization dimension of the measure P exists and is equal to the quantization dimension $D(\nu)$ of the measure ν. It turns out that the $D(\nu)$-dimensional quantization coefficient for P does not exist. (Received July 28, 2017)

1133-37-320 **James Keesling*** (kees@ufl.edu), Department of Mathematics, University of Florida, P.O. Box 118105, Gainesville, FL 32611-8105, and **Burton H. Singer** and **Celeste Vallejo**. *A Method of Modeling Stochastic Systems Using Little's Law.* Preliminary report.

In this presentation Little's Law is used to analyze a stochastic system. Suppose that α is the arrival rate of individuals to a facility. Suppose that the average waiting time at the facility is W and the overage number in the facility is $\overline{n}$. Then Little's Law states the following.

$$\alpha \cdot W = \overline{n}$$

This is the limit version of Little's Law over infinite time and assumes that the limits exist and are finite. The proof is purely combinatorial. There is also a finite time version which is an identity.

The proposed method applies Little's Law at each of the nodes of the system. The proposed method allows one to minimize assumptions about the system and base conclusions as much as possible on gathered data. We give several applications of this method in analyzing specific biological systems. (Received July 31, 2017)

39 ► Difference and functional equations

1133-39-10 **Turhan Koprubasi*** (tkoprubasi@kastamonu.edu.tr), Kastamonu Universitesi Fen Edebiyat Fakultesi, Matematik Bolumu Kuzeykent, 37150 Kastamonu, Kastamonu, Turkey, and **Ram N. Mohapatra** (ram.mohapatra@ucf.edu), Mathematics Department, University of Central Florida, Orlando, FL 32816. *Spectral properties of discrete Sturm-Liouville equation with generalized eigenparameter in boundary condition.*

Let the boundary value problem,

$$a_{n-1}y_{n-1} + b_n y_n + a_n y_{n+1} = \lambda y_n,$$
$$\sum_{k=0}^{p} \left(y_1\gamma_k + y_0\beta_k\right)\lambda^k = 0$$

is considered where $\{a_n\}_{n\in\mathbb{N}}$ and $\{b_n\}_{n\in\mathbb{N}}$ are complex sequences, γ_i, $\beta_i \in \mathbb{C}$ for $i = 0, 1, 2, ..., p$ and λ is a spectral parameter. In this study, several spectral properties of the above boundary value problem as Jost solution, Jost function, eigenvalues and spectral singularities are mentioned for the condition

$$\sum_{n=1}^{\infty} n\left(|1-a_n| + |b_n|\right) < \infty.$$

(Received April 05, 2017)

1133-39-372 **H. Michael Allison*** (hallison2007@my.fit.edu). *Lyapunov-Razumikhin Stability Analysis of Partial Element Equivalent Circuit NFDE's.* Preliminary report.

The stability of Neutral Functional Differential Equations (NFDE's) arising in the Partial Element Equivalent Circuit (PEEC) Model with time delay are examined using a number of Lyapunov-Razumikhin functions. (Received August 01, 2017)

40 ► Sequences, series, summability

1133-40-12 **EKREM SAVAS*** (ekremsavas@yahoo.com), Istanbul Commerce University, 34445 Istanbul, Turkey. *Double Lacunary Statistical Convergence of order α in Topological Groups Via Ideal.*

In this paper, we intend to introduce the concept of $\mathcal{I}$-double statistical convergence and $\mathcal{I}$-double lacunary statistical convergence of order α in topological groups .

By X, we will denote an abelian topological Hausdorff group, written additively, which satisfies the first axiom of countability. We now have the following definitions.

Definition. A double sequences $x = (x_{k,l})$ is said to be $\mathcal{I}$-lacunary statistically convergent of order α to L or $S^{\alpha}_{\theta_2}(\mathcal{I})$-convergent to L if for each neighborhood U of 0 and $\delta > 0$

$$\{(r,s) \in \mathbb{N} : \frac{1}{h^{\alpha}\_r, s}|\{(k,l) \in I_{r,s} : x_{k,l} - L \notin U\}| \geq \delta\} \in \mathcal{I}.$$

(Received April 08, 2017)

1133-40-323 **John Paul Ward***, Department of Mathematics, Marteena Hall, 1601 East Market Street, Greensboro, NC 27411. *Review of results related to a theorem of Szegö.*

Szegö's theorem concerns power series with coefficients coming from a finite set. It is easy to see that such series will converge for all complex numbers in the open unit disc centered at the origin. However, what is less obvious is what happens at the boundary. Under certain smoothness assumptions on the boundary, one may conclude that such a series represents a rational function with poles at the roots of unity in the complex plane. In this talk, we shall discuss several related results. (Received July 31, 2017)

1133-40-354 **Salih Aytar*** (salihaytar@sdu.edu.tr), Süleyman Demirel University, 32260 Isparta, Turkey. *Rough statistical convergence of a sequence of intervals of fuzzy numbers.*

In this talk, we define the concept of rough statistical convergence of a sequence of intervals of fuzzy numbers (briefly, SIFN). Then we examine some properties of the set of rough statistical limit of a SIFN. Finally, we obtain a rough statistical convergence criterion for this type of sequences. (Received August 01, 2017)

41 ► Approximations and expansions

1133-41-11 **Gürhan ·Içöz** (gurhanicoz@gazi.edu.tr), Department of Mathematics, Ankara, Turkey, **R. N. Mohapatra*** (ram.mohapatra@ucf.edu), Department of Mathematics, Orlando, FL 32816, and **M. A. Sarigol** (msarigol@pau.edu.tr), Department of Mathematics, 20007 Denizli, Turkey. *Approximation Properties of q-Phillips-Durremeyer-Stancu Operators,.*

In this paper, we deal with optimal approximation of a function by q-Phillips-Durrmeyer-Stancu operators. Firstly, we calculate moments of these operators. We also establish the approximation properties and estimate convergence results of the operators. Furthermore, we study the weighted approximation and the statistical convergence and discuss the optimality of such approximation. (Received April 08, 2017)

1133-41-55 **Joe Ward*** (jward@math.tamu.edu), jward@math.tamu.edu. *Inverse Estimates for Compact Domains in R^d Using Localized Kernel Bases.*

This talk will discuss inverse estimates for finite dimensional spaces arising in radial basis function approximation and meshless methods. The inverse estimates we consider control Sobolev norms of linear combinations of a localized basis by the L_p norm over a bounded domain. These estimates are valid for Matern and polyharmonic families of radial basis functions. The localized basis is generated by forming certain local Lagrange functions.

This talk is based on joint work with T. Hangelbroek, F. J. Narcowich and C. Rieger. (Received July 18, 2017)

1133-41-62 **Buthinah A. Bin Dehaish*** (bbindehaish@yahoo.com), Mathematics Department, College of Science, King Abdulaziz University, jeddah, 21593, Saudi Arabia. *On monotone nonexpansive mapping and their approximation fixed point results.*

Suppose that C is a nonempty closed bounded and convex subset of a metric space X. Let T be a monotone nonexpansive mapping on C. During this talk we will present some existence fixed point result of this mapping. Furthermore, we will describe the behavior of its fixed point by using some constructive iteration. (Received July 08, 2017)

1133-41-115 **Alexander M. Powell***, Department of Mathematics, Vanderbilt University, Nashville, TN 37240, and **Anneliese H. Spaeth**, Department of Mathematics, Huntingdon College, Montgomery, AL 36106. *Nonnegativity constraints for structured complete systems.*

We investigate nonnegativity as an obstruction to various forms of structured completeness in Lp spaces. For example, we prove that if each element of a system of functions in Lp is pointwise nonnegative, then the system cannot be an unconditional basis or unconditional quasibasis (unconditional Schauder frame) for Lp. In particular, in L2 this precludes the existence of nonnegative Riesz bases and frames. On the other hand, there exist pointwise nonnegative conditional quasibases in Lp, and there also exist pointwise nonnegative exact systems and Markushevich bases in Lp. (Received July 18, 2017)

1133-41-148 **Vasiliy A Prokhorov*** (prokhoro@southalabama.edu), Department of Math and Statistics University, University of South Alabama, 411 University Boulevard North, Mobile, AL 36688-0002. *On some extremal problems.* Preliminary report.

We discuss some minmax extremal problems for polynomial and rational functions. We also present results related to asymptotics of singular numbers of Hankel matrces, n-widths and the degree of rational approximation of Markov functions on discrete sets. The results obtained are based on extremal problems of potential theory, central among which is the problem of equilibrium in an external field. (Received July 22, 2017)

1133-41-200 **Radu Balan*** (rvbalan@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *An L1 Matrix Factorization.* Preliminary report.

In this talk we analyze several factorizations of a positive semi-definite matrix and associated optimization problems. This is a joint work with Kasso Okoudjou (UMD), Joey Iverson (UMD), Anirudha Poria (IIT). (Received July 25, 2017)

1133-41-203 **Alexander V Tovstolis*** (oleksandr.tovstolis@ucf.edu), Department of Mathematics, University of Central Florida, 4393 Andromeda Loop N, Orlando, FL 32816, and **Xin Li** (xin.li@ucf.edu), Department of Mathematics, University of Central Florida, 4393 Andromeda Loop N, Orlando, FL 32816. *Approximation of Smooth Functions on* $[1,\infty)$ *and* $\mathbb{R}\setminus(-1,1)$ *by Entire Functions of Exponential Type.*

In 1946, S. M. Nikolskĭi discovered an effect of better pointwise approximation of a smooth function by algebraic polynomials. Namely, for a function from Sobolev class $W^1[-1,1]$, there is a sequence of algebraic polynomials $\{p_n\}_{n=0}^{\infty}$, $p_n \in \mathbb{R}_n[x]$, s.t.

$$|f(x)-p_n(x)| \le \frac{\pi}{2}\frac{\sqrt{1-x^2}}{n+1} + O\left(\frac{\ln(n+2)}{(n+1)^2}\right).$$

The constant $\pi/2$ in the first term cannot be improved.

There are several generalizations of this result due to A. F. Timan, I. E. Gopengauz, S. A. Teljakovskiĭ, R. M. Trigub, and others. We focus on pointwise approximation of a function from the Sobolev class $W^{r,\infty}(\mathbb{R}\setminus(-1,1))$ by entire functions of exponential type at most σ.

Known estimates of such approximation is due to Ju. A. Brudnyĭ (1953). However, the Brudnyĭ's result is not valid as stated. We found a fix. As in the Trigub's article, we deduce our estimates from the corresponding sharp result on the uniform approximation. In our case, this is the Akhiezer's theorem on uniform approximation. Some useful trick from the Ju. A. Brudnyĭ's proof also plays an important role. (Received July 25, 2017)

1133-41-226 **Laura De Carli*** (decarlil@fiu.edu) and **Pierluigi Vellucci**. *p-Riesz bases in quasi-shift invariant spaces.*

Given $X = \{x_j\}_{j\in\mathbb{Z}}$, a countable subset of $\mathbb{R}^d$ without limit points, and a function $\psi \in L^p(\mathbb{R}^d)$, with $1 \le p < \infty$, we let $V^p(\psi;\, X) = \overline{\text{Span}\{\psi(.-x_j)\}}$ where "bar" denotes the closure in L^p. We discuss the following problem: assuming that the translates $\{\psi(.-x_j)\}_{j\in\mathbb{Z}}$ form a p-Riesz basis in $V^p(\psi;\, X)$, can we find $\delta > 0$ such that, for every $Y = \{y_j\}_{j\in\mathbb{Z}}$ that satisfies $|y_j - x_j| < \delta$, the set $\{\psi(.-y_j)\}_{j\in\mathbb{Z}}$ form either a p-Riesz basis in $V^p(\psi;\, X)$ or a p-Riesz basis in $V^p(\psi;\, Y)$ (Received July 26, 2017)

1133-41-255 **Abdul J. Jerri*** (jerria12@yahoo.com), Prof. Abdul J. Jerri, 5030 Cardinal Grove BLVD, Raleigh, NC 27616, and **Masaru Kamada**. *New Hill Functions for Self Truncating the Generalized Kramer -Weiss Sampling Series.* Preliminary report.

The discretized Fourier transform of the well known Hill Functions have been used ,in an equivalent way, by H. D. Helms and J.B.Thomas in the sixties, to make the Shannon Sampling series a self- truncating one,that resulted in a tighter truncation error bound. Here ,we present a new Hill Functions-associated with the kernel of the general(bandlimited)integral transform of the Generalized Kramer-Weiss sampling Series.This is in order to use their (discretized)transform as a factor inside such series,to make it self-truncating,for a tighter truncation error bound. This is illustrated,for a start,with the Bessel function of the first kind of order m as a kernel,and the Legendre transform. (Received July 28, 2017)

1133-41-272 **Brian Simanek*** (brian_simanek@baylor.edu) and **Matthew Fleeman**. *Torsional Rigidity and Bergman Polynomials.*

The torsional rigidity of a simply connected domain is a constant indicative of the resistance to twisting of a cylindrical beam with the given cross-section. We will show how one can use Bergman polynomials to calculate or estimate the torsional rigidity of a Jordan domain. Several examples will be discussed that show the simplicity and utility of our algorithm. (Received July 28, 2017)

1133-41-326 **Xin Li*** (xin.li@ucf.edu) and **Rajitha Ranasinghe**. *Boas Formula for Askey-Wilson Operator on Entire Functions of Exponential Type.* Preliminary report.

Boas formula is an interpolating formula for the derivative of an entire function of exponential type in terms of its values at equally spaced points. Boas used his formula to gave a shorter proof of his generalization of Bernstein inequality to entire functions. In this talk, an analogue will be presented for Askey-Wilson operator. We will then establish generalizations of Bernstein inequality for Askey-Wilson operator to entire functions in uniform and L_2 norms. Finally, as a further application of our formula, we will prove some interesting identities of Ramanujan. (Received July 31, 2017)

1133-41-334 **Josef Aaron Sifuentes*** (josef.sifuentes@utrgv.edu), 1201 W. University Drive, School of Mathematical And Statistical Scienc, Edinburg, TX 78539, and **Mrinal Kanti Roychowdhury** and **Santanu Chakraborty**. *High precision numerical computation of principal points for univariate distributions.* Preliminary report.

Quantization for probability distributions concerns the best approximation of a probability measure P defined on a metric space by a measure supported on a finite number of points, or in other words, the best approximation of a d-dimensional random vector X with distribution P by a random vector Y with at most n-values in its image. In this paper, we present an efficient numerical method for high precision computation of the optimal sets of n-means and the n^{th} quantization errors for different values of n for some common univariate absolutely continuous distributions. (Received July 31, 2017)

1133-41-350 **Erwin Miña-Díaz*** (minadiaz@olemiss.edu), The University of Mississippi, Department of Mathematics, Hume Hall 305, P. O. Box 1848, University, MS 38677, and **Arno Kuijlaars**. *Universality for conditional measures of the sine point process.*

The sine process is a determinantal point process in the real line with correlation kernel $\frac{\sin \pi(x-y)}{\pi(x-y)}$. It is obtained as a limit from the eigenvalues of many random matrices as their size tends to infinity. The sine process has the remarkable property of being rigid (in the sense of Ghosh and Peres), meaning that for almost all configurations, the number of points in an interval $[-R, R]$ is determined by the points outside of the interval. The conditional measures is the joint distribution of the points in $[-R, R]$ given the points outside. Alexander Bufetov showed that these are orthogonal polynomials ensembles with a weight constructed out of the points outside $[-R, R]$. We prove a universality result for these orthogonal polynomials ensembles that in particular implies that the correlation kernel of the orthogonal polynomials ensemble tends to the sine kernel as $R \to \infty$, answering a question posed by Bufetov. (Received August 01, 2017)

42 ► Fourier analysis

1133-42-22 **Christopher Heil*** (heil@math.gatech.edu), School of Mathematics, Georgia Tech, Atlanta, GA 30332-0160. *Some Problems in Time-Frequency Analysis.*

We will survey some (still) open problems in time-frequency analysis, including the Linear Independence of Time-Frequency Translates Conjecture (also known as the HRT Conjecture), the Olson-Zalik Conjecture on Schauder bases of translates, and other problems. (Received May 08, 2017)

1133-42-42 **Cheng Cheng*** (cheng.cheng@knights.ucf.edu), **Junzheng Jiang** and **Qiyu Sun**. *Phaseless sampling and reconstruction in a shift-invariant space.*

Phase retrieval arises in various fields of science and engineering. In this talk, we consider an infinite-dimensional phase retrieval problem to reconstruct real-valued signals living in a shift-invariant space from their phaseless samples taken either on the whole line or on a discrete set with finite sampling rate. We find an equivalence between nonseparability of signals in a shift-invariant space and their phase retrievability with phaseless samples taken on the whole line. For spline signals of order N, we show that they can be well approximated, up to a sign, from their noisy phaseless samples taken on a set with sampling rate $2N-1$. We also propose a robust algorithm to reconstruct nonseparable signals in a shift-invariant space from their phaseless samples corrupted by bounded noises. (Received June 28, 2017)

1133-42-64 **Christopher D Sogge*** (sogge@jhu.edu), Department of Mathematics, Johns Hopkins University, 3400 N Charles ST, Baltimore, MD 21218. *On the concentration of eigenfunctions.*

I shall present some results in global harmonic analysis that concern properties of eigenfunctions on compact Riemannian manifolds. Using local arguments we can show that L^p norms of eigenfunctions over the entire manifold are saturated if and only if there are small balls (if p is large) or small tubular neighborhoods of geodesics (if p is small) on which the eigenfunctions have very large L^p mass. Neither can occur on manifolds of nonpositive curvature, or, more generally, on manifolds without conjugate points. (Received July 09, 2017)

1133-42-73 **Eric S Weber*** (esweber@iastate.edu), Department of Mathematics, 396 Carver Hall, 411 Morrill Road, Ames, IA 50011. *A Paley-Wiener Type Theorem for Singular Measures on* $\mathbb{T}$. Preliminary report.

The classical Paley-Wiener theorem says that an entire function of exponential type at most π whose restriction to the real axis is square-integrable is the Fourier transform of a function in $L^2(-1/2, 1/2)$. We consider the following analogue: for a fixed singular measure μ on $[-1/2, 1/2]$, when is an entire function the Fourier transform of a function in $L^2(\mu)$? We give a complete characterization of such entire functions in terms of the Fourier transform of μ as well as the Cauchy transform of μ. While the characterization is very different from the classical case–it does not involve any integrability conditions–we show that by reinterpreting the Paley-Wiener theorem, our characterization is in fact analogous. (Received July 11, 2017)

1133-42-79 **Deguang Han**, **David Larson**, **Sam Scholze*** (scholzsl@uwec.edu) and **Wenchang Sun**. *Erasure Recovery Matrices.*

In this talk, I will be discussing an efficient method of erasure reconstruction first introduced by Han and Sun which utilizes erasure recovery matrices. An m-erasure recovery matrix for an analysis frame $G = \{g_j\}_{j=1}^N$ is an $m \times N$ full spark matrix which annihilates the range of the analysis operator for G. Using an m-erasure recovery matrix, it is possible to reconstruct up to m frame coefficient erasures by inverting an $L \times L$ matrix, where L is the size of the erased set of indices. Constructions will be provided for pairs of erasure recovery matrices and analysis frames for which the reconstruction is robust to additive channel noise. Numerical experiments will also be presented pertaining to additive channel noise. (Received July 11, 2017)

1133-42-87 **Ruixiang Zhang*** (ruixiang@math.princeton.edu), 8 Lawrence Drive, Apt 305, Princeton, NJ 08540. *Endpoint perturbed Brascamp-Lieb inequalities.*

We will discuss some ideas behind our proof of endpoint perturbed Brascamp-Lieb inequalities using polynomial partitioning. (Received July 12, 2017)

1133-42-113 **Paul J Koprowski*** (pkoprows.math@gmail.com), Norbert Wiener Center, Department of Mathematics, University of Maryland, College Park, MD 20742, and **Kasso Okoudjou**, **Radhakrishnan Balu** and **Justin Park**. *Equiangular companion frames and applications in quantum key distribution.* Preliminary report.

In an effort to extend Rene's quantum key distribution algorithms, we find examples of equiangular frames and their companions in $N = p - 1$ dimensions where p is prime. Our construction is based on finding eigenvectors of the p dimensional discrete Fourier transform with entry 0 in the first component and entries ± 1 elsewhere. When $N = 2^n$, these companion frames lead to generalizations of Rene's protocol. (Received July 19, 2017)

1133-42-129 **Paul Hagelstein*** (paul_hagelstein@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798. *Tauberian Constants 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 $0 < \alpha < 1$, the associated Tauberian constant $C_{\mathcal{B}}(\alpha)$ is given by

$$C_{\mathcal{B}}(\alpha) = \sup_{E \subset \mathbb{R}^n : 0 < |E| < \infty} \frac{1}{|E|} |\{x \in \mathbb{R}^n : M_{\mathcal{B}} \chi_E(x) > \alpha\}| \, .$$

Tauberian constants provide considerable information regarding the basis $\mathcal{B}$. For example, a classical result of Busemann and Feller is that, provided $\mathcal{B}$ is homothecy invariant, $\mathcal{B}$ is a density basis if and only if $C_{\mathcal{B}}(\alpha) < \infty$ for every $0 < \alpha < 1$. In this talk, we will present recent results involving Tauberian constants and associated applications to the Halo Conjecture, Solyanik estimates, weighted norm inequalitites, and necessary and sufficient conditions for a translation invariant centered differentiation basis to be a density basis. (Received July 19, 2017)

1133-42-134 **Barry Booton*** (bbooton@fau.edu), 1675 NW 4th Ave., Apt. 305, Boca Raton, FL 33432-1535. *General monotone functions and their Fourier coefficients.*

We first establish results on general monotone functions, as defined by Liflyand and Tikhonov. These results are used to establish norm equivalences between such functions defined on $(0, \pi)$ and the sequences of their Fourier coefficients. The norms involved are both weighted $L^q_{\omega(p,q)}$ and $l^q_{\omega(p,q)}$ norms and Lorentz space $L(p, q)$ and $l(p, q)$ norms, where $1 < p < \infty$, $1 \leq q < \infty$. This is an further generalization of results originally obtained by Hardy, and later extended by Askey and Boas, Sagher, and Liflyand and Tikhonov. (Received July 20, 2017)

1133-42-136 **Youfa Li*** (youfalee@hotmail.com), Nanning, Peoples Rep of China. *Phase retrieval with low sampling rate for a subspace of shift-invariant space and the recovery algorithm.*

Phase retrieval is the nonlinear sampling problem that seeks to recover a signal by using its magnitude measurements. PR for the real-valued shift-invariant space generated from a compactly supported function was first studied by Qiyu Sun. The sampling rate is an important topic for PR. Recently, Wenchang Sun proved that any real-valued signal in shift-invariant of B-spline can be determined, up to a global sign, from its magnitude measurements at the sampling rate 2. Suppose that the coefficient sequence $\{C(k)\}_{k=0}^{N-1}$ of f is derived from a probability model. We first establish a sign pre-unwrapping algorithm for the measurements $\{|f(t_1 + k)|_{k=0}^{N-1}$ where $t_1 \in (0, 1)$. By the pre-unwrapping, the measurements can be categorized into blocks. In some bocks, the data have the same sign. Based on the sign-blocks, we investigate how many the additional measurements are sufficient for the PR of f. Under some conditions in the sign blocks, we prove that PR can be accomplished by the magnitude measurements at the sampling rate being strictly smaller than 2. Numerical simulations are conducted to confirmed our results. Our PR algorithm contains the alternation of sign unwrapping and updating coefficient which can prohibit the forward transmission of error. (Received July 20, 2017)

1133-42-174 **Jean-Pierre Gabardo*** (gabardo@mcmaster.ca), Department of Mathematics & Statistics, Hamilton Hall, Room 218, McMaster University, Hamilton, Ontario L8S 4K1, Canada. *Weighted Beurling densities and sampling theory.*

In this talk, we consider Hilbert (and Banach) spaces of functions or distributions supported on a fixed compact subset of $\mathbb{R}^d$ and for which the norm of an element is defined in terms of a weighted L^p-norm of its Fourier transform. The weight in question is assumed to be tempered and moderate. We explore the connection between sampling sets for these spaces and a suitable weighted version of Beurling density. In particular, in the Hilbert space case corresponding to $p = 2$, we obtain weighted versions of the classical density results of H. Landau which relates the measure of a compact set K to the allowable sampling rate for the Fourier transform of the L^2-functions vanishing a.e. outside of K. (Received July 24, 2017)

1133-42-191 **Dorin Dutkay**, Department of Mathematics, 4393 Andromeda Loop N, Orlando, FL 32816, **Gabriel Picioroaga***, Department of Mathematical Sciences, Patterson Hall, 414 E. Clark St, Vermilion, SD 57069, and **Sergei Silvestrov**, Division of Applied Mathematics, UKK, Mlardalen University, 721 23 Vsters, Sweden. *On generalized Walsh bases.* Preliminary report.

We study properties of a new set of orthonormal bases on $L^2[0,1]$ introduced through the action of the Cuntz algebra $\mathcal{O}_N$. We show that a signal's representation in such bases has coefficients that can be easily read off a tensor matrix entries. This allows the introduction of a fast generalized Walsh transform. We use this transform for a classic compression scheme to compare the performance of Walsh and generalized Walsh representations of 1-dimensional signals. (Received July 25, 2017)

1133-42-208 **Niraj Kumar Shukla*** (nirajshukla@iiti.ac.in), Discipline of Mathematics, Indian Institute of Technology Indore, Simrol, Khandwa Road, Indore, Indore, 453552, India. *A pairwise orthogonal frames generated by unitary representations of LCA groups.*

By investigating the dual Gramian analysis tools of Ron and Shen through a pre-Gramian operator over the set-up of locally compact abelian (LCA) groups, we fiberize some operators associated with Bessel families generated by unitary actions of co-compact (not necessarily discrete) subgroups of LCA groups. Using this fiberization, we study and characterize a pair of orthogonal frames generated by the action of a unitary representation ρ of a co-compact subgroup $\Gamma \subset G$ on a separable Hilbert space $L^2(G)$, where G is a second countable, LCA group. Precisely, we consider frames of the form $\{\rho(\gamma)\psi : \gamma \in \Gamma, \psi \in \Psi\}$ for a countable family Ψ in $L^2(G)$. We pay special attention to this problem in the context of translation-invariant space by assuming ρ as the action of Γ on $L^2(G)$ by left translation. As an application, we illustrate our results for the case of co-compact Gabor systems over LCA groups. This is a joint work with Anupam Gumber. (Received July 26, 2017)

1133-42-216 **Angel San Antolin**, Universidad de Alicante, Spain, and **Richard A Zalik*** (zalik@auburn.edu), Department of Mathematics and Statistics, Auburn University, Auburn, AL 36849. *Some smooth compactly supported tight framelets associated to the quincunx matrix.*

We construct two families of tight wavelet frames in $L^2(R^2)$ associated to the quincunx matrix. The first family has five generators and the second has only three. The generators have compact support, any given degree of regularity, and any fixed number of vanishing moments. Our construction is made in Fourier space and involves some refinable functions, the Oblique Extension Principle, and a slight generalization of a theorem of Lai and Stöckler. The refinable functions we use are constructed from the Daubechies low pass filters and are compactly supported. The main difference between these two families is that while the refinable functions associated to the five generators in the first family have symmetries, the refinable function used to construct the three generators in the second family do not. (Received July 28, 2017)

1133-42-284 **Alex Iosevich*** (iosevich@math.rochester.edu), 145 Dunrovin Lane, Rochester, NY 14618, and **Azita Mayeli**. *Gabor bases and curvature.*

We shall discuss some recent developments in the theory of Gabor bases and frames. In particular, we shall see that an indicator function of a symmetric convex body with a smooth boundary and non-vanishing curvature cannot be a window function for an orthogonal Gabor basis on $L^2(\mathbb{R}^d)$. The method of stationary phase and combinatorial considerations play a key role. (Received July 29, 2017)

1133-42-336 **Dorina Mitrea*** (mitread@missouri.edu), University of Missouri, 202 Math Sci Bldg, Columbia, MO 65211. *Quantitative characterization of VMO.*

Let $\mathrm{BMO}(\mathbb{R}^n)$ denote the space of functions with bounded mean oscillations in $\mathbb{R}^n$ and let $\mathrm{VMO}(\mathbb{R}^n)$ denote Sarason's space of functions with vanishing mean oscillations in $\mathbb{R}^n$. In this talk I will present a new characterization of the space $\mathrm{VMO}(\mathbb{R}^n)$ as the closure in $\mathrm{BMO}(\mathbb{R}^n)$ of classes of smooth functions contained in $\mathrm{BMO}(\mathbb{R}^n)$ within which uniform continuity may be suitably quantified (such as the class of smooth functions satisfying a Hölder or Lipschitz condition). This improves on Sarason's classical result describing $\mathrm{VMO}(\mathbb{R}^n)$ as the closure in $\mathrm{BMO}(\mathbb{R}^n)$ of the space of uniformly continuous functions with bounded mean oscillations. As an application, the boundedness of Calderón-Zygmund operators on the space of functions of vanishing mean oscillations will be discussed.

This is joint work with J.M. Martell, I. Mitrea, and M. Mitrea. (Received August 01, 2017)

1133-42-338 **Marius Mitrea*** (mitream@missouri.edu), University of Missouri, 202 Math Sci Bldg, Columbia, MO 65211. *The role of infinitesimal flatness in the solvability of elliptic boundary problems in uniformly rectifiable domains.*

The goal of this talk is to illustrate the phenomenon that uniform rectifiability together with infinitesimal flatness (understood as the demand that the outward unit normal is close to having vanishing mean oscillations) typically implies solvability results for elliptic boundary value problems formulated in such a geometric setting. (Received August 01, 2017)

1133-42-361 **Ahmed I Zayed***, Department of Mathematical Sciences, DePaul University, Chicago, IL 60614, and **Ayush Bhandari**. *Shift–Invariant and Sampling Spaces Associated with the Special Affine Fourier Transform.*

The Special Affine Fourier Transformation or the SAFT generalizes a number of well-known unitary transformations as well as signal processing and optics related mathematical operations. Shift-invariant spaces also play an important role in sampling theory, multiresolution analysis, and many other areas of signal and image processing.

In this talk we discuss shift-invariant spaces associated with the special affine Fourier transform and their relationship with convolution and semi–discrete convolution operators associated with the SAFT. (Received August 01, 2017)

43 ► Abstract harmonic analysis

1133-43-131 **Ian Long*** (ian.long@colorado.edu). *Spectral Hutchinson Measures with 3-Element Iterated Function Systems and Operator Fractals.*

In 1981, Hutchinson showed that for each iterated function system $\{\tau_1, \cdots, \tau_n\}$ on $\mathbb{R}$, there exists a unique probability measure, called a Hutchinson measure or fractal measure, whose support is the attractor of the of the iterated function system. A common question that has been asked about measures among this class is whether or not there exists a set $\Lambda \subseteq \mathbb{R}$, called a spectrum for μ, such that the set of exponentials $\{e^{2\pi i \lambda x} : \lambda \in \Lambda\}$ is an orthonormal basis for $L^2(\mu)$. I will present an if and only if condition on integers R, b_1, b_2, b_3 that determines precisely when the measure associated to the iterated function system $\{\frac{1}{R}(x + b_1), \frac{1}{R}(x + b_2), \frac{1}{R}(x + b_3)\}$ is spectral. Furthermore, I will devote attention to "operator fractals." This term was first used by Jorgensen, Kornelson, and Shuman to describe a remarkable operator in the L^2-space of the 1/4-Cantor measure with unusual fractal-like properties. I will describe operators with similar properties contained in the L^2-spaces of other Hutchinson measures. (Received July 19, 2017)

1133-43-292 **Oscar F Lopez*** (lopezo@math.ubc.ca) and **Ozgur Yilmaz** (oyilmaz@math.ubc.ca). *Embracing Off-the-Grid Samples.*

This work considers frugal acquisition and denoising of bandlimited signals via *off-the-grid* samples, i.e., samples taken at locations randomly deviated from an equispaced grid. Using the theory of compressive sensing, we incorporate the nonuniform grid into the basis pursuit problem as our interpolation scheme. We show that if $\mathcal{O}(s \log(2e\omega/s))$ off-the-grid samples of an ω-bandlimited signal are obtained, our methodology approximates the signal of interest with reconstruction error proportional to the measurement noise level and the error of the best s-sparse approximation. The average sampling density required is drastically reduced for compressible signals in comparison to standard conditions (e.g., Nyquist rate, Landau density) and we extend our results to 2D signals via the theory of low-rank matrix recovery. (Received July 30, 2017)

1133-43-313 **Constanze Liaw*** (liaw@udel.edu) and **Sergei Treil**. *General Clark model for finite rank perturbations.*

The unitary perturbations of a given unitary operator by finite rank d operators can be parametrized by $d \times d$ unitary matrices; this generalizes the rank $d = 1$ setting, where the Clark family is parametrized by the scalars on the unit circle. For finite rank perturbations we investigate the functional model of a related class of contractions, as well as a (unitary) Clark operator that realizes such a model representation for a particular contraction. We find a universal representation of the adjoint of the Clark operator, which features a matrix-valued Cauchy integral operator. By universal we simply mean that our formula is given in the coordinate free Nikolski–Vasyunin functional model. We express the matrix-valued characteristic functions of the model (for the class of contractions). In the case of inner characteristic functions results suggest a generalization of the normalized Cauchy transform to the finite rank setting. (Received July 31, 2017)

44 ► Integral transforms, operational calculus

1133-44-57 **Peter Kuchment*** (kuchment@math.tamu.edu), Mathematics Department, Texas A&M University, Ireland Str., TAMU 3368, College Station, TX 77843-3368, and **Fatma Terzioglu** (fatma@math.tamu.edu), Mathematics Department, Texas A&M Univ., Ireland Street, TAMU 3368, College Station, TX 77843-3368. *Mathematics of Compton camera imaging.*

Compton γ -cameras are used for medical (emission) imaging, as well as for astronomy and homeland security applications. Mathematically (although not in terms of the underlying physics) similar neutron detectors are also being developed for homeland security. The talk will survey the mathematics related to such applications. Namely, the so called cone transform and its properties and inversion. (Received July 06, 2017)

1133-44-154 **Gaik Ambartsoumian***, gambarts@uta.edu, and **Mohammad J. Latifi Jebelli**. *Generalizations of the broken-ray transform and conical differentiation.* Preliminary report.

The talk will discuss a new approach to the inversion of the broken-ray transform (BRT) and its generalizations. Such transforms appear in mathematical models of single-scattering optical tomography, various imaging techniques based on Compton scattering effect and some other modalities. We present several new formulas, as well as prove some known results with a new simpler approach. The efficiency of the method is demonstrated on several numerical examples. Using our inversion formula for BRT, we also describe the range of that transform when applied to a fairly broad class of functions. (Received July 23, 2017)

1133-44-221 **Alexander Katsevich*** (alexander.katsevich@ucf.edu), Mathematics Department, University of Central Florida, Orlando, FL 32816, and **Alexander Tovbis**, **Elliot Blackstone** and **Marco Bertola**. *Finite Hilbert transforms - spectral analysis and applications in tomography.* Preliminary report.

In this talk we study the interior problem of tomography by reducing it to the problem of inverting the finite Hilbert transform (FHT) with incomplete data. In particular, the degree of ill-posedness of solving the interior problem can be deduced from the spectral properties of the corresponding integral operators. We illustrate different types of interior problems and the associated FHTs. Spectral analysis of the latter is based on the technique of the commuting differential operator in simple cases, and on the technique of the Riemann-Hilbert Problem - in general cases. We also describe one simple case, where the resolvent operator and resolution of the identity can be computed explicitly. (Received July 31, 2017)

1133-44-231 **Willi Freeden*** (freeden@rhrk.uni-kl.de), Department of Mathematics, MPI Building 26, 67663 Kaiserslautern, Rhineland-, Germany, and **M. Zuhair Nashed** (znshed@mail.ucf.edu), Department of Mathematics, Orlando, FL 32816. *Inverse Gravimetry: Geomathematical Background and Geothermal Exploration.*

This lecture deals with the characteristic ill-posed and inverse features of transferring input gravitational information in the form of Newtonian volume integral values to geological output characteristics of the density contrast function. Some properties of the Newton volume integral are recapitulated. Different methodologies of the resolution of the inverse gravimetry problem and their numerical implementations are examined dependent on the data source. Three cases of input information may be distinguished, namely internal (borehole), terrestrial (surface), and/or external (spaceborne) gravitational data sets. Singular integral theory based inversion of the Newtonian integral equation such as Haar-type solutions are proposed in a multi-scale framework to decorrelate specific geological signal signatures with respect to inherently available features. Reproducing kernel Hilbert space regularization techniques are studied (together with their transition to mollified variants) to provide geological contrast density distributions by downward continuation from terrestrial and/or spaceborne data. Finally, reproducing kernel Hilbert space solutions are formulated for use of gravimeter data, independent of a specifically chosen input area, i.e., in whole Euclidean space. (Received July 27, 2017)

1133-44-305 **Juergen Frikel*** (juergen.frikel@oth-regensburg.de), Universitätsstrasse 31, 93049 Regensburg, Germany. *On the general limited data problem for the 2D Radon transform.*

In this talk, we present characterizations visible and added singularities for the general limited data problem for the 2D Radon transform. In particular, we consider FBP type reconstructions from data where an arbitrarily shaped region in the sinogram is missing. Our results cover classical and well studied problems such as limited angle tomography, interior and exterior tomography, but they also extend to novel data acquisition methods. In particular, we report on a special imaging setup that is used to examine the micro- and nanostructures of chalk samples from the North Sea in order to predict its petrophysical parameters. In this case the boundary of the cutoff curve in the sinogram domain is nonsmooth and the data truncation is dependent on the view angle as

well as on the displacement variable. Hence, the underlying mathematical problem is significantly different from limited angle tomography and reconstructions from this kind of data show added artifacts that have different characteristics than limited angle artifacts.

This is joint work with Leise Borg, Jakob Jorgensen, and Eric Todd Quinto. (Received July 31, 2017)

1133-44-327 **Marco Bertola** (marco.bertola@concordia.ca), Concordia University, Montreal, Quebec, **Elliot Blackstone** (eblackstone@knights.ucf.edu), University of Central Florida, Orlando, FL 32816, **Alexander Katsevich** (alexander.katsevich@gmail.com), University of Central Florida, Orlando, FL 32816, and **Alexander Tovbis*** (alexander.tovbis@ucf.edu), University of Central Florida, Orlando, FL 32816. *Finite Hilbert transforms - spectral analysis and applications in tomography, continuation.* Preliminary report.

This talk is the second part of the talk described in the abstract 1133-44-221. We consider the general case when spectral analysis of the corresponding FHTs with multiple intervals is based on the technique of the Riemann-Hilbert Problem (RHP). The case of the separated (disjoint) intervals corresponds to the discrete spectrum of the FHTs; it has been sufficiently studied in the literature. Here we study the case of the adjacent intervals, which gives rise to a continuous spectrum. In this situation the challenge starts with (approximate) solving of the corresponding RHP, followed by using this solution to study the spectral properties we are interested in. We will report the current progress in our work. (Received July 31, 2017)

1133-44-339 **Yulia Hristova*** (yuliagh@umich.edu). *Photoacoustic tomography with circular detectors and spherical geometry.*

We propose a detector geometry for photoacoustic tomography that offers the practical advantage of using a single rotating circular detector. We show that the data can be decomposed into the spherical Radon and Funk transforms. An inversion formula, range description, and numerical simulations will be presented. This is a joint work with S. Moon and D. Steinhauer. (Received August 01, 2017)

46 ► Functional analysis

1133-46-16 **Naeem Saleem*** (naeem.saleem2@gmail.com), Department of Mathematics, University of Mana, gement and Technology, C-II Johar Town, Lahore, Pakistan, Lahore, Punjab 50400, Pakistan. *Optimal coincidence fixed point results in fuzzy metric spaces.*

In this paper, some sufficient conditions for existence and uniqueness of the best proximity and optimal coincidence points for a new class of non-self mappings in non-Archimedean fuzzy metric space are discussed. Also, some interesting aspects of best proximity point theory in the setup of fuzzy metric spaces are studied. This talk could be viewed as a discussion on extension of recent development on proximal contraction mappings in non-Archimedean fuzzy metric and fuzzy metric spaces. (Received April 18, 2017)

1133-46-28 **Judith A. Packer*** (packer@euclid.colorado.edu), Department of Mathematics, University of Colorado, Boulder, Campus Box 395, Boulder, CO 80309. *Monic and atomic representation of higher-rank graph C^*-algebras.* Preliminary report.

Specific properties of certain representations of C^*-algebras associated to higher-rank graphs Λ are discussed. Roughly speakly, monic representations are those most closely related to representations on the infinite path space associated to Λ and arise from so-called Λ-semibranching systems, and atomic representations are those for which the associated projection-valued measure on the infinite path space for Λ is purely atomic. Many of the higher-rank graph C^*-algebras discussed here are non-type I and purely infinite, so one cannot hope to parameterize equivalence classes of all irreducible representations. Nevertheless, the monic and atomic representations arise in numerous studies when constructing representations and here some partial results on characterizing these representations are discussed. This work is joint with Carla Farsi, Elizabeth Gillaspy, Palle Jorgensen, and Sooran Kang. (Received May 18, 2017)

1133-46-44 **Peter G Casazza*** (casazzap@missouri.edu), Department of Mathematics, The University of Missouri, Columbia, MO 65211, and **Desai Cheng** (chengdesai@yahoo.com), Department of Mathematics, The University of Missouri, Columbia, MO 65211. *associating vectors in C^n with rank 2 projections in R^{2n}: with applications.*

We will see that vectors in C^n have natural analogs as rank 2 projections in R^{2n} and that this association transfers many vector properties into properties of rank two projections. We believe that this association will answer many open problems in C^n where the corresponding problem in R^n has already been answered - and

vice versa. As a application, we will see that phase retrieval in C^n transfers to a variation of phase retrieval by rank 2 projections on R^{2n}. As a consequence, we will answer the open problem: Give the complex version of Edidin's Theorem which classifies when projections do phase retrieval in R^n. As another application we answer a longstanding open problem concerning fusion frames by showing that fusion frames in C^n associate with fusion frames in R^{2n} with twice the dimension and the same fusion frame bounds. As another application, we will show that a family of mutually unbiased bases in C^n has a natural analog as a family of mutually unbiased rank 2 projections in R^{2n}. We will also show that equiangular tight frames in C^n have an analog as equiangular tight families of rank 2 projections in R^{2n}. (Received June 29, 2017)

1133-46-45 **Peter D. Johnson*** (johnspd@auburn.edu), Department of Mathematics and Statistics, Auburn University, AL 36849, and **Faruk Polat** (faruk.polat@gmail.com), Cankiri Karatekin University, Department of Mathematics, 18000 Cankiri, Turkey. *Problems in matricially derived solid sequence spaces.*

Let A be an infinite matrix with non-negative entries, and let X(0) be a solid vector space of scalar sequences. Having determined X(m), let X(m+1) consist of the scalar sequences x such that A multiplies the absolute value of x into X(m). If X(0) is equipped with a solid t.v.s. topology, then, in a natural way, so is each X(m), and multiplication by A is a continuous linear map from X(m+1) into X(m). With X(0) and A confined to certain classes, we have numerous question about the derived sequence X(0), X(1),..., and a few answers. (Received June 29, 2017)

1133-46-53 **Richard Kadison*** (kadison@math.upenn.edu). *Operator Algebras, Derivations, and Commutators – problems related to these and their applications in quantum physics.*

We discuss derivations and automorphisms of operator algebras and commutators of operators associated with these derivations in their relation to both quantum physics and the structure of von Neumann algebras. We do this in the light of problems that are open and those on which recent progress has been made. (Received July 04, 2017)

1133-46-60 **Ted Juste***, Department of Mathematics, University of Central Florida, Orlando, FL 32816, and **Deguang Han**, **Youfa Li** and **Wenchang Sun**. *Frame phase-retrievability and exact phase-retrievable frames.*

We introduce the concepts of phase-retrievability redundancy and exact phase-retrievable frames. We will discuss some preliminary results on the existence of exact phase-retrievable frames and maximal phase-retrievable subspaces for non phase-retrievable frames. (Received July 07, 2017)

1133-46-81 **Trubee Hodgman Davison*** (trubee.davison@colorado.edu). *A Positive Operator-Valued Measure Associated to an Iterated Function System.*

Given an iterated function system (IFS) on a complete and separable metric space Y, there exists a unique compact subset $X \subseteq Y$ satisfying a fixed point relation with respect to this IFS. This subset is called the fractal set associated to the IFS. The fractal set supports a specific Borel probability measure, called the Hutchinson measure, which itself satisfies a fixed point relation. P. Jorgensen generalized the Hutchinson measure to a projection-valued measure, under the assumption that the IFS does not have essential overlap. The situation when the IFS exhibits essential overlap has also been studied by Jorgensen and colleagues K. Kornelson and K. Shuman. We build off their work to generalize the Hutchinson measure to a positive operator-valued measure for a general IFS, that may exhibit essential overlap. We also discuss Naimark's dilation theorem with respect to this positive operator-valued measure. (Received July 12, 2017)

1133-46-88 **Weihua Liu*** (liuweih@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47403. *Noncommutative distributional symmetries in noncommutative probability.*

I will be introducing the notion of distributional symmetries in noncommutative probability. In noncommutative probability, there are three types of independence, namely classical independence, Voiculescu's freeness and Boolean independence. We will see that noncommutative distributional symmetries can be used to characterize these independences i.e. de Finetti's Type theorems associated with them. (Received July 13, 2017)

1133-46-89 **Ping Wong Ng***, png@louisiana.edu. *Purely infinite corona algebras, extensions and double commutants.*

Recent progress on the topics mentioned in the title. (Received July 13, 2017)

1133-46-101 **Akram Aldroubi*** (akram.aldroubi@vanderbilt.edu), **Longxiu Hunag** and **Armenak Petrosyan**. *Frames induced by powers of operators.*

Let A be an operator in a Hilbert space $\mathcal{H}$, and let $\mathcal{G} \subset \mathcal{H}$ be a countable set of vectors. We investigate the relations between A, $\mathcal{G}$ and $I \subset \mathbb{R}$ that make the system of iterations $\{A^t g : g \in \mathcal{G}, t \in I\}$ complete, Bessel, a basis, or a frame for $\mathcal{H}$. Several cases of this problem have already been considered. We will give a brief review of previous results and present several new ones. The problem is motivated by the dynamical sampling problem and is connected to several topics in functional analysis, including, frame theory and spectral theory. It also has relations to topics in applied harmonic analysis including, wavelet theory and time-frequency analysis. (Received July 18, 2017)

1133-46-102 **Marc A Rieffel*** (rieffel@math.berkeley.edu). *Dirac operators for "Matrix algebras converge to the sphere".* Preliminary report.

In the high-energy quantum-physics literature one finds statements such as "matrix algebras converge to the sphere". Earlier I provided a general setting for understanding such statements, in which the matrix algebras are viewed as compact quantum metric spaces, and convergence is with respect to a quantum Gromov-Hausdorff-type distance. More recently I have dealt with corresponding statements in the literature about vector bundles on spheres and matrix algebras. I will very briefly indicate how some of this works.

But physicists want, even more, to treat structures on spheres (and other spaces) such as Dirac operators, Yang-Mills functionals, etc., and they want to approximate these by corresponding structures on matrix algebras. I am currently exploring how to make precise the situation for Dirac operators. This is confusing because in the physics literature there are at least 3 inequivalent suggestions as to what the Dirac operators on the matrix algebras should be. This is work in progress. I will report on what I have found by the time of the meeting. (Received July 15, 2017)

1133-46-110 **Chun-Kit Lai***, Department of Mathematics, San Francisco State University, 1600 Holloway Ave, San Francisco, CA 94132, and **Luke Evans**. *Conjugate phase retrieval on $\mathbb{C}^M$ by real vectors.* Preliminary report.

Complex phase retrieval on a Hilbert space $\mathcal{H}$ is to recover unknown vectors up to a phase angle from the absolute value of its linear measurements with a frame. i.e.

$$|\langle x, \varphi_n\rangle| = |\langle y, \varphi_n\rangle| \ \forall n \text{ implies } x = e^{i\theta} y.$$

However, it suffers from the problem that none of the φ_n can be a real vector. Otherwise, x and $\overline{x}$ cannot be distinguished. We propose a new notion called *conjugate phase retrieval*

$$|\langle x, \varphi_n\rangle| = |\langle y, \varphi_n\rangle| \ \forall n \text{ implies } x = e^{i\theta} y \text{ or } x = e^{i\theta}\overline{y}.$$

In particular, we show that conjugate phase retieval on $\mathbb{C}^M$ by real vectors is possible. Moreover, We also study the minimum numbers of real vectors required generic real frame performing conjugate phase retrieval. This is a joint work with Luke Evans. (Received July 16, 2017)

1133-46-126 **Zhe Liu*** (zhe.liu@ucf.edu). *Derivations, Commutators, and Reflexivity of Murray-von Neumann Algebras.*

We discuss some recent results on derivations, commutators, and reflexivity of algebras of operators (bounded, unbounded) affiliated with finite von Neumann algebras. (Received July 19, 2017)

1133-46-140 **Frederic Latremoliere*** (frederic@math.du.edu). *The Modular Gromov-Hausdorff Propinquity.*

I will introduce in this talk a new distance between Hilbert modules equipped with some metric data which generalize, for my purpose, the idea of a connection. My new distance extends the quantum Gromov-Hausdorff propinquity, a noncommutative analogue of the Gromov-Hausdorff distance which I introduced as a well-behaved distance with respect to the C*-algebraic structure of quantum metric spaces — notions which I will briefly review in this talk as well. I will then discuss how my modular distance can be applied to prove the continuity of families of Heisenberg modules over quantum 2-tori when the modules are equipped with their natural connections. The modular propinquity represents an exciting step in my program of extending metric geometry to noncommutative geometry, opening the possibility to approximate not only (quantum) spaces, but their vector bundles as well, and is new even in the classical setting. (Received July 20, 2017)

1133-46-149 **Akram Aldroubi*** (akram.aldroubi@vanderbilt.edu). *Interaction of dynamical sampling, functional analysis and operator theory.*

Dynamical sampling is the problem of recovering an unknown function from a set of space-time samples. This problem has many connections to problems in frame theory, operator theory and functional analysis. In this talk,

we will state the problem and discuss its relations to various areas of functional analysis and operator theory, and we will give a brief review of previous results and present several new ones. (Received July 22, 2017)

1133-46-172 **H Thomas Banks*** (htbanks@ncsu.edu), CRSC Box 8212 NCSU, Raleigh, NC 27695.
Using the Prohorov Metric to Inform GBM Modeling.

Glioblastoma Multiforme (GBM) is a malignant brain cancer with a tendency to both migrate and proliferate. We propose modeling GBM using a random differential equation version of the reaction-diffusion equation, where the diffusion parameters D and growth rates are random variables. We investigate the ability to perform the inverse problem to recover the probability distributions of D and the growth rates using the Prohorov metric. We give an overview of use of the Prohorov metric which is equivalent to the weak* topology on the space of probability measures when imbedded in the topological dual of the space of bounded continuous functions. This represents joint efforts with Erica Rutter and Kevin Flores at NCSU. (Received July 24, 2017)

1133-46-234 **Theodore A. Kilgore*** (kilgota@auburn.edu), Department of Mathematics and Statistics, 218 Parker Hall, Auburn University, AL 36849. .

Under the condition that the weight function W is positive and continuous on $[0,\infty)$ and satisfies $\frac{-\ln W(x)}{x^\alpha} \to \infty$ as $x \to \infty$ for some $\alpha > 1$, then the approximation theorem of Weierstrass is shown to hold for $f(x) \in C^0_W[0,\infty)$, the set of continuous functions for which $W(x)f(x) \to 0$ as $x \to \infty$.

Similarly, if W defined on $(-\infty,\infty)$ and is positive and continuous and satisfies $\frac{-\ln W(x)}{x^{2\alpha}} \to \infty$ as $x \to \pm\infty$ for some $\alpha > 1$, then the approximation theorem of Weierstrass is shown to hold for $f(x) \in C^0_W(-\infty,\infty)$, the set of continuous functions for which $W(x)f(x) \to 0$ as $x \to \pm\infty$.

The proofs of the above two results will be based upon a generalization by Chlodowsky of the Bernstein polynomial operators.

These results are presented in memory of Katalin Balázs 08/13/1949 - 09/07/2016, who was for 26 years my mathematical collaborator and my very devoted and very beloved wife. (Received July 27, 2017)

1133-46-247 **Elliot Blackstone*** (eblackstone@knights.ucf.edu), **Alexander Katsevich** and **Alexander Tovbis**. *Riemann-Hilbert methods and the interior problem of tomography.* Preliminary report.

We study the spectrum of an operator related to the finite Hilbert transform on two adjacent intervals. This operator is linked to a 2×2 matrix Riemann-Hilbert problem which we solve asymptotically via Deift-Zhou steepest descent method. The relation to tomography comes from the Gelfand-Graev formula, which converts the tomographic data into the finite Hilbert transform along a collection of lines. (Received July 29, 2017)

1133-46-264 **Fapeng Du*** (jsdfp@163.com), Xuzhou insititute of technology, Xuzhou, Jiangsu 221006, Peoples Rep of China. *Perturbation analysis of metric generalized inverses in Banach spaces.*

Various metric generalized inverses of bounded or closed linear operators on Banach spaces have been defined and studied depending on properties of the metric projectors that are used. In this talk we present perturbation results for metric generalized inverses in the setting where the metric projector is a bounded homogenous operator. (Received July 28, 2017)

1133-46-274 **David R Pitts*** (dpitts2@unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Local Structure for Regular Inclusions.*

A regular inclusion is a pair $(\mathcal{C},\mathcal{D})$ of unital C^*-algebra s where $\mathcal{D} \subseteq \mathcal{C}$, $\mathcal{D}$ is abelian and the set

$$\mathcal{N} := \{v \in \mathcal{C} : v\mathcal{D}v^* \cup v^*\mathcal{D}v \subseteq \mathcal{D}\}$$

has dense span in $\mathcal{C}$.

For $\sigma \in \hat{\mathcal{D}}$, $H_\sigma := \{v \in \mathcal{N} : \sigma(v^*dv) = \sigma(d) \forall\ d \in \mathcal{D}\}$ is a $*$-monoid generating a C^*-algebra $\mathcal{C}_\sigma$. The *local algebra at* σ is the quotient of $\mathcal{C}_\sigma$ by the ideal $\mathfrak{I}_\sigma$ of $\mathcal{C}_\sigma$ generated by $\ker\sigma$. It measures the failure of σ to extend uniquely to a state on $\mathcal{C}$.

The *local group at* σ, G_σ, is the quotient of H_σ by a certain equivalence relation R. The map $[u]_R \mapsto u + \mathfrak{I}_\sigma$ is a homomorphism of G_σ into the unitary group of $\mathcal{C}_\sigma/\mathfrak{I}_\sigma$ whose image generates $\mathcal{C}_\sigma/\mathfrak{I}_\sigma$. G_σ is a topological group, which is often locally compact (e.g. when $\mathcal{D}$ is a MASA).

In this talk, we will explore the structure of G_σ and discuss pre-homomorphisms on G_σ. We will use these ideas to describe certain ideals in $\mathcal{C}$ having trivial intersection with $\mathcal{D}$. (Received July 28, 2017)

1133-46-276 **Huaxin Lin*** (hlin@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97402, and **Guihua Gong**. *Classification of simple amenable C*-algebras.*

We will report recent results in classification of simple amenable C*-algebras. (Received July 28, 2017)

1133-46-277 **Hanfeng Li*** (hfli@math.buffalo.edu), Math Department, SUNY at Buffalo, Buffalo, NY 14260, and **Bingbing Liang**. *Mean dimension and von Neumann-Lueck rank.*

Mean dimension is an invariant in topological dynamics, while von Neumann-Lueck rank is closely related to L2-Betti numbers. I will discuss the relation between these two invariants in the setting of algebraic actions. This is joint work with Bingbing Liang. (Received July 28, 2017)

1133-46-317 **Alexandra Smirnova*** (asmirnova@gsu.edu), Department of Mathematics and Statistics, Georgia State University, 30 Pryor Street, Atlanta, GA 30303. *On New Developments in Iterative Regularization Motivated by Parameter Identification Problems in Epidemiology.*

A considerable number of parameter identification ill-posed problems come from epidemiology and infectious disease modeling. Classical compartmental epidemic models of infectious diseases track the dynamic transition of individuals between different epidemiological states or risk groups. However, with limited epidemiological data available in the case of an emerging disease, simple phenomenological models based on a smaller number of parameters can play an important role in our quest to make forward projections of possible outbreak scenarios. In this talk, we employ the generalized Richards model for stable numerical estimation of the epidemic size and its turning point using early incidence data. The minimization is carried out by what we call the Reduced Iteratively Regularized Gauss-Newton (RIRGN) algorithm, a problem-oriented numerical scheme that takes full advantage of the specific structure of the nonlinear operator at hand. The convergence analysis of the RIRGN method is suggested and numerical simulations are conducted with real case incidence data for the 2014-15 Ebola epidemic in West Africa. We show that the proposed RIRGN provides a stable algorithm for early parameter estimation and forecasting using simple phenomenological models with limited data. (Received July 31, 2017)

1133-46-322 **Galia Dafni**, **Tuomas Hytönen**, **Riikka Korte** and **Hong Yue*** (hong.yue@gcsu.edu). *The space JN_p: nontriviality and duality.*

We study a function space JN_p based on a condition introduced by John and Nirenberg as a variant of BMO. It is known that $L^p \subset JN_p \subsetneq L^{p,\infty}$, but otherwise the structure of JN_p is largely a mystery. Our first main result is the construction of a function that belongs to JN_p but not L^p, showing that the two spaces are not the same. Nevertheless, we prove that for monotone functions, the classes JN_p and L^p do coincide. Our second main result describes JN_p as the dual of a new Hardy kind of space $HK_{p'}$. (Received July 31, 2017)

1133-46-348 **Adam Fuller*** (fullera@ohio.edu), **Michael Hartz** and **Matrino Lupini**. *Boundary representations of Operator Spaces.*

Convexity has plays a crucial role in analysis, e.g. it lies at the heart of the Krein-Milman theorem and Choquet's boundary theory. In this talk we discuss convexity in the theory of operator spaces. We will introduce the notion of boundary representations for an operator space and show that an operator space has enough boundary representations to generate the triple envelope (or Shilov boundary) of an operator space. We will also discuss a Krein-Milman type theorem in this setting. (Received August 01, 2017)

1133-46-364 **Christopher Schafhauser*** (cschafhauser@uwaterloo.ca), Pure Mathematics, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L 1W6, Canada. *MF traces and Crossed Products.*

A tracial state on a C*-algebra A is called *matricial field* (MF) if there is a net of self-adjoint, linear, finite rank maps φ_n on A which approximately preserve the multiplication and approximately preserve the trace. To date, there is no known example of a trace which is not MF. We will discuss some recent progress on verifying the MF property for traces (notably, the Tikuisis-White-Winter Theorem) and some new examples of MF traces.

For traces on crossed products, the best known results involve actions of free groups on nuclear C*-algebras. For instance, in joint work with Tim Rainone, we showed if A is AH with real rank zero and F is a free group, all traces on $A \rtimes_r F$ are MF. More, recently, this result has been extended beyond the real rank zero setting (still with some restrictions). The new step involves a finite-dimensional approximation result for states on Cuntz semigroups. (Received August 01, 2017)

1133-46-376 **Pando G Georgiev*** (pandogeorgiev@gmail.com), Orlando, FL 32816. *Reproducing Kernel Spaces with Multivalued Kernels.* Preliminary report.

We extend the theory of Reproducing Kernel Spaces (RKS) in two directions: the first one is when the resulting RKS is a non-Hilbert space; the second is when the kernel function depends on several variables. Some applications are given: in tensor networks - an emerging tool for dealing with big data, and in non-linear signal separation, showing that we can reveal the underlying latent variables by observing sufficiently large number of sensor signals obtained by transforming the latent variables by a non-linear mapping. (Received August 02, 2017)

47 ► Operator theory

1133-47-18 **Claudio Cioffi-Revilla*** (ccioffi@gmu.edu), George Mason University, 4400 University Drive, MSN 6B2, Fairfax, VA 22030. *The nabladot operator for integrated calculus of hybrid functions with continuous and discrete variables.*

Science equations sometimes consist of hybrid functions containing both continuous and discrete variables; i.e., so-called "concrete" multivariate functions, in the sense of D. Knuth. Examples include fundamental probability functions for compound events, the binomial probability formula, graph geodesic distance, Amdahl's law, Zipf's law, and various quantum equations, among others. Traditional gradient-based operators from classical multivariate differential calculus and sensitivity analysis are not strictly applicable to a broad class of such functions due to the presence of discrete variables and relatively low-range integer values, such as small cardinalities in the neighborhood of Miller's number, 7 ± 2. The "nabladot" operator for hybrid concrete functions of continuous and discrete variables is proposed and illustrated with examples from diverse domains in the natural, social, and engineering sciences. Results show new features previously unavailable through extant classical analysis and continuous approximations. (Received April 27, 2017)

1133-47-30 **Jinlu Li*** (jli@shawnee.edu), 940 Second St., Portsmouth, OH 45662. *Ordered Variational Inequalities on Partially Ordered Banach Spaces.* Preliminary report.

The concept of ordered variational inequalities on partially ordered Banach spaces is a natural extension of vector variational inequalities on Banach spaces. The results about ordered variational inequalities are immediately applied to solving ordered optimization problems. In this paper, we prove the solvability of some ordered variational inequalities by using some fixed point theorems on partially ordered Banach spaces, in which the considered mappings may not be required to have any type of continuity and they just satisfy some order-monotonic conditions. As a generalization of the definition of ordered variational inequalities, we introduce the concept of constrained ordered variational inequalities and constrained ordered optimization problems. We also study the existence of solutions for these problems and investigate the inductive properties of the solution sets. (Received May 29, 2017)

1133-47-75 **Soumyashant Nayak*** (nsoum@upenn.edu), 10-100, Smilow Research Center, 3400 Civic Center Blvd., Philadelphia, PA 19104. *The Hadamard Determinant Inequality in Finite von Neumann Algebras.*

The classical Hadamard determinant inequality in essence says that an n-parallelopiped with prescribed lengths of sides has maximum volume iff the sides are mutually orthogonal. It is useful in proving convergence results in the classical Fredholm theory of integral equations. Further, Fischer's generalization of the inequality has seen many applications in statistics. Our goal is to view these results in the setting of finite von Neumann algebras. We will briefly discuss the notion of a determinant, due to B. Fuglede and R. Kadison, for finite von Neumann algebras and review some basic results on conditional expectations on von Neumann algebras. In this setting, we will see a proof of a generalized form of the Hadamard inequality and a simple characterization of the equality condition. We further extend this inequality in the context of operator monotone functions on $[0, \infty)$ still retaining the simple form of the equality condition. Finally we will see some applications to obtain estimates for determinants of perturbed positive-definite matrices. (Received July 11, 2017)

1133-47-98 **Zeljko Cuckovic*** (zcuckovi@math.utoledo.edu), University of Toledo, Department of Mathematics and Statistics, 2801 W. Bancroft Street, Toledo, OH 43606, **Sonmez Sahutoglu**, University of Toledo, Department of Mathematics and Statistics, Toledo, OH 43606, and **Yunus Zeytuncu**, University of Michigan-Dearborn, Department of Mathematics and Statistics, Dearborn, MI 48128. *A local weighted Axler-Zheng theorem in C^n.*

Axler-Zheng theorem characterizes the compactness of finite sums of finite products of Toeplitz operators acting on the Bergman space on the unit disk in terms of the Berezin transform of the operators. We prove a local version of Axler-Zheng's theorem for weighted Bergman spaces on smooth bounded pseudoconvex domains in C^n. (Joint work with Sonmez Sahutoglu and Yunus Zeytuncu) (Received July 14, 2017)

1133-47-114 **Philip M Gipson*** (philip.gipson@cortland.edu). *Equivalences for Representations of Toeplitz Algebras.*

A Toeplitz algebra is C^*-algebra which is universal for being generated by a countable family of isometric operators. These algebras and their representations are surprisingly pervasive throughout the theory of operator algebras. In this talk we present two new notions of equivalence for representations of a finitely generated Toeplitz algebra, termed "free-equivalence" and "quasifree-equivalence," which take their inspiration from the theory of Hilbert modules. We will conclude with two new theorems which use these new equivalences to generalize known results in the theory of endomorphisms of operator algebras. (Received July 17, 2017)

1133-47-246 **Waleed K. Al-Rawashdeh*** (walrawashdeh@mtech.edu), Montana Tech, 1300 West Park Street, Butte, MT 59701. *Weighted Differentiation Composition Operators from Nevanlinna Classes to Weighted-type Spaces.*

Let ϕ be an analytic self-map of open unit disk $\mathbb{D}$. Let $\mathcal{H}(\mathbb{D})$ be the space of all analytic functions on $\mathbb{D}$. For a nonnegative integer n, the weighted differentiation composition operator on $\mathcal{H}(\mathbb{D})$ is defined as $D^n_{\phi,u}f(z) = u(z)f^{(n)}(\phi(z))$, for $f \in \mathcal{H}(\mathbb{D})$ and $z \in \mathbb{D}$. In this talk, we characterize the boundedness and compactness of the weighted differentiation composition operator $D^n_{\phi,u}$ from the weighted Nevanlinna classes $\mathcal{N}^p_\alpha$ to the weighted-type space H^∞_μ and the little weighted-type space $H^\infty_{\mu,0}$. (Received July 27, 2017)

1133-47-250 **Don Hadwin*** (operatorguy@gmail.com), 33 Academic Way, Math Dept Unh, Durham, NH 03824, and **Tatiana Shulman** (tshulman@impan.pl), Institute of Mathematics of the Polish Academ, Warsaw, Poland. *Tracial Stability for C*-algebras.*

We consider tracial stability, which requires that tuples of elements of a C*-algebra with a trace that nearly satisfy a relation are close to tuples that actually satisfy the relation. Here both "near" and "close" are in terms of the associated 2-norm from the trace, e.g. the Hilbert-Schmidt norm for matrices. Precise definitions are stated in terms of liftings from tracial ultraproducts of C*-algebras. We completely characterize matricial tracial stability for nuclear C*-algebras in terms of certain approximation properties for traces. We also characterize the tracial stability of a separable unital C*-algebra in terms of a new topological property of its maximal ideal space. (Received July 27, 2017)

1133-47-349 **Mubariz Tapdıkoğlu Garayev** (mgarayev@ksu.edu.sa), , Turkey, and **Mehmet Gurdal*** (gurdalmehmet@sdu.edu.tr), 32260 , Turkey. *Remarks on the zero Toeplitz product problem in the Bergman and Hardy spaces.*

In this article, we are interested in the zero Toeplitz product problem: for two symbols $f, g \in L^\infty(\mathbb{D}, dA)$, if the product $T_f T_g$ is identically zero on $L^2_a(\mathbb{D})$ then can we claim T_f or T_g is identically zero? We give a particular solution of this problem. A new proof of one particular case of the zero Toeplitz product problem in the Hardy space $H^2(\mathbb{D})$ is also given.
(Received August 01, 2017)

49 ► Calculus of variations and optimal control; optimization

1133-49-14 **N. K. Sahu*** (nabin6582@gmail.com), Department of Mathematics, Veer Surendra Sai University of Technology, Burla, Orissa 768018, India. *Existence of Solutions to Variational Inequalities on Banach Lattices.*

In 2012 (Mathematics of Operations Research, 37, pages 608-625) Hiroki Nishimura, Efe A. Ok obtained results on solvability of variational inequalities on Hilbert lattices. Their approach was lattice-theoretic and was not

based on topological fixed point theorems. This approach helped them to avoid making assumptions on the set-valued mapping to be hemicontinuous or monotonic. Also, the same authors obtained results on the maximum and minimum solutions of variational inequalities on Banach lattices (Hiroki Nishimura and Efe A. Ok, Optimal solutions to variational inequalities on Banach lattices, J. Math. Anal. Appl. 388 (2012) 1157–1165). In this paper we extend the scope of the previous study with the help of variational characterization of the generalized metric projection operator and the order theoretic fixed point theory. (Received April 13, 2017)

1133-49-27 **Rachid N Ait Maalem Lahcen*** (rachid@ucf.edu), Modeling and Simulation program, Department of Mathematics, 4393 Andromeda Loop N, Orlando, FL 32816. *Using Graph Networks to Optimize UAV Network Survivability Against a Cyber Attack:A Simulation Study.*

An unmanned Arial Vehicle(UAV) depends on communication links to do its assigned duties. The adversaries (attacker) can hack the UAV's sensitive sensory data and feed malicious information or jam its communication links to create malfunctioning of the vehicle so that it doesn't do the assigned job. In this presentation, we discuss the vulnerabilities due the network inter-connectivity in an attempt to mitigate the exploitation of vulnerabilities across the network and transmission of hacks. Barabási gave the typical example of 2003 blackout which was a cascading failure. The blackout illustrated the vulnerability due to inter-connectivity. Our approach is to optimize the network by exploring three different types of graph networks: Lattice, random and preferential-attachment and their survivability measurement based on the definition adopted from Thadakamalla et al. We shall also provide simulation results (Received May 18, 2017)

1133-49-37 **Debasis Giri*** (debasis_giri@hotmail.com), Dean, College of Computer Science, Haldia Institute of Technology, HALDIA, WestBengal , India. *An Optimal method for Image Encryption based on Random Vectors.*

We will discuss an image encryption method based on changing the pixel positions as well as pixel values to confuse the relationship between the cipher image and the plain-image using four random shared secret vectors and two secret numbers. In the proposed method, four random vectors are generated according to the size of the image which acts as a key for this encryption algorithm. One of the random vectors is used to shuffle the first row and then the random vector is modified using two random integers which are relatively prime with the size of the image. Same process is repeated for the other rows of the image. We then shuffle the pixels of columns as the method of rows shuffling using another random vector. The diffusion process is carried out by other two random vectors, one for row and the other for column. The pixel values are changed using simple exclusive-or operation and shifting operation.

From the results, it is observed that the proposed technique significantly reduces the correlation among the pixels by shuffling the image matrix using the random vectors. . The use of four random vectors increases the key space which provides better security against Brute Force Attack. (Received June 16, 2017)

1133-49-118 **Manish Kumar*** (manish.math.bhu@gmail.com), Department of Mathematics, Room # E217, BITS PILANI, Hyderabad Campus, Hyderabad, TELANGANA 500010, India, and **R. N. MOHAPATRA** (ram.mohapatra@ucf.edu), 4000 Central Florida Blvd., ORLANDO, FL 32816. *An Optimal Method in Image Encryption.*

Image encryption has been a subject of current research activity because of the necessity to transfer data in a secured manner. There has been considerable effort to use hyper chaotic system in image encryption. Transform techniques like Fourier transform and wavelet transforms have been used efficiently for the same purpose with competing algorithms. We present a method of image encryption with large key space generated randomly with the use of generalized heat equation obtained by the use of fractional Fourier transform. We show that the method is robust and the NPCR and UACI are satisfactory. (Received July 18, 2017)

1133-49-187 **Akhtar A. Khan*** (aaksma@rit.edu), Center for Applied and Computational Mathemat, School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14623. *Contingent Derivatives and Elliptic Regularization for Noncoercive Elliptic Inverse Problems Under Data Perturbation.* Preliminary report.

In this talk, we discuss the inverse problem of parameter identification in non-coercive variational problems which appear commonly in applied models. We examine the differentiability of the set-valued parameter-to-solution map by using first-order and second-order contingent derivatives. We explore the inverse problem by posing optimization problems using the output least-squares and the modified output least-squares. By regularizing the non-coercive variational problem, we obtain a single-valued parameter-to-selection map and investigate it smoothness and boundedness. We consider optimization problems using the output least-squares and the modified output least-squares for the regularized variational problem. We provide a complete convergence

analysis showing that the regularized problems approximate the original problem suitably. We also give first-order, and second-order adjoint method for the computation of the first-order and second-order derivatives of the output least-squares objective. We provide a discretization scheme and give discrete formulas for the gradient and Hessian calculation. (Received July 25, 2017)

1133-49-188 **Akhtar A. Khan***, Center for Applied and Computational Mathemat, School of Mathematical Sciences, Rochester Institute of Technology, Rochester, NY 14623. *Inverse Problems for Variational and Quasi-Variational Inequalities.* Preliminary report.

In this talk, our objective is to investigate the inverse problem of identifying variable parameters in certain variational and quasi variational inequalities. We develop a trilinear form based optimization framework that has been used quite effectively for parameter identification in variational equations emerging from partial differential equations. An abstract nonsmooth regularization approach is developed that encompasses the total variation regularization and permits the identification of discontinuous parameters. We investigate the inverse problem in an optimization setting using the output-least squares formulation. We give existence and convergence results for the optimization problem. We also penalize the variational inequality and arrive at an optimization problem for which the constraint variational inequality is replaced by the penalized equation. For this case, the smoothness of the parameter-to-solution map is studied and convergence analysis and optimality conditions are given. We also discretize the identification problem for quasi-variational inequalities and give the convergence analysis for the discrete problems. Numerical examples are given to justify the theoretical framework. (Received July 25, 2017)

1133-49-211 **Ugur G Abdulla**, **Evan Cosgrove*** (ecosgrove2011@my.fit.edu) and **Jonathan Goldfarb**. *On the Frechet differentiability in optimal control of coefficients in parabolic free boundary problems.*

We consider the inverse Stefan type free boundary problem, where the coefficients, boundary heat flux, and density of the sources are missing and must be found along with the temperature and the free boundary. We pursue an optimal control framework where boundary heat flux, density of sources, and free boundary are components of the control vector. The optimality criteria consists of the minimization of the L_2-norm declinations of the temperature measurements at the final moment, phase transition temperature, and final position of the free boundary. We prove the Frechet differentiability in Besov-Hölder spaces, and derive the formula for the Frechet differential under minimal regularity assumptions on the data. Necessary condition for optimality opens the way to the application of projective gradient methods in Besov-Hölder spaces for the numerical solution of the inverse Stefan problem. The results are published in *Evolution Equations and Control Theory,* **6***, 3(2017).* (Received July 26, 2017)

1133-49-222 **Ugur G. Abdulla**, **Vladislav Bukshtynov** and **Saleheh Seif*** (sseif2014@my.fit.edu), 150 W University Blvd, Melbourne, FL 32901. *Breast Cancer Detection through Electrical Impedance Tomography and Optimal Control Theory: Theoretical and Computational Analysis.*

We analyze the inverse problem of breast cancer detection through Electrical Impedance Tomography. EIT is a non-invasive medical imaging method to recover electrical conductivity of the body from electrical measurements on its surface. Mathematical formulation of the problem is referred to as Calderon's inverse problem on the identification of the conductivity coefficient of the second order elliptic PDE from additional boundary measurements. We pursue variational formulation and consider the optimal control problem on the minimization of the L_2-norm declination of the flux on certain subset of the boundary for the uniformly elliptic PDE

$$(a_{ij}(x)u_{x_j})_{x_i} + b_i(x)u_{x_i} + a(x)u = f(x)$$

with unknown matrix a_{ij}, and subject to the mixed Neumann-Robin type boundary conditions. We prove Frechet differentiability in the Banach space of bounded measurable matrix functions, and derive first order optimality condition. We pursue numerical analysis in a simplified two-dimensional case by implementing projective gradient method in Banach spaces, re-parametrization and space reduction based on principal component analysis, Tikhonov regularization and sensitivity analysis with respect to relative size and locations of cancerous tumors. (Received July 26, 2017)

1133-49-278 **Holly Carley*** (hkcarley@gmail.com), 300 Jay Street, Namm Hall 711 (N-711), Brooklyn, New York, NY 11201. *A path integral formulation for the ground state energy.*

Here we consider a toy model of the much studied polaron model. The polaron is an distortion that occurs when a charged particle moves in a crystal. The toy model, describes a particle interacting with a harmonic oscillator,

with a coupling parameter. When the parameter is small, use of perturbation theory will give an expression for the ground state energy. When the parameter is large, a different method must be used. We will develop a path integral formulation for the ground state energy and discuss developments concerning a hypothetical asymptotic expression for the ground state energy. (Received July 29, 2017)

1133-49-279 **Donald D Porchia*** (donald.porchia@ucf.edu), Department of Mathematics, University of Central Florida, ORLANDO, FL 32816. *Modeling Optimal Vaccination Strategies in a Heterogeneous Population.*

In this talk, we consider the spread of a disease through a heterogeneous population. An optimal control problem is formulated with the aim at minimizing the number of infected individuals as well as the number of required group specific vaccinations. Further, we examine how the optimal vaccination strategy changes under preferential or proportional mixing. We shall illustrate with examples. (Received July 29, 2017)

1133-49-345 **Jiongmin Yong*** (jiongmin.yong@ucf.edu), 4000 Central Florida Blvd, Orlando, FL 32816. *Time-Inconsistent Optimal Control Problems.*

Classical optimal control problems for (stochastic) differential equations are time-consistent, by which we mean that an optimal control found for a given time moment will stay optimal later on. In reality, however, this might not be always true. This is mainly due to the time-preferences and risk-preferences of the decision makers. In the current talk, we will briefly present some results in the investigation of time-consistent equilibrium strategies for time-inconsistent problems. (Received August 01, 2017)

1133-49-374 **Jonathan M Goldfarb*** (jgoldfar@fit.edu) and **Ugur G. Abdulla** (abdulla@fit.edu). *Frechet Differentiability in Besov Spaces in the Optimal Control of Parabolic Free Boundary Problems.*

We consider an inverse Stefan type free boundary problem for a general second order linear parabolic PDE, for which the temperature, domain, heat flux on the fixed boundary, density of sources, and coefficients are to be determined; the cost functional consists of the L_2-declination of the trace of the temperature at the final moment, temperature at the free boundary and final position of the free boundary from available measurements.

This problem arises when considering a phase transition process with unknown temperature function, phase transition boundary, source term and boundary heat flux. A new variational formulation developed in

U. G. Abdulla, *Inverse Problems and Imaging*, 7, 2 (2013), 307–340

which addresses the dual issues of possible measurement errors and large computational cost associated with classical variational formulations of the inverse Stefan problem.

With the delicate use of sharp embedding theorems in Sobolev-Besov spaces the Frechet differentiability is proven, and the formula for the Frechet gradient expressed in terms of the traces of the state vector and the solution of the adjoint problem. (Received August 02, 2017)

51 ► Geometry

1133-51-65 **Grigory Tikhomirov**, **Philip Petersen** and **Lulu Qian*** (luluqian@caltech.edu). *Programmable disorder in random DNA tilings.*

Scaling up the complexity and diversity of synthetic molecular structures will require strategies that exploit the inherent stochasticity of molecular systems in a controlled fashion. Here we demonstrate a framework for programming random DNA tilings and show how to control the properties of global patterns through simple, local rules. We constructed three general forms of planar networks — random loops, mazes and trees — on the surface of self-assembled DNA origami arrays on the micrometre scale with nanometre resolution. Using simple molecular building blocks and robust experimental conditions, we demonstrate control of a wide range of properties of the random networks, including the branching rules, the growth directions, the proximity between adjacent networks and the size distribution. Much as combinatorial approaches for generating random one-dimensional chains of polymers have been used to revolutionize chemical synthesis and the selection of functional nucleic acids, our strategy extends these principles to random two-dimensional networks of molecules and creates new opportunities for fabricating more complex molecular devices organized by DNA nanostructures. (Received July 09, 2017)

1133-51-100 **Andrew Vince*** (avince@ufl.edu). *Fractal Transformations of Euclidean Space.*

The attractor is a central object of an iterated function system (IFS), and *fractal transformations* are natural maps from the attractor of one IFS to the attractor of another. A global point of view is taken, extending the domain of a fractal transformation from an attractor to the ambient space. Intimately related is the extended

IFS addressing of the set of points of the ambient space. Definitions, examples, results, and applications will be provided. (Received July 14, 2017)

1133-51-267 **Emmy Murphy*** (e_murphy@math.northwestern.edu) and **Roger Casals**. *Legendrian surfaces and planar cubic graphs.*

Given a graph G embedded in the plane of valence 3, we associate to it a Legendrian surface in the standard contact $\mathbb{R}^5$. We describe how to compute the Legendrian contact homology of this Legendrian, in terms of the combinatorics of the graph. As explained by Treumann-Zaslow, the category of constructable sheaves recovers the chromatic data of G. Inspired by the larger "augmentations are sheaves" conjecture we show how the LCH contains the colorings of G. If times allows we may discuss the relationship with SL_2 gauge theory. (Received July 28, 2017)

53 ► Differential geometry

1133-53-15 **Rodrigo Montes*** (rrmontes74@gmail.com), Rua Amazonas 818 ap 32, Curitiba, PR 80610030, Brazil. *Constant Contact Angle Surfaces in the Lorentz Group L3.*

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 L3. Using the Gaussian equation we prove that constant mean curvature surfaces in L3 with constant contact angle have constant Gaussian curvature. Also, we provide a congruence theorem for constant mean curvature surfaces immersed in the Lorentz group L3. (Received April 13, 2017)

1133-53-135 **Plamen Stefanov*** (stefanov@math.purdue.edu). *Local Boundary Rigidity.*

The boundary rigidity problem consist of recovering the metric in a domain, up to an isometry, from the distance between boundary points. We show that in dimensions three and higher, knowing the distance near a fixed strictly convex boundary point allows us to reconstruct the metric inside the domain near that point, and that this reconstruction is stable. We also prove semi-global and global results under certain convexity conditions. The problem can be reformulated as a recovery of the metric from the arrival times of waves between boundary points; which is known as travel-time tomography. The interest in this problem is motivated by imaging problems in seismology: to recover sub-surface structure of the Earth given travel-times from the propagation of seismic waves. In oil exploration, the seismic signals are man-made and the problem is local in nature. In particular, we can recover locally the compressional and the shear wave speeds for the elastic Earth model, given local information. Similar but much less complete results for Lorentzian metrics will be discussed. The talk is based on joint work with Uhlmann (UW) and Vasy (Stanford). (Received July 20, 2017)

1133-53-161 **Nina Miolane*** (ninamio78@gmail.com), 2004 route des lucioles - INRIA, Equipe-projet Asclepios, Batiment Fermat, 06902 Sophia Antipolis, France. *Estimation on manifolds: synchronization of rotations for cryo-electron microscopy.*

Cryo-electron microscopy is an imaging technique that allows to infer the 3D structure of a macromolecule, like a protein, in its native environment. A beam of electrons is transmitted through the protein. This produces several 2D images that are different projections of the protein's 3D structure. In order to reconstruct the protein's 3D structure from these projections, one needs to register these 2D images, i.e. one needs to estimate the 3D rotations that allow to map one onto another. The estimation of this sequence of rotations - also called synchronization of rotations - is a problem of estimation on manifolds. Manifolds are generalizations of vector spaces, on which usual linear statistics need to be redefined. In this talk, we see how the theory of estimation on manifolds allows to tackle the synchronization of rotations, and possibly of other geometric transformations. (Received July 23, 2017)

1133-53-195 **Kei Irie*** (iriek@kurims.kyoto-u.ac.jp). *Chain-level string topology, pseudo-holomorphic disks, and Kuranishi structures.*

I will talk about an application of chain-level string topology to pseudo-holomorphic curve theory in symplectic topology. Specifically, given a closed, oriented, and spin Lagrangian submanifold L in a symplectic vector space, one can define a Maurer-Cartan element of the chain-level loop bracket on the free loop space of L, using the virtual fundamental chain of the moduli space of pseudo-holomorphic disks with boundary on L. This idea is due to Fukaya, who also pointed out its important consequences in symplectic topology. I will explain how to rigorously carry out this idea, using a novel chain model of the free loop space and theory of Kuranishi structures. (Received July 25, 2017)

1133-53-230 **Jean Gutt** and **Michael Usher*** (usher@uga.edu). *Knotted symplectic embeddings between domains in R^4.*

I will discuss a proof that many toric domains $X \subset R^4$ admit symplectic embeddings f into dilates of themselves which are knotted in the strong sense that there is no symplectomorphism of the target that takes $f(X)$ to X. For instance X can be taken equal to a polydisk $P(1,1)$, or to any convex toric domain that both is contained in $P(1,1)$ and properly contains a ball $B^4(1)$; by contrast a result of McDuff shows that $B^4(1)$ (or indeed any four-dimensional ellipsoid) cannot have this property. The embeddings are constructed based on recent advances on symplectic embeddings of ellipsoids, though in some cases a more elementary construction is possible. The fact that the embeddings are knotted is proven using filtered S^1-equivariant symplectic homology. (Received July 27, 2017)

1133-53-251 **Samuel T Lisi*** (stlisi@olemiss.edu). *On fillings of $M \times T^2$.* Preliminary report.

An important question in contact topology is to classify the fillings of a contact manifold. Worded differently, the question is, given a contact manifold, which symplectic manifolds can it bound? The question comes in different flavors, depending on the precise bounding condition. There are a large number of important results in dimension 3, but much less is known in dimensions 5 and higher.

We will discuss an interesting class of five dimensional examples. Bourgeois constructed a family of contact structures on $M \times T^2$ if M is contact, using Giroux's open book decomposition. We will see that these are very sensitive to the page of the open book, but less so to the monodromy. We will also see that many of these are weakly fillable, by a family of constructions. This is partially joint work with Marinkovic and Niederkrüger. (Received July 27, 2017)

1133-53-254 **Timothy Perutz*** (perutz@math.utexas.edu). *Fixed-point Floer homology in spaces of stable pairs over Riemann surfaces.*

Joint work with Andrew Lee. One can obtain 3-manifold invariants via symplectic avatars of gauge-theoretic constructions: Heegaard Floer homology as a model for Seiberg–Witten Floer homology, or Lagrangian Floer homology in representation varieties as a model for instanton homology. The latter approach is limited by difficulties with singularities. I will describe an approach to circumventing such problems by working in a space of stable (or Bradlow) pairs over a Riemann surface—a smooth, compact, monotone symplectic manifold. While Lagrangian submanifolds seem to be hard to construct, the action of the mapping class group leads to fixed-point Floer homology invariants, which we compute in the genus 1 case, and find that they contain the expected information form Seiberg–Witten theory. (Received July 27, 2017)

1133-53-301 **François Monard*** (fmonard@ucsc.edu), McHenry 4126, UC Santa Cruz Math Department, 1156 High St., Santa Cruz, CA 95064, and **Gabriel P Paternain**. *The geodesic X-ray transform with a $GL(n,\mathbb{C})$ connection on simple surfaces.*

We will discuss recent results regarding the injectivity and inversion of geodesic X-ray transforms with connections, defined on certain Riemannian surfaces with boundary. Such a problem arises for instance as the linearization of the inverse problem of reconstructing a connection from knowledge of its parallel transport along geodesics (in short, its "scattering data"). It also arises in medical imaging applications, in the context of attenuated x-ray transforms where the attenuation term depends linearly on the tangent vector.

While prior literature tackled the case of injectivity for unitary connections, the present case tackles inversion for general, non-unitary ones. The starting point is the derivation of Fredholm inversion formulas, obtained by studying certain transport equations on the unit tangent bundle. The error operators involved are then explicit enough, that further properties can be inferred on the injectivity of such equations (and as a result, of the transform itself) for almost all connections, including a significant drop in regularity requirements. Numerical examples will be presented. (Received July 30, 2017)

54 ► General topology

1133-54-5 **Clement Boateng Ampadu*** (drampadu@hotmail.com), West Roxbury, MA 02132-6303. *Higher-Order Banach Contraction Mapping Theorem in Heptagonal Multiplicative b-Metric Space.* Preliminary report.

This talk is largely motivated by ideas contained in Chapter 1 [Clement Ampadu (2016). Characterization Theorems Inspired by the Higher-Order Banach Mapping I: Some Results in Multiplicative b-Metric Space. ISBN: 1365212602,9781365212604]. By combining the notions of multiplicative metric space [Agamirza E Bashirov et.al , Multiplicative Calculus and its Applications, J. Math. Anal. Appl. 337 (2008) 36–48], b-metric space [I. A.

Bakhtin, The contraction mapping principle in quasimetric spaces, Funct. Anal., Unianowsk Gos. Ped. Inst.,30 (1989), 26-37] and the heptagonal property [Clement Boateng Ampadu, CHATTERJEA CONTRACTION MAPPING THEOREM IN CONE HEPTAGONAL METRIC SPACE, Fundamental Journal of Mathematics and Mathematical Sciences Vol. 7, Issue 1, 2017, Pages 15- 23] we introduce a concept of heptagonal multiplicative b-metric space and obtain the higher-order Banach Contraction Principle [Ezearn Fixed Point Theory and Applications (2015) 2015:88 ; Ampadu, Clement(2015): Generalization of Higher Order Contraction Mapping Theorem, Unpublished] in this setting (Received February 03, 2017)

1133-54-90 **Murthy Parvateesam Penumarthy*** (ppmurthy@gmail.com), Department of Pure and Applied Mathematics, Guru Ghasidas Vishwavidyalaya, Bilaspur (CG), 495009, India.
Consequences of Banach's and Jungck's fixed point theorems.

This talk is to provide an elegant survey of the impact of Banach's result of 1922 [**?**] in a Complete Metric Space as well as Jungck's result of 1976 [**?**].After Jungck's theorem for a pair of commuting self maps in a complete metric space a spate of research papers appeared in the area of **Metric Fixed Point Theory**. Most of the fixed point theorist divided into the following groups:
(i) A few researchers extended the pair of commuting maps for obtaining common fixed points in different spaces such as Normed Linear Spaces, Probabilistic Metric Spaces, Fuzzy Metric Spaces, Saks Spaces, Complex Valued Metric Spaces, Partially Ordered Metric Spaces, etc. for example [**?**].
(ii) Few researchers generalized commuting pair of maps in a metric spaces by weakening it, for example Weakly Commuting Maps[**?**], Compatible Maps[**?**], Compatible Maps of Type(A)[**?**], Weakly Compatible Maps[**?**] and many more[**?**].
(iii) Some applications of Banach and Jungck's can be found in solving the Dynamic Programming Problem [**?**], Solution of Integral Equation, Game Theory, etc.
In view of the above we are going to discuss various kinds of weakly commutativity for obtaining common fixed points. (Received July 13, 2017)

1133-54-111 **Lyall Reid*** (lyall.reid@ucf.edu). *Lattice-valued T-Cauchy spaces.* Preliminary report.
A lattice $(L, \wedge, \vee)$ is called a frame provided it is complete and obeys: $\alpha \wedge \left(\bigvee_{j \in J} \beta_j \right) = \bigvee_{j \in J} (\alpha \wedge \beta_j)$ for all $\alpha, \beta_j \in L$, $j \in J$. Let $\top$ denote the top element of the lattice, then the notion of a $\top$-filter has been defined. In this context, $\top$-Cauchy spaces are defined, and sufficient conditions are given which ensure the existence of a $\top$-completion. Further, the notion of $\top$-uniform spaces are defined and connections are made to $\top$-Cauchy spaces. Categorical properties are also studied. (Received July 17, 2017)

55 ► Algebraic topology

1133-55-213 **Ann Sizemore**, **Elisabeth Karuza**, **Chad Giusti*** (cgiusti@seas.upenn.edu) and **Danielle Bassett**. *Node filtrations in biological complexes.*

Using persistent homology for data analysis relies on the existence of a natural filtration on a complex derived from the data of interest. In many common TDA complexes, like the Vietoris-Rips complex of a point cloud, the nodes are present throughout the filtration and the data is encoded in a weighting on the faces. Here, we study biological systems where the filtration naturally occurs on the level of nodes, with all other data prescribed by this filtration. Examples will include semantic learning and fungal growth. (Received July 26, 2017)

57 ► Manifolds and cell complexes

1133-57-258 **Leonid Polterovich**, **Egor Shelukhin*** (shelukhin@dms.umontreal.ca) and **Vukasin Stojisavljevic**. *Persistence modules and Hamiltonian diffeomorphisms.*

We discuss applications of the theory of persistence modules to the geometry and dynamics of Hamiltonian diffeomorphisms. This talk is partially based on joint work with Leonid Polterovich and Vukasin Stojisavljevic. (Received July 28, 2017)

1133-57-269 **James Pascaleff*** (jpascale@illinois.edu), University of Illinois at Urbana-Champaign, 1409 W. Green St., Urbana, IL 61801. *Fukaya categories and Poisson geometry.*

From time to time, one hears the question "can a Fukaya category be associated to a Poisson manifold?" I will show that, if one is willing to replace a Poisson manifold by a so-called "integration," there is a sense in which such a thing is possible. It turns out the question is not idle, as the resulting framework allows one to (1) unify

a variety of known constructions in symplectic topology, (2) give a new symplectic interpretation of the cup product on the cohomology of the free loop space, and (3) expand the range of structures on the A-side that can be matched under mirror symmetry. (Received July 28, 2017)

58 ► Global analysis, analysis on manifolds

1133-58-35 **Xiaolong Han*** (xiaolong.han@csun.edu), California State University, Northridge, Northridge, CA 91325. *Distribution of real nodal sets of ergodic eigenfunctions on analytic manifolds.*

This talk is concerned with the distribution of the real nodal sets of Laplacian eigenfunctions on analytic manifolds. In particular, given equidistribution of the eigenfunctions at certain scales, we show that the hypersurface volume form of the nodal sets is comparable with the volume form of the manifold. (Received June 12, 2017)

1133-58-78 **Christopher D. Sogge** and **Yakun Xi*** (forevenone@gmail.com), 68 Lilac Rd, #1, Rochester, NY 14620, and **Cheng Zhang**. *Geodesic Period Integrals of Eigenfunctions on Riemannian Surfaces and Gauss-Bonnet Theorem.*

We use the Gauss-Bonnet theorem and the triangle comparison theorems of Toponogov to show that on compact Riemannian surfaces of negative curvature,period integrals of eigenfunctions over geodesics go to zero at the rate of $O((\log\lambda)^{-\frac{1}{2}})$ if λ are their frequencies. No such result is possible in the constant curvature case if the curvature is greater or equal to 0. (Received July 12, 2017)

1133-58-82 **Emmett L Wyman*** (emmett.wyman@gmail.com), 2701 NORTH CALVERT ST, Baltimore, MD 21218. *Explicit bounds on integrals of eigenfunctions over curves in surfaces of nonpositive curvature.*

Let (M, g) be a compact, 2-dimensional manifold without boundary with non-positive sectional curvature. Let Δ_g denote the Laplace-Beltrami operator on M with respect to the metric g, and let e_λ be L^2-normalized eigenfunctions of Δ_g with eigenvalue λ, i.e.

$$-\Delta_g e_\lambda = \lambda^2 e_\lambda.$$

We prove that, given a smooth arc-length parametrized curve γ in M and $b \in C_0^\infty(\mathbb{R})$, we have

$$\int b(s) e_\lambda(\gamma(s))\, ds = O((\log\lambda)^{-1/2}) \qquad \text{as } \lambda \to \infty,$$

provided that for all $t \in \operatorname{supp} b$ the geodesic curvature of γ at t avoids two critical curvatures $\mathbf{k}(\gamma'(t)^\perp)$ and $\mathbf{k}(-\gamma'(t)^\perp)$. (Received July 12, 2017)

1133-58-245 **Robert Chang*** (hchang@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60201. *Log-scale equidistribution of zeros of quantum ergodic eigensections.*

Let $(L, h) \to (M, \omega)$ be a prequantum line bundle over a compact Kähler manifold. A symplectic map $\chi\colon M \to M$ may be quantized as a sequence of quantum maps that act on the spaces of holomorphic sections of L^N. In a joint work with Steve Zelditch, we show that if χ satisfies certain dynamical assumptions, then for a density one subsequence of eigensections of the quantum maps, the masses and zeros are asymptotically equidistributed in balls of shrinking radii $(\log N)^{-\gamma}$, where $N \to \infty$ is the degree of the line bundle and $\gamma > 0$ is a constant independent of N. (Received July 27, 2017)

1133-58-256 **Tianyi Ren*** (tyren@math.jhu.edu), Krieger Hall, 3400 N. Charles Street, Baltimore, MD 21218, and **Yakun Xi** and **Cheng Zhang**. *An Endpoint Version of Uniform Sobolev Inequalities.*

We prove an endpoint version of the uniform Sobolev inequalities in a classical paper of Kenig, Ruiz and Sogge. Although strong inequality no longer holds for the pairs of exponents that are endpoints in the classical theorem of Kenig, Ruiz and Sogge, they enjoy restricted weak type inequality. The key ingredient in our proof is an interpolation technique first introduced by Bourgain. We also prove restricted weak type Stein-Tomas restriction inequalities on some parts of the boundary of a pentagon in which strong Stein-Tomas inequalities hold. This completely solves the exponents for which Stein-Tomas inequalities hold, and will be essential in our proof of the endpoint uniform Sobolev inequalities when first order terms enter. (Received July 28, 2017)

1133-58-314 **Lotfi Hermi***, Department of Mathematics, Florida International University, 11101 S.W. 13 ST., Miami, FL, Miami, FL 33199. *Isoperimetric inequalities for convex cones.*

We use the weighted isoperimetric inequality of J. Ratzkin for a wedge domain in higher dimensions to prove new isoperimetric inequalities for weighted L_p-norms of the fundamental eigenfunction of a bounded domain in a convex cone–generalizing earlier work of Chiti, Kohler-Jobin, and Payne-Rayner. We also introduce relative torsional rigidity for such domains and prove a new Saint-Venant-type isoperimetric inequality for convex cones. Finally, we prove new inequalities relating the fundamental eigenvalue to the relative torsional rigidity of such a wedge domain thereby generalizing our earlier work to this higher dimensional setting, and show how to obtain such inequalities using the Payne interpretation in Weinstein fractional space. (Joint work with A. Hasnaoui) (Received July 31, 2017)

60 ► Probability theory and stochastic processes

1133-60-8 **Palle Jorgensen*** (palle-jorgensen@uiowa.edu), Dept Mathematics MLH, University of Iowa, 2 Wash Street, Iowa City, IA 52242. *Multiresolution analysis from Markov processes.*

The talk is a report on recent research with D. Alpay and S. Bezuglyi, dealing with a Markov process approach to multiresolution constructions (MRA). It is modeled on the more traditional MRA approach to wavelets, but our framework here is that of measurable dynamics; more specifically, we show that there is a MRA approach which yields powerful results in the context of the study of dynamics of endomorphisms in measure space. (Received February 28, 2017)

1133-60-51 **Parisa Fatheddin*** (parisa.fatheddin@afit.edu), 2950 Hobson Way, WPAFB, OH 45433, **P. Sundar** (sundar@math.lsu.edu), Louisiana State University, Baton Rouge, LA 7080, and **Jie Xiong** (jiexiong@umac.mo), University of Macau, Macau, Peoples Rep of China. *Asymptotic Behavior of a Class of SPDEs.*

We will introduce a class of stochastic PDEs that is used to characterize two commonly studied population models: super-Brownian motion and Fleming-Viot process. Super-Brownian motion is the continuous version of a branching process and Fleming-Viot is the continuous version of step-wise mutation model related to Wright-Fisher model. We begin by providing some background on these and then discuss our results on proving four fundamental limit theorems for the class of SPDEs and population models. Namely, we present their large and moderate deviations, central limit theorem, and law of the iterated logarithm, where tightness of the process plays a major role. These results are from joint work with P.Sundar and Jie Xiong. (Received July 03, 2017)

1133-60-58 **Eugune H. Dshalalow**, 150 W University Blvd, Melbourne, FL 32901, and **Ahmed I. Merie*** (amerie2013@my.fit.edu), 150 W University, Melbourne, FL 32901. *FLUCTUATION ANALYSIS IN QUEUES WITH SEVERAL OPERATIONAL MODES AND PRIORITY CUSTOMERS.*

We consider a class of queues with a single server who operates in four different modes, attends two queues, and dependent on circumstances, processes two different queues simultaneously. The server capacity is r $>$ 1 , when serving primary customers. When the primary queue drops below r and unless it is empty the server continues working in a slower mode and takes on a secondary queue simultaneously. There are different switching policies that specify when the server works on one or two queues. There are elements of a non-cooperative stochastic game when the server attends two queues. The main tools pertain to recent results in fluctuation theory, namely . level-crossing techniques applied to piece-wise linear jump processes. One of the objectives in the paper is to model processes that occurs in software, computer, and electrical engineering, and argue that methods of fluctuation theory produce closed form functionals. Key words: Single-server queueing systems, fluctuation theory, marked point processes, stochastic games, semi-regenerative processes. AMS Subject Classification: 60K10, 60K25, 60G51, 60G55, 60K05, 60G57. (Received July 06, 2017)

1133-60-72 **Jewgeni H. Dshalalow** and **Ali Hussein Mahmood Al-Obaidi*** (aalobaidi2013@my.fit.edu), 1245 Palm Bay Rd, Apt# R102, Palm Bay, FL 32905. *Modulated Random Measures On Hausdorff Topological Spaces.*

In this paper, we will introduce random measures on σ-compact Hausdorff spaces and define their stochastic integrals of functions of one and two variables. We further form a rigorous construction of a random measure perturbed by a stochastic process and target its stationary intensity often occurring in control theory. To obtain that intensity we modify and refine the classic Campbell's theorem for random measures. Examples of modulated Poisson measures are discussed. (Received July 11, 2017)

1133-60-83 **Ilie Grigorescu*** (igrigore@math.miami.edu). *Hydrodynamic limit for the Bak-Sneppen branching diffusions.*

We prove a hydrodynamic limit for a system of N diffusions moving in an open domain $D \subseteq \mathbb{R}^d$ undergoing branching when one particle reaches a certain subset of the boundary. The branching mechanism represents a hybrid between the Fleming-Viot branching and a mean-field version of the Bak-Sneppen fitness model where the absorbing boundary represents the *minimal* configuration, seen as biologically not viable. The limiting profile is the normalization of the solution of a heat equation with mass creation, which is studied using its representation via an auxiliary measure-valued supercritical process. Connections to the standard Fleming-Viot model and the particle representations of the resolvent of a killed process are also discussed.

Based in part on work with Min Kang and Yishu Song. (Received July 12, 2017)

1133-60-92 **Amarjit Budhiraja*** (budhiraj@email.unc.edu), Dept. of Statistics and OR, UNC-Chapel Hill, Chapel Hill, NC 27516. *Scaling Limits for Large Stochastic Networks.*

We discuss several models for large stochastic networks given as weakly interacting pure jump (controlled) Markov processes. Under suitable scaling we establish diffusion approximations, limits of stochastic control problems, and of many-player stochastic dynamic games. Some features of limit models include infinite dimensional state descriptors,degenerate diffusions, and mean field games for reflected processes. Based on joint works with Erhan Bayraktar, Asaf Cohen and Eric Friedlander. (Received July 13, 2017)

1133-60-104 **Andrey Sarantsev*** (sarantsev@pstat.ucsb.edu), South Hall 5607A, Department of Statistics, and Applied Probability, University of California, Santa Barbara, CA 93106, and **Tomoyuki Ichiba** (ichiba@pstat.ucsb.edu), South Hall 5607A, University of California, Santa Barbara, CA 93106. *Convergence Rates of Diffusions.* Preliminary report.

We find explicit estimates for rates of exponential convergence for solutions of stochastic differential equations on the real line, on the half-line with reflection, and for related processes. (Received July 15, 2017)

1133-60-109 **Michael A Kouritzin*** (michaelk@ualberta.ca), Mathematics and Statistics, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Exchangeable branching processes in filtering and finance.*

We will start by building a case for weakly-interacting branching particle systems in filtering, option pricing and insurance. Then, we will discuss some of the convergence properties for a class of such filters with a flexible resampling scheme as the number of particles increases. The key tools are exchangeability and coupling to a McKean-Vlasov particle system that can also be used to predict performance. (Received July 16, 2017)

1133-60-133 **Wei Sun*** (wei.sun@concordia.ca), Department of Mathematics and Statistics, 1455 De Maisonneuve Blvd. W., Montreal, Quebec H3G 1M8, Canada. *Hunt's hypothesis (H) and Getoor's conjecture.*

A Markov process X is said to satisfy Hunt's hypothesis (H) if every semi-polar set is polar. Roughly speaking, this means that if a set A cannot be immediately hit by X for any starting point, then A will never be hit by X. Which Lévy processes satisfy Hunt's hypothesis (H) is a long-standing open problem in probabilistic potential theory. In this talk, I will summarize the results that we have obtained for this problem in recent years. In particular, I will present theorems and examples on the validity of (H) for one-dimensional Lévy processes and the sum of two independent Lévy processes. This talk is based on joint papers with Zechun Hu. (Received July 20, 2017)

1133-60-139 **Kandethody M Ramachandran*** (ram@usf.edu), 4202 East Fowler Ave, CMC342, Department of Mathematics & Statistics, Tampa, FL 33620-5700. *STOCHASTIC GAME MODELS FOR CYBER SECURITY.* Preliminary report.

First, an attack detection and classification method will be presented. Then, we will discuss a game-theoretic modeling for cyber security by viewing security attack scenarios as an optimization game comprising the interactions between an attacker and administrators and give a model for stochastic game. Attack detection and classification reduces the space of actions for the administrator. In this scenario, a discussion of the Nash equilibrium or best-response strategies for the players (attacker and administrators) will be given. (Received July 20, 2017)

1133-60-155 **Abey Lopez-Garcia*** (abey.lopez-garcia@ucf.edu), University of Central Florida, Department of Mathematics, 4393 Andromeda Loop N, Orlando, FL 32816, and **Vasiliy Prokhorov**. *Random polynomials satisfying a three-term recurrence relation.*

In this talk we consider polynomials P_n satisfying a three-term recurrence relation of the form $zP_n = P_{n+1} + a_n P_{n-1}$, with random positive coefficients a_n. Assuming the coefficients a_n are i.i.d., we study the mean zero asymptotic distribution and mean Padé asymptotic distribution of these polynomials, as well as relations between them. This is a joint work in progress with V. Prokhorov. (Received July 23, 2017)

1133-60-158 **Jewgeni H Dshalalow** and **Kizza M Nandyose*** (knandyose2012@my.fit.edu). *Continuous Time Interpolation of Marked Random Measures and their Applications.*

We study a class of monotone and non-monotone delayed marked point processes that model stochastic networks (under attacks), optional trading, status of queuing systems during vacation modes, responses to cancer treatments (such as chemotherapy and radiation), hostile ambushes in economics and warfare. We are interested in the behavior of such a process about a fixed threshold. It presents an analytic challenge, because of the arbitrary nature of random marks. We target the first passage time, pre-first passage time, the status of the associated continuous time parameter process between these two epochs, and the status of the process upon these two epochs. A joint functional of these stochastic quantities is investigated in the transient mode. (Received July 23, 2017)

1133-60-178 **Xiangdong Liu**, **Jie Xiong** and **Yong Zeng*** (zengy@umkc.edu), Department of Mathematics and Statistics, University of Missouri at Kansas City, 5100 Rockhill Rd, Kansas City, MO 64110, and **shuaiqi Zhang**. *Mean-Variance Portfolio Selection for Partially-Observed Point Processes.*

In a ultra-high frequency trading environment, we study the classical mean–variance portfolio selection problem in an incomplete market with one bond and multiple stocks. Each stock price is modeled as a marked point process, the noisy observation of the intrinsic value process. With incomplete information, we obtain a separation principle. Using the maximum principle for stochastic control of forward-backward stochastic differential equations (FBSDEs) with jump, we explicitly derive the efficient strategies, which rely on filtering. (Received July 24, 2017)

1133-60-296 **Sandun Perera** and **Hongwei Long*** (hlong@fau.edu), Department of Mathematical Sciences, Florida Atlantic University, Boca Raton, FL 33431. *An Approximation Scheme for Impulse Control with Random Reaction Periods.*

We propose an approximation scheme for impulse control models when the controller's action affects the state as well as the dynamics of the state process for a random amount of time. In particular, we show that the optimal solutions of the impulse control model with random reaction periods(ICRRP)can be found by solving a sequence of optimal stopping problems when the number of interventions in the original model is finite. Hence, our work enhances viability of the existing ICRRP framework for applications as well as the general literature on stochastic control theory. The efficacy of our approximation scheme is validated by applying it to compute a market-reaction-adjusted optimal central bank intervention policy for a country. (Received July 30, 2017)

1133-60-300 **Yaozhong Hu*** (yaozhong@ualberta.ca), Dept of Math and Stat Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada, and **Khoa Le** (khoa.le.n@gmail.com), Dept of Math and Stat Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Density of parabolic Anderson random field.* Preliminary report.

We study the density $\rho(t,x;y)$ of the law of the solution $u(t,x)$ to a stochastic partial differential equation $\frac{\partial}{\partial t}u(t,x) = \frac{1}{2}\Delta u(t,x) + u \diamond \dot{W}(t,x)$, where $\dot{W}$ is a general Gaussian noise. We mainly concern with the asymptotic behavior of $\rho(t,x;y)$ when $y \to \infty$. Both upper and lower bounds are obtained and these two bounds match each other in exponential scale. If the initial data is positive, then $\rho(t,x;y)$ is supported on $y \in [0,\infty)$ and in this case we also study the asymptotic behavior of $\rho(t,x;y)$ when $y \to 0+$. (Received July 30, 2017)

1133-60-302 **Ryan T. White*** (rwhite2009@fit.edu), Department of Mathematical Sciences, Florida Institute of Technology, 150 W. University Blvd., Melbourne, FL 32901. *Time Sensitive Analysis of d-dim Independent and Stationary Increment Processes.*

We study the behavior of the random walk of a particle on a d-dimensional random grid enclosed by an open rectangle. Since the grid is randomly generated as the particle moves, determining the first crossing time and the position of the particle upon escape is nontrivial. We model this by a d-dimensional independent and stationary increment jump process $A(t)$. The problem is further embellished by observing $A(t)$ only upon a point process $\{\tau_n\}$, so that the behavior of $A(t)$ around the threshold is unavailable. The focus of the work is

to probabilistically "interpolate" from pre- and post-crossing observation times to revive probabilistic data on the process upon its real-time crossing. We obtain key information about $A(t)$ within a random vicinity of the real-time crossing as a characteristic function jointly with the observation times immediately before and after the crossing and the position of the process upon these times. The process has two primary applications: (1) modeling networks under attacks disabling valuable nodes, where the results can predict their crashes and offer remedies, and (2) modeling the short-term accumulation of funds, which is useful in tracking suspicious financial transactions. (Received July 31, 2017)

1133-60-330 **Tao Pang*** (tpang@ncsu.edu), Campus Box 8205, Raleigh, NC 27695-8205. *Portfolio Optimization with Stochastic Volatility and Stochastic Dividend.*

We consider a portfolio optimization model of Merton's type with one risky asset and one riskless asset. In this model, not only the price of the risky asset follows a stochastic process with a stochastic volatility given by a mean-reverting process, but also there is a random productivity output from the risk asset. This model can be used to model stock with uncertain dividend rate or real estate properties with productivity income such as rent or farm products. The goal is to choose the optimal investment and consumption controls to maximize the investor's expected total discounted utility. We derive the Hamilton-Jacobi-Bellman (HJB) equation using the dynamic programming principle. Then, using the subsolution/supersolution method, we can establish the existence result of classical solution to the HJB equation. Finally, we verify that the solution is equal to the value function, and derive the optimal investment and consumption controls. (Received July 31, 2017)

1133-60-356 **Celeste Vallejo*** (cvallejo@ufl.edu), **James Keesling** and **Burton H. Singer**. *Analyzing a Stochastic Model of Cholera Using Little's Law.* Preliminary report.

Consider a system in which customers arrive at a given rate, wait for a specified time, and then depart. Little's Law states that if the average of these processes exists and stabilizes over a given time interval ($[0, T]$) then the average arrival rate to the facility ($\alpha(T)$) multiplied by the average waiting time in the facility ($w(T)$) is equal to the average number in the facility ($\overline{n}(T)$), or $\alpha(T)w(T) = \overline{n}(T)$. This result holds independent of any statistical distribution assumption on the rates. In this talk, I will introduce the novel technique of analyzing a system using Little's Law. The benefit of this approach is that there is no need to specify a distribution by which customers arrive, wait, or depart from a facility. I will describe the method of finding a one-to-one correspondence between a Little's Law system and a stochastic microsimulation model. As an application of this technique, I will apply this method to a model of cholera. By applying a Little's Law analysis to the cholera model, we can restrict ourselves to only those rates that can be measured. (Received August 01, 2017)

1133-60-360 **Jebessa B Mijena*** (jebessa.mijena@gcsu.edu), 231 W Hancock St., CBX 017, Milledgeville, GA 31061, and **Erkan Nane**. *Space-time fractional stochastic partial differential equations.*

We consider non-linear time-fractional stochastic heat type equation

$$\partial_t^\beta u_t(x) = -\nu(-\Delta)^{\alpha/2} u_t(x) + I_t^{1-\beta}[\sigma(u)\, \dot{W}\,(t,x)]$$

in $(d+1)$ dimensions, where $\nu > 0, \beta \in (0,1)$, $\alpha \in (0,2]$ and $d < \min\{2, \beta^{-1}\}\alpha$, ∂_t^β is the Caputo fractional derivative, $-(-\Delta)^{\alpha/2}$ is the generator of an isotropic stable process, $I_t^{1-\beta}$ is the fractional integral operator, $\dot{W}\,(t,x)$ is space-time white noise, and $\sigma : \mathbb{R} \to \mathbb{R}$ is Lipschitz continuous. Time fractional stochastic heat type equations might be used to model phenomenon with random effects with thermal memory. We prove existence and uniqueness of mild solutions to this equation and establish conditions under which the solution is continuous. In sharp contrast to the stochastic partial differential equations studied earlier by Foondun and Khoshnevisan and by Walsh, in some cases our results give existence of random field solutions in spatial dimensions $d = 1, 2, 3$. Under faster than linear growth of σ, we show that time fractional stochastic partial differential equation has no finite energy solution. (Received August 01, 2017)

1133-60-362 **Tamer F Oraby*** (tamer.oraby@utrgv.edu), 1201 W university Dr., Edinburg, TX 78539, and **Mrinal K Roychowdhury** (mrinal.roychowdhury@utrgv.edu), 1201 W University Dr., Edinburg, TX 78539. *Quantization of Triangular Distributions.* Preliminary report.

In this talk, we show some results about quantization of the triangular distribution on the unit interval. Other problems will also be discussed. (Received August 01, 2017)

62 ► Statistics

1133-62-95 **Ramchandra Rimal***, 3781 Khayyam Avenue, 3781, ORLANDO, FL 32826, and **Marianna Pensky**. *ESTIMATION WITH BERKSON ERRORS.*

To be added later (Received July 14, 2017)

1133-62-212 **Rasika Rajapakshage*** (udara@knights.ucf.edu), **Marianna Pensky** and **Rida Benhaddou**. *Anisotropic functional Laplace deconvolution.*

In the present paper we consider the problem of estimating a three-dimensional function f based on observations from its noisy Laplace convolution. Our study is motivated by the analysis of Dynamic Contrast Enhanced (DCE) imaging data. We construct an adaptive wavelet-Laguerre estimator of f, derive minimax lower bounds for the L^2-risk when f belongs to a three-dimensional Laguerre-Sobolev ball and demonstrate that the wavelet-Laguerre estimator is adaptive and asymptotically near-optimal in a wide range of Laguerre-Sobolev spaces. We carry out a limited simulations study and show that the estimator performs well in a finite sample setting. Finally, we use the technique for the solution of the Laplace deconvolution problem on the basis of DCE Computerized Tomography data. (Received July 26, 2017)

1133-62-299 **Teng Zhang*** (teng.zhang@ucf.edu), 2580 Greenhill Way, Apt 108, Oviedo, FL 32765. *Robust Principal Component Analysis by Manifold Optimization.* Preliminary report.

This work considers the problem of robust PCA as an optimization problem on the manifold of low-rank matrices, and proposes two algorithms based on manifold optimization. It is shown that, with a proper designed initialization, the proposed algorithms are guaranteed to converge to the underlying low-rank matrix linearly. Compared with the previous works based on the Burer-Monterio decomposition of low-rank matrices, the proposed algorithms reduce the dependence on the conditional number of the underlying low-rank matrix, both theoretically and numerically. (Received July 30, 2017)

1133-62-318 **Pawan Kumar Gupta*** (gupta.pawan@knights.ucf.edu), APT 201, 3142 Alafaya Club Drive, Orlando, FL 32817, and **Marianna Pensky** (marianna.pensky@ucf.edu), Department of Mathematics, University of Central florida, Orlando, FL 32816. *Solution of linear ill-posed problems using random dictionaries.*

In the present paper we consider application of overcomplete dictionaries to solution of general ill-posed linear inverse problems. In the context of regression problems, there has been enormous amount of effort to recover an unknown function using such dictionaries. One of the most popular methods, lasso and its versions, is based on minimizing empirical likelihood and unfortunately, requires stringent assumptions on the dictionary, the, so called, compatibility conditions. Though compatibility conditions are hard to satisfy, it is well known that this can be accomplished by using random dictionaries. In the present paper, we show how one can apply random dictionaries to solution of ill-posed linear inverse problems. We put a theoretical foundation under the suggested methodology and study its performance via simulations. (Received July 31, 2017)

65 ► Numerical analysis

1133-65-207 **Ugur Abdulla**, **Vladislav Bukshtynov** and **Ali Hagverdiyev*** (ahaqverdiyev2011@my.fit.edu), Melbourne, FL 32901. *Gradient method in Besov spaces for the optimal control of parabolic free boundary problems.*

We pursue numerical analysis of the optimal control problem introduced recently as a variational formulation of the inverse Stefan problem in *U.G.Abdulla, Inverse Problems and Imaging, 7, 2(2013), 307-340 & 10, 4(2016), 869-898.* By employing Frechet differentiability result of the recent paper by *Abdulla et.al., Evolution Equations and Control Theory, 6, 3(2017), 319-344*, iterative numerical algorithm based on the projective gradient method in Besov spaces is implemented. We pursue sensitivity analysis with respect to initial guess, and comparison of alternative approaches of simultaneous reconstruction vs. nested optimization of the control vector components. Numerical results are demonstrated for model examples with various levels of complexity. (Received July 26, 2017)

1133-65-248 **Sami E Merhi*** (merhisam@math.msu.edu), **Aditya Viswanathan** and **Mark A Iwen**. *Recovery of Compactly Supported Functions from Spectrogram Measurements via Lifting.*

A novel phase retrieval method, motivated by ptychographic imaging, is proposed for the approximate recovery of a compactly supported specimen function $f : \mathbb{R} \to \mathbb{C}$ from its continuous short time Fourier transform (STFT) spectrogram measurements. The method, partially inspired by the well known PhaseLift algorithm, is based on

a lifted formulation of the infinite dimensional problem which is then later truncated for the sake of computation. Numerical experiments demonstrate the promise of the proposed approach. (Received July 27, 2017)

1133-65-324 **Cara D. Brooks***, 10501 FGCU Blvd. South, Fort Myers, FL 33967. *An improved first-order local regularization method for ill-posed Volterra equations.* Preliminary report.

Solutions of linear and nonlinear inverse problems, particularly those with special structure or for which non-smooth solutions are expected, can be effectively reconstructed using *local regularization* methods. These methods allow for the utilization of data most relevant to the desired solution and regularization to be applied in a non-global manner. For Volterra equations, these methods retain the causal structure of the original equation (in contrast to classical regularization methods) and lead to fast sequential numerical algorithms to solve the inverse problem.

In this talk, we present an improved first-order local regularization method for solving ν-smoothing Volterra equations that is shown to be both stable and convergent for *all* values of $\nu = 1, 2, \ldots$. A numerical implementation of the method and scheme for determining the initial condition are described. Examples are provided to illustrate newfound stability in the cases $\nu = 4$ and higher. (Received July 31, 2017)

1133-65-342 **Taufiquar R Khan*** (khan@clemson.edu), O-201 Martin Hall Box 340975, Clemson, SC 29631. *Image Reconstruction In Electrical Impedance Tomography For Damage Detection In Concrete.*

The complete electrode model for the inverse problem in electrical impedance tomography for damage detection in concrete is presented. The appropriate function spaces and regularization required to solve this ill-posed inverse problem is described. Both the deterministic and the statistical inversion approaches are compared with preliminary results using data. (Received August 01, 2017)

68 ► Computer science

1133-68-49 **Aritra Dutta*** (aritra.dutta@kaust.edu.sa), Visual Computing Center, Division of CEMSE, Al Khwarizmi Bldg 1, Thuwal, 23955, Saudi Arabia, **Xin Li** (xin.li@ucf.edu), 4393 Andromeda Loop N, Orlando, FL 32816, and **Peter Richtarik** (peter.richtarik@kaust.edu.sa), Visual Computing Center, Division of CEMSE, Al Khwarizmi Bldg 1, Thuwal, 23955, Saudi Arabia. *A Batch-Incremental Video Background Estimation Model using Weighted Low-Rank Approximation of Matrices.*

Principal component pursuit (PCP) is a state-of-the-art approach for background estimation problems. Due to their higher computational cost, PCP algorithms, such as robust principal component analysis (RPCA) and its variants, are not feasible in processing high definition videos. To avoid the curse of dimensionality in those algorithms, several methods have been proposed to solve the background estimation problem in an incremental manner. We propose a batch-incremental background estimation model using a special weighted low-rank approximation of matrices. Through experiments with real and synthetic video sequences, we demonstrate that our method is superior to the state-of-the-art background estimation algorithms such as GRASTA, ReProCS, incPCP, and GFL. (Received July 03, 2017)

1133-68-61 **Lila Kari*** (lila@uwaterloo.ca), School of Computer Science, University of Waterloo, Waterloo, ON N2L 3G1, Canada. *Was the Chimaera a reptile or mammal? Measuring (real or synthetic) species' relatedness using genome syntactic information.*

Phylogenetic trees have been the traditional means to represent evolutionary history and species classification, but there is a growing realization that some type of graphs or networks rather than trees are often needed, to take into account phenomena such as recombination, hybridization, horizontal gene transfer, and convergent evolution. We propose Molecular Distance Maps (MoDMaps), a novel alignment-free method for computing and displaying sequence and species' relatedness.

MoDMaps compute pairwise distances between Chaos Game Representations (CGR) of all input DNA sequences, and visualize the interrelationships thus obtained as an interactive map in three-dimensional Euclidean space: Each point on a map represents a DNA sequence, and the spatial proximity between any two points reflects the degree of structural similarity between the corresponding sequences.

MoDMaps is a general-purpose method that can compute and display the interrelationships within any set of sequences, biological, simulated, synthetic or computer-generated, sequences that closely related or completely unrelated, of the same length or of different lengths, several kilo-basepair-long or complete genomes. (Received July 08, 2017)

1133-68-177 **Keaton Hamm*** (keaton.hamm@vanderbilt.edu). *CUR Matrix Decomposition and Subspace Segmentation.* Preliminary report.

The subspace segmentation problem seeks to classify, or cluster, data in a high-dimensional space that is drawn from the union of much smaller dimensional subspaces. One method of attack for this problem is to find a similarity matrix from the data which identifies the clusters. This talk will discuss an intriguing matrix decomposition method called CUR decomposition, and describe how most of the known similarity matrix methods are special cases of this general decomposition in the case that the subspaces are independent. (Received July 24, 2017)

1133-68-205 **Maryam Jaberi*** (mjaberi@cs.ucf.edu), **Marianna Pensky** (marianna.pensky@ucf.edu) and **Hassan Foroosh** (foroosh@cs.ucf.edu). *PROBABILISTIC SUBSPACE CLUSTERING.*

Subspace clustering algorithms are designed to discover separate clusters in a mixture of high dimensional vectors drawn from multiple probability distributions. When a subset of high dimensional data belongs to one cluster, then all those points lie near a low dimensional subspace. Therefore, each subspace can be represented in a lower dimensional subspace. Existing methods have been focused on solving this problem through two steps: computing an affinity matrix and finding clusters. The drawback of these methods is that the results are final and cannot be improved. Therefore, there is an incentive to combine the two steps into an iterative algorithm. In this work, we propose an iterative method that (i) delays association of points to subspace clusters by updating an association matrix in each iteration, defined in terms of membership probabilities. In particular, at each iteration, points are divided into two groups of "certain" and "uncertain", with the assignment of the latter group delayed until their subspace association certainty improves. (ii) We show that delayed association is better suited for clustering subspaces that have ambiguities, i.e. when subspaces intersects or contaminated by outliers/noise. (Received July 25, 2017)

1133-68-261 **Irene Muzi**, **Michael P. O'Brien**, **Felix Reidl** and **Blair D. Sullivan*** (blair_sullivan@ncsu.edu). *When being even slightly shallow makes life hard.*

Identifying dense substructures is a frequent task in analyzing real-world graphs, with a rich history of results characterizing its computational complexity for various notions of substructure. For example, one can find the densest subgraph in polynomial time using flow-based methods, yet finding the densest clique or graph minor is NP-complete. We show that in some sense, finding dense substructures which are just slightly 'less local' than subgraphs seems to be intrinsically difficult.

Specifically, we consider r-shallow minors, which naturally intermediate between the local nature of subgraphs ($r = 0$) and the global notion of minors ($r = \infty$). Finding densest 0-shallow minors is in P, but Densest 1-Shallow Minor is NP-complete, so we focus on substructures that fall between 0- and 1-shallow. Specifically, we prove that Densest $r/2$-Shallow Topological Minor and Densest r-Subdivision are NP-complete already in sub-cubic apex-graphs for $r \geq 1$, and that neither problem can be solved in time $O(2^{o(n)})$ unless the Exponential Time Hypothesis (ETH) fails. Further, for Densest 1-Shallow Topological Minor, we show the problem is FPT for bounded treewidth, but no algorithm with running time $O(2^{o(tw(G)^2)}n)$ can exist unless the ETH fails. (Received July 28, 2017)

1133-68-295 **Mostafa Rahmani** and **George Atia*** (george.atia@ucf.edu), Orlando, FL 32816. *Robust Principal Component Analysis Through Coherence Pursuit.*

We present a fast and powerful algorithm for robust Principal Component Analysis (PCA) termed Coherence Pursuit (CoP). Adopting a global view of a data point, CoP differentiates between an outlier and an inlier based on their total mutual coherence with the rest of the data. We establish theoretical performance guarantees for CoP under both unstructured and structured outlier models. CoP is the first robust PCA algorithm that is simultaneously fast, provably robust to both unstructured and structured outliers, and can tolerate a large number of unstructured outliers. (Received July 30, 2017)

76 ► Fluid mechanics

1133-76-297 **Dambaru Bhatta*** (dambaru.bhatta@utrgv.edu). *Finite Element Solution for a Transient Incompressible Viscous Fluid Flow in a Rectangular Cavity.* Preliminary report.

Here we consider a transient flow for an incompressible, viscous and Newtonian fluid in a rectangular cavity whose top lid is moving at a constant speed. Fluid movement is governed by the laws of conservation of mass and momentum as a set of partial differential equations. Weak formulation for the governing system is derived

and then matrix form at element level is obtained. The elements considered here are of Taylor-Hood type elements. Numerical results for the velocity for a square cavity are presented. (Received July 30, 2017)

82 ► Statistical mechanics, structure of matter

1133-82-117 **Kenneth M. Golden*** (golden@math.utah.edu), University of Utah, Department of Mathematics, 155 S 1400 E, Rm 233, Salt Lake City, UT 84112-0090. *Arctic melt ponds, fractal geometry, and Anderson transitions.*

Melt ponds on the surface of Arctic sea ice in late spring and summer determine sea ice albedo or reflectance, a key parameter in climate modeling. As the ponds grow and coalesce, forming large scale connected structures, their fractal dimension undergoes a transition from 1 to about 2, around a critical length scale of 100 square meters in area. As the ponds evolve they take complex, self-similar shapes with boundaries resembling space-filling curves. In studies of two phase composites, such as the ice-water surface of melting sea ice, we have found unexpected behavior in the eigenvalues and eigenvectors of a random matrix governing classical transport in these media as a connectedness threshold is approached. They display strikingly similar behavior to what is observed in Anderson transitions in condensed matter, optics, acoustics, and water waves, with a transition to universal Wigner-Dyson eigenvalue statistics and a localization transition. I will discuss these findings as well as models we are developing to investigate melt pond evolution, such as an Ising model. (Received July 18, 2017)

86 ► Geophysics

1133-86-359 **Mitchell P Thayer*** (mitchellpthayer@gmail.com), Chemistry Department, 1101 University Avenue, Madison, WI 53706, and **Kaixi (Cathy) Zhu**, **Huijing Gao** and **Amir H Assadi**. *Topological Methods for Modeling Stochastic Events in Atmospheric Chemistry.*

Air quality heavily impacts human morbidity and mortality, so it is of paramount importance to understand and model dynamic atmospheric events to inform science-driven policy.

We share our development of novel approaches for modeling stochastic events in atmospheric chemistry, inspired by Local-to-Global methods in topology. We construct generalizable techniques from basic principles:
1) Air quality is time-varying and non-deterministic, with practical complications from measurement noise, stochastic events, and other artifacts.
2) Scientific inference involves integration and assimilation of data from spatially-disjoint and/or temporally-disjoint sources.
3) Statistical correlations and variations exist at scales ranging from centimeters to continents.

The appropriate topological model is a time-series structure whose constituent objects are sheaves, constructed from vector bundles of atmospheric attributes, endowed with the structure of a hierarchical Markov random field.

Hebei analysis by: Cathy Zhu Kaixi, Sun Qing, Wu Shang, Steven Yang Chenglang, Mike Wu Zhengyan. Global public health study (lung cancer deaths due to natural disaster-related air quality variations) by: Crystal Zhu Zhaorong, Nancy Liu Yuxin, Echo Zhuo Yizhou. (Received August 01, 2017)

90 ► Operations research, mathematical programming

1133-90-13 **S. K. Padhan*** (sarojpadhan@gmail.com), Department of Mathematics, Burla, Orissa 768018, India. *A new approach of duality in nonlinear programming.*

The goal of the present investigation is to introduce the third order duality in nonlinear programming problems, because in certain situations,fi rst and second order duality do not yield solutions where as the third order duality succeeds in fi nding the desirable results. Desired duality theorems are proved for the pair of primal and the corresponding third order dual problem. Again the above results are proved for the variational problems. The importance of the present work is justi fied through appropriate counterexamples. It is also seen that many existing results of previous authors are particular cases of the present works. (Received April 11, 2017)

1133-90-23 **Murat Adivar*** (madivar@uncfsu.edu), 1200 Murchison Rd, Fayetteville, NC 28301, and **Shu-Cherng Fang** (fang@ncsu.edu), Industrial and Systems Engineering, College of Engineering, Raleigh, NC 27695. *Convex Analysis and Duality over Discrete Domains.*

The aim of this paper is to establish a fundamental theory of convex analysis for the sets and functions over a discrete domain. By introducing conjugate/biconjugate functions and a discrete duality notion for the cones over discrete domains, we study duals of optimization problems whose decision parameters are integers. In particular, we construct duality theory for integer linear programming, provide a discrete version of Slater's condition that implies the strong duality and discuss the relationship between integrality and discrete convexity. (Received May 08, 2017)

91 ► Game theory, economics, social and behavioral sciences

1133-91-70 **Alec N Kercheval*** (akercheval@fsu.edu). *A jump threshold approach to credit risk.* Preliminary report.

We describe a structural credit risk model framework where the default event corresponds to the first jump of a firm's stock price below a given (possibly stochastic) threshold. This has the tractability of the much simpler reduced form models while still connecting to endogenous stock price information. The method handles multidimensional problems via the Levy copula, and can be extended to stochastic volatility of the underlying stock while still yielding explicit formulas for the default time distribution and prices of credit default swaps. Contributors to this work include Pierre Garreau, Chun-Yuan Chiu, and Chenchen Zhou. (Received July 11, 2017)

92 ► Biology and other natural sciences

1133-92-7 **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, Louisiana State University, 301 Lockett Hall, Field House Drive, Baton Rouge, LA 70803-4918. *Stability and Robustness Analysis for a Multispecies Chemostat Model with Delays in the Growth Rates and Uncertainties.*

The chemostat is a laboratory device and a mathematical model for the continuous culture of microorganisms. Chemostat models have been studied extensively, because of their importance in biotechnology and ecology. The well known competitive exclusion principle for chemostat models of multiple species competing for one limiting nutrient gives general conditions under which only one species persists. However, it is often observed in experiments that multiple competing species can persist in chemostats with one limiting substrate. Numerous methods have been developed to generate or explain coexistence in chemostats. For instance, Jean-Luc Gouze and Gonzalo Robledo provided sufficient conditions for coexistence of multiple species in chemostat models with one limiting substrate and with nonnegative constant species inputs. Here we study generalized versions of the Gouze-Robledo models with delays and uncertainties whose equilibria allow persistence of multiple species. We derive bounds on the delays that ensure asymptotic stability of the equilibria when the uncertainties are zero. Under delays and uncertainties, we provide bounds on the delays and on the uncertainties that ensure input-to-state stability of the equilibria. This work is joint with Frederic Mazenc and Gonzalo Robledo. (Received February 23, 2017)

1133-92-20 **Mustafa Hajij*** (mhajij@usf.edu), tampa, FL 33647, **Natasha Jonoska** (jonoska@mail.usf.edu), tampa, FL 33647, and **Masahico Saito**. *Graph Based Analysis for Gene Segment Interactions In a Scrambled Genome.*

Oxytricha trifallax, a species of ciliate, undergoes massive genome rearrangements during the development of a somatic macronucleus (MAC) from a germline micronucleus (MIC). Gene segments of MDSs locaed in MIC contig can oberlap, included, or interleaved. We represent these gene segment interactions by graphs, with vertices and edges corresponding to MAC genes and their interactions, respectively. Then we use common graph properties to represent these graphs as a data cloud in a Euclidean space, to apply the topological data analysis (TDA). The cluster formations under the TDA is presented, and the genes isolated from the major cluster is identified and studied. (Received May 07, 2017)

1133-92-31 **Alan Paris*** (atparis@knights.ucf.edu), **Azadeh Vosoughi**, **George Atia** and **Stephen A. Berman**. *A Maximum Entropy Principle for 1/f-type Noises in Neurological Systems.*

Neurological signals have high noise at all scales, from ion channels to EEG. This noise is not mere interference: simple models of channel noise have supported breakthroughs yielding several Nobel prizes and it is likely that cognition depends on noise. Neurological noise signals are often of the $1/f$*-type*; i.e., with power spectra $S(f) \sim 1/f^\theta$ for a range of frequencies f and a *spectral exponent* $\theta > 0$. Unusual spectral exponents may be associated with diseases such as Alzheimer's. Also common are the *Lorentzian noises* with

$$S(f) \sim \int_{\mathrm{T}} \frac{\mathrm{d}w(\tau)}{1 + (2\pi\tau)^2},$$

where T is related to the eigenvalues and w to the eigenvectors of a *hidden Markov model*. But there has been no systematic principle to select these eigenvectors or relate the $1/f$ and Lorentzian families and it has been claimed that there can be no such principle. But we have shown that a maximum entropy optimization in a simple quantum mechanical setting can, in fact, give rise to Lorentzian noises with $1/f^\theta$ spectral characteristics in which θ is a *Lagrange multiplier*. The resulting family of noises shows superior performance in *brain-computer interface* algorithms. (Received June 02, 2017)

1133-92-63 **Elena S Dimitrova*** (edimit@clemson.edu), O-303 Martin Hall, Clemson, SC 29634. *Molecular Network Control Through Boolean Canalization.*

Boolean canalization, a type of hierarchical clustering of the inputs of a Boolean function, has been extensively studied in the context of network modeling where each layer of canalization adds a degree of stability in the dynamics of the network. Recently, dynamic network control approaches have been used for the design of new therapeutic interventions and for other applications such as stem cell reprogramming. This talk will discuss the role of canalization in the control of Boolean molecular networks and present a method for identifying the potential edges to control in the wiring diagram of a network for avoiding undesirable state transitions. (Received July 08, 2017)

1133-92-107 **Liming Cai**, **Xue-Zhi Li**, **Necibe Tuncer** and **Maia Martcheva*** (maia@ufl.edu), Departent of Mathematics, 358 Little Hall, University of Florida, Gainesville, FL 32611, and **Abid Ali Ashari**. *Optimal control of a malaria model with asymptomatic class and superinfection.*

We introduce a malaria model with an asymptomatic class in human population, exposed classes in human and vector populations, re-infection of asymptomatic individuals, and incomplete treatment of symptomatic individuals. The model exhibits backward bifurcation generated by two mechanisms; standard incidence and superinfection. Simulations suggest that total prevalence of malaria is the highest if all individuals show symptoms upon infection, but then undergo an incomplete treatment and the lowest when all individuals first move to the symptomatic class then are treated successfully. We study optimal control strategies applied to bed-net use and treatment as main tools for reducing the total number of symptomatic and asymptomatic individuals. Simulations suggest that the optimal control always leads to decrease in the symptomatic infectious individuals, but may lead to increase in the number of asymptomatic infectious individuals. This last scenario occurs if a large portion of newly infected individuals move to the symptomatic class but many of them do not complete treatment. (Received July 15, 2017)

1133-92-153 **Robert Stephen Cantrell*** (rsc@math.miami.edu), Department of Mathematics, The University of Miami, Coral Gables, FL 33124, and **Brian Coomes** and **Yifan Sha**. *Analysis of a model inspired by a nano-ecology experiment.*

In this talk we employ a discrete-diffusion modeling framework to examine a system inspired by the nano-ecology experiments on the bacterium Escherichia coli reported upon in Keymer et al. (2006). In these experiments, the bacteria inhabit a linear array of 85 microhabitat patches "(MHP's)", linked by comparatively thinner corridors through which bacteria may pass between adjacent MHP's. Each MHP is connected to its own source of nutrient substrate, which flows into the MHP at a rate that can be controlled in the experiment. Logistic dynamics are assumed within each MHP, and nutrient substrate flow determines the prediction of the within MHP dynamics in the absence of bacteria dispersal between patches. Patches where the substrate flow rate is sufficiently high sustain the bacteria in the absence of between patch movement and may be regarded as sources, while those with insufficient substrate flow lead to the extinction of the bacteria in the within patch environment and may be regarded as sinks. We examine the role of dispersal in determining the predictions of the model under source-sink dynamics. (Received July 23, 2017)

1133-92-167 **Carina Curto*** (ccurto@psu.edu). *Topological organization of neural networks.*
Neural networks serve as data summaries and dynamic models of neural activity in the brain. Recently, methods from topological data analysis have been used to gain insights into the structure of such networks, using various types neural activity data. In this talk, we will turn our attention to how network structures uncovered by topological methods might shape dynamics. We will illustrate these ideas in the context of threshold-linear networks of simple neurons, whose dynamics are controlled purely by the pattern of connectivity as defined by a directed graph. This enables us to study directly the role of connectivity in shaping network dynamics, without worrying about effects stemming from the intrinsic properties of neurons. Here we find some interesting connections between topologically-relevant features of the network structure and its dynamic attractors. We also identify some aspects of the connectivity that are not picked up by standard tools, but may be amenable to new types of topological analyses. (Received July 24, 2017)

1133-92-175 **Paola Bonizzoni***, Viale Sarca 336, 20126 Milan, Italy, and **Gianluca Della Vedova**.
Reconstructing and comparing the evolution of genomic mutations from discrete data.
The reconstruction of trees from discrete data and the comparison of trees built from different methods are two closely related fundamental topics in Computational Biology. With the advent of next generation sequencing (NGS) technologies, these research topics have gained a renewed attention from mathematicians and computer scientists since NGS data are cheaply and widely available, hence making the construction of large phylogenies a necessity, even in fields that were not explored before. Two important examples of problems in this direction are (1) inferring an evolutionary history in cancer genomics, and (2) reconstructing an evolutionary history of species from the evolution of several independently- evolved genes. We discuss some recent results on a general combinatorial framework for modeling the reconstruction of evolutionary trees under a generalization of the Perfect Phylogeny model. We first explore the algorithmic solutions based on a graph modeling of the problem of reconstructing trees from binary data. Then we show a related approach based on the idea of completing matrices obeying certain constraints: this approach leads to a solution based on Integer Linear Programming. We show the applications of these concepts to evolutionary cancer genomics. (Received July 24, 2017)

1133-92-197 **Angela Angeleska*** (aangeleska@ut.edu) and **Zoran Nikoloski** (nikoloski@mpimp-golm.mpg.de). *Coherent Network Partitions.*
The main motivation for our study of network partitions was the clustering problem in biological networks with applications to gene function and functional module prediction. The clique and biclique partition problems have found applications in biclustering of microarray data and analysis of gene co-expression. Therefore, the new type of partitions that we introduce and study here, called coherent partitions, are also relevant in the aforementioned fields. A coherent partition of a graph G is defined as a vertex partition that yields partition composed only of disconnected subgraphs in the complement of G. In addition, a coherent number of a graph G is defined as the size of the minimum edge cut over all coherent partitions of G. Coherent partitions (coherent numbers) are studied in connection to clique and biclique partitions (clique and biclique cover numbers). We also investigate the complexity of the problem of finding optimal coherent partitions, which is polynomial for trees, but NP in general. (Received July 25, 2017)

1133-92-198 **Michael Li**, **Weishi Liu** and **Chunhua Shan*** (chunhua.shan@utoledo.edu), Toledo, OH 43606, and **Yingfei Yi**. *Turning points and relaxation oscillations in an epidemic model.*
We study the interplay between effects of disease burden on the host population and the effects of population growth on the disease incidence in an SIR type epidemic model. Under the assumption that the host population has a small intrinsic growth rate, using singular perturbation techniques and the phenomenon of the delay of stability loss due to turning points, we prove the existence of large-amplitude relaxation oscillation cycles, which contrast sharply to oscillations via Hopf bifurcation. Simulations are provided to support the theoretical results. Our results offer new insight into the classical periodicity problem in epidemiology. (Received July 25, 2017)

1133-92-202 **Jemal Mohammed-Awel*** (jmohammedawel@valdosta.edu), 1500 North Patterson Street, Valdosta, GA 31698, and **Ruijun Zhao**, **Eric Numfor** and **Suzanne Lenhart**.
Management Strategies in a Malaria Model Combining Human and Transmission-Blocking Vaccines.
We propose a new mathematical model studying control strategies of malaria transmission. The control is a combination of human and transmission-blocking vaccines and vector control (larvacide). When the disease induced death rate is large enough, we show the existence of a backward bifurcation analytically if vaccination control is not used, and numerically if vaccination is used. The basic reproduction number is a decreasing function of the vaccination controls as well as the vector control parameters, which means that any effort on

these controls will reduce the burden of the disease. Numerical simulation suggests that the combination of the vaccinations and vector control may help to eradicate the disease. We investigate optimal strategies using the vaccinations and vector controls to gain qualitative understanding on how the combinations of these controls should be used to reduce disease prevalence in malaria endemic setting. Our results show that the combination of the two vaccination controls integrated with vector control has the highest impact on reducing the number of infected humans and mosquitoes. (Received July 25, 2017)

1133-92-206 **Javier Arsuaga*** (jarsuaga@ucdavis.edu), Dept. of Mol. & Cell. Biology and Mathematics, One Shields Avenue, Davis, CA 95616. *Topological Analysis of Chromosome Conformation Capture Data.* Preliminary report.

Chromosome Conformation Capture (CCC) has revolutionized chromosome biology by uncovering information of the 3D genome that was completely inaccessible by other experimental techniques. The data obtained in a CCC experiment, contact probabilities between different loci of the genome, are estimations of a true underlying distance map between the genomic loci. In this work we first show that the fractal model for mammalian 3D organization is one of several models that are in a agreement with the CCC data and that in fact current CCC methodologies cannot determine the topology of a dense chromosome system (such as the human genome). We end by characterizing some 3D patterns that can be unequivocally extracted from a distance map. (Received July 25, 2017)

1133-92-210 **Libin Rong*** (libinrong@ufl.edu), Math Department, Univ of Florida, Gainesville, FL 32611. *Multistage models in HIV infection and treatment.*

HIV infection and replication involves multiple intracellular processes. Different classes of antiretroviral drugs target different stages. Some studies showed that patients receiving the integrase inhibitor raltegravir based therapy were faster to achieve undetectable viral load than other therapy and that treatment intensification with raltegravir led to a lower viral load and an increase in 2-LTR, a marker for ongoing viral replication. In this talk, using multistage models we will provide a quantitative and systematic comparison of the effect of different drug classes on HIV decay dynamics and particularly explain the viral load decline in HIV patients treated with raltegravir-based regimens. We will also evaluate the influence of raltegravir intensification on viral load and 2-LTR dynamics in HIV patients on suppressive antiretroviral therapy. (Received July 26, 2017)

1133-92-217 **Fidel Barrera-Cruz**, **Christine Heitsch** and **Svetlana Poznanović*** (spoznan@clemson.edu). *The Structure of the Branching Polytopes for RNA Structures.*

Like proteins, RNA assumes complex three-dimensional structures to perform specific roles and understanding this structure helps our understanding of the ways the noncoding RNAs perform their regulatory functions. That is why the problem of finding methods that can quickly and reliably identify the structure of a given RNA has been an important problem in computational biology. However, the methods developed still vary widely in the prediction accuracy. An important component of this problem is predicting the secondary structure, which identifies both the canonically base-paired regions (helices) and non-paired regions (loops). In this work we focus on understanding the effects of the parameters used for scoring the multibranch loops in the nearest-neighbor thermodynamic model. For this purpose, for each RNA we built and analyzed a so called branching polytope. We discovered that there is a lot of structural similarity in the normal fans of these branching polytopes as the nucleotide sequences change. In this talk I will present our findings. (Received July 26, 2017)

1133-92-219 **Robert Stephen Cantrell**, **Chris Cosner*** (gcc@math.miami.edu) and **Xiao Yu**. *Dynamics of populations with individual variation in dispersal on bounded domains.*

Most classical models for the movement of organisms assume that all individuals have the same patterns and rates of movement, but there is empirical evidence that movement rates and patterns may vary among individuals. One way to capture variation in dispersal is to allow individuals to switch between two distinct dispersal modes. We consider models for populations with logistic-type local population dynamics whose members can switch between two different nonzero rates of diffusion. The resulting reaction-diffusion systems can be cooperative at some population densities and competitive at others. We analyze the dynamics of such systems on bounded regions. (Traveling waves and spread rates have been studied by others for similar models in the context of biological invasions.) The analytic methods include ideas and results from reaction-diffusion theory, semi-dynamical systems, and bifurcation/continuation theory. (Received July 26, 2017)

1133-92-220 **Amir H Assadi*** (ahassadi@wisc.edu), 3407 Circle Close, Madison, WI 53705, and **Hamid Eghbalnia** (heghbalnia@gmail.com), Madison, WI 53706. *Biological Computation at Molecular and Cellular Scales.* Preliminary report.

Biological Computation at Molecular and Cellular Scales. Formation of bacterial biofilms (quorum sensing QS) is a highly complex dynamical behavior. QS is studied for decades by micro-/molecular-biologists, and plays a key role in bacterial toxicity, pathology (e.g. Cystic Fibrosis by Pseudomonas aeruginosa) and bioremediation. Advances in bacterial genomics reveal that Quorum Sensing involves a highly-organized system of biochemical interactions of genomic origin that reflect evolutionary and physiological diversification. We propose for a model of biological computation inspired by QS. We outline the steps to verify computation steps from transformation of the measurements from the relevant biological molecular/cellular events. Acknowledgement. Partial Financial Support by NSF. (Received July 26, 2017)

1133-92-229 **Ileana Streinu*** (istreinu@smith.edu), Smith College, Computer Science Department, 100 Green Street, Northampton, MA 01063, and **Mojtaba Nouri Bygi** (mnouribygi@smith.edu), Smith College, Computer Science Department, 100 Green Street, Northampton, MA 01063. *Efficient protein rigidity and flexibility analysis for large scale applications.* Preliminary report.

Pebble game rigidity analysis is an efficient method for extracting rigidity and flexibility information of biomolecules without performing costly molecular dynamics simulations. The algorithm works on a multi-graph associated to a mechanical model constructed from an arbitrary atom-bond network. Motivated by large scale protein flexibility and simulated unfolding applications, we have developed a faster and more robust variation tailored to the specificities of bio-polymers. We demonstrate this new 'backbone pebble game' as implemented in the new release of our software Kinari-2. (Received July 26, 2017)

1133-92-259 **Sergei S. Pilyugin*** (pilyugin@ufl.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611, and **Jan Medlock** and **Patrick De Leenheer**. *The effectiveness of marine protected areas for fish populations with varying mobility.*

Marine protected areas (MPAs) are regions in the ocean where fishing is restricted or prohibited. It is expected that upon establishment of MPA, the ratio of fish densities inside and outside of MPA (the local ratio) must decrease with fish mobility as diffusive coupling typically tends to equalize the density gradients, but there exists a body of experimental evidence to the contrary. In this talk, I will discuss the interplay between various factors and types of species mobility that affect the local effect. (Received July 28, 2017)

1133-92-270 **Rafik Neme*** (rn2419@cumc.columbia.edu), 710 West 168th Street, Office 712, Dept of Biochemistry and Molecular Biophysics, New York, NY 10032, and **Jaspreet Khurana**, **Derek Covert**, **Masahico Saito**, **Natasha Jonoska** and **Laura F Landweber**. *Topological, evolutionary and molecular insights from ciliate genome rearrangements.* Preliminary report.

Ciliates are unicellular eukaryotes with two different types of nuclei. Their nuclei have partitioned genetic inheritance (micronucleus) from the instructions that cells need to function, i.e. transcription (macronucleus). During sexual conjugation, ciliates exchange micronuclear material, and destroy their macronucleus. Following conjugation, the cell regenerates the macronucleus by editing a copy of the micronucleus. In Oxytricha trifallax this process involves the selective removal of more than 90% of the genome, and approximately one third of the remaining material undergoes drastic rearrangements. Rearrangements can be studied as topological problems, assuming that the remodeling reactions (breaking, folding, ligation) alter DNA topology. We explore the molecular functions that carry out DNA remodeling in O. trifallax and their relatives. Using evolutionary and comparative genomics, we are able to combine ideas about the origin and function of these genes, with mathematical approaches to understand possible relationships between the topology of the DNA, its functional elements, and the molecular evolutionary forces shaping this complex system. (Received July 28, 2017)

1133-92-328 **Jorge X. Velasco-Hernandez*** (jx.velasco@im.unam.mx), Cerro Coporo 16, Campestre Churubusco, Coyoacán, 04200 Mexico, CDMX, Mexico. *On the theoretical consequences of vector- and sexual transmission when simultaneously involved in the spread of an infectious disease.*

We describe some mathematical models framed in differential equations to understand the dynamics of spread of the Zika, considering vector and sexual transmission. The analysis of these models allows us to have a clear view of the effects of sexual transmission versus vector transmission in the spread of the virus (Received July 31, 2017)

1133-92-332 **Abba Gumel*** (agumel@asu.edu), School of Mathematical and Stat. Sciences, Tempe, AZ 85287, **Kamaldeen Okuneye**, Tempe, AZ 85287, and **Steffen Eikenberry**. *Modeling the effect of temperature on the dynamics of malaria vector.*

Temperature (ambient and water) is known to significantly affect the transmission dynamics of mosquito-borne diseases. This talk presents a new model for the population biology of malaria mosquitoes, that take into account the lifecycle of the mosquito, the gonotrophic cycle of the vector and the parasite's sporogonic cycle. Suitable temperature ranges for maximum mosquito abundance (hence, malaria incidence) will be presented. (Received July 31, 2017)

1133-92-347 **Shigui Ruan*** (ruan@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33146. *Modeling the Transmission Dynamics of Avian Influenza H7N9 Virus in China.*

In March 2013, a novel avian-origin influenza A (H7N9) virus was identified among human patients in China and a total of 124 human cases with 24 related deaths were confirmed by May 2013. There were no reported cases in the summer and fall 2013. However, the virus has been coming back in November every year. In fact, the second outbreak from November 2013 to May 2014 caused 130 human cases with 35 deaths, the third outbreak from November 2014 to June 2015 caused 216 confirmed human cases with 99 deaths, the fourth outbreak from November 2015 to July 2016 caused 114 confirmed human cases and 45 deaths, respectively. The current outbreak starting from November 2016 has caused hundreds of cases and deaths. In this talk, I will introduce some recent studies on modeling the transmission dynamics of the avian influenza A (H7N9) virus from birds to humans and apply our models to simulate the open data for numbers of the infected human cases and related deaths reported by the Chinese Center for Disease Control and Prevention. The basic reproduction number R_0 is estimated and sensitivity analysis of R_0 in terms of model parameters is performed. Our studies demonstrate that H7N9 virus has been well established in birds and will cause regular outbreaks in humans again in the future. (Received August 01, 2017)

1133-92-352 **Lauren L. Sullivan** and **Bingtuan Li***, Department of Mathematics, University of Louisville, Louisville, KY 40292, and **Tom E. X. Miller**, **Michael G. Neubert** and **Allison K. Shaw**. *Density Dependence in Demography and Dispersal Generates Fluctuating Invasion Speeds.*

It is well-known that density dependence generates temporal fluctuations in population density. However, the ways in which density dependence affects spatial population processes, such as species invasions, is less understood. In this talk, we explore endogenous density dependence as a mechanism for inducing variability in biological invasions with a set of integro-difference population models that incorporate density dependence in demographic or dispersal parameters. We show that density dependence in demography at low populatio densities—i.e., an Allee effect—combined with spatiotemporal variability in density behind the invasion front can produce fluctuations in spreading speed. The necessary density fluctuations behind the front can arise from either overcompensatory population growth or from density-dependent dispersal, both of which are common in nature. Our results demonstrate that simple rules can generate complex spread dynamics, and highlight a novel source of variability in biological invasions that may aid in ecological forecasting (Received August 01, 2017)

1133-92-370 **Christine Heitsch*** (heitsch@math.gatech.edu). *Strings, trees, and RNA folding.*

Under a suitable abstraction, complex biological problems can reveal surprising mathematical structure. We will illustrate this phenomenon — without assuming any biological knowledge beyond high school. As will be explained, a challenging open problem in molecular biology (i.e. RNA folding) is nicely abstracted to discrete models (e.g. strings and trees). In this way, we prove theorems which yield insight into the structure, and therefore function, of RNA molecules. We also obtain some new results in combinatorics which are of interest independent of their original biological motivation. Thus, the interaction of discrete mathematics and molecular biology is both fruitful for the former while also beneficial for the latter. (Received August 01, 2017)

1133-92-371 **Keith A. Carlson*** (keith.carlson@ucf.edu), Department of Mathematics, University of Central Florida, 4393 Andromeda Loop N., Orlando, FL 32816. *Mathematical Modeling of Infectious Diseases with Latency: Homogeneous Mixing and Contact Network.*

In mathematical epidemiology, the standard compartmental models assume homogeneous mixing in the host population, in contrast to the disease spread process over a real host contact network. One approach to incorporating heterogeneous mixing is to consider the population to be a network of individuals whose contacts follow a given probability distribution. Here we investigate in analogy both homogeneous mixing and contact network models for infectious diseases that admit latency periods, such as dengue fever, Ebola, and HIV. We consider

the mathematics of the compartmental model as well as the network model, including the dynamics of their equations from the beginning of disease outbreak until the disease dies out. After considering the mathematical models we perform software simulations of the disease models. We consider epidemic simulations of the network model for three different values of $(R)_0$ and compare the peak infection numbers and times as well as disease outbreak sizes and durations. We examine averages of these numbers for one thousand simulation runs for three values of $(R)_0$. Finally we summarize results and consider avenues for further investigation. (Received August 01, 2017)

93 ► Systems theory; control

1133-93-19 **Michael Malisoff*** (malisoff@lsu.edu), Louisiana State University, Department of Mathematics, 301 Lockett Hall, Baton Rouge, LA 70803-4918. *Bounded Backstepping for Nonlinear Control Systems.*

Systems and controls is a central area at the interface of applied mathematics and engineering that develops methods for influencing the behavior of dynamical systems to achieve some objective. One approach involves feedbacks, which are ways to automatically adjust the behavior of a system, in response to information about the system's own state and surroundings. One desirable objective is global asymptotic stabilization, which requires that all trajectories of the system converge to a desired set of states. For systems having certain structures, feedback stabilization can often be done using backstepping, which is a recursive method for building feedback controllers by first building controllers for subsystems of the original systems. However, standard backstepping does not lend itself to global asymptotic feedback stabilization for systems of differential equations that are nonlinear in the state variables and where there are also boundedness constraints on the allowable control values. This talk provides an approach to feedback stabilization for broad classes of systems in a partially linear form, based on a new bounded backstepping approach that produces controls that satisfy boundedness constraints. This work is joint with Frederic Mazenc, Jerome Weston, and others. (Received May 07, 2017)

1133-93-142 **Haimei Shao*** (hshao@bbandt.com) and **Jiongmin Yong**. *Does the Fed make mistakes?*

The original Taylor Rule has been a benchmark for monetary policy, which traces the actual monetary policy well during Greenspan's era, however, the Fed did not follow the original Taylor Rule after the great recession of 2008. In fact, the Fed followed variants of the Taylor rule since 2008. By reconciling the actual monetary policy using historical data, we nd that (1) the Fed puts more weights on unemployment rate rather than GDP growth; (2) the Fed considers the participants rate as well as unemployment rate; (3) the Fed also considers the financial market conditions which is not included in the original Taylor rule. This study leads us to reflect what the optimal policy would be in the future U.S. economy that baby boomers are retiring, the government debt is historically high and the Tax cut is possibly on its way.

Keywords: Monetary Policy, Fed Funds Rate, Unemployment Rate, Inflation,financial market condition, baby boomer, tax cut. (Received July 21, 2017)

1133-93-335 **Abdulla Ugur** (abdulla@fit.edu) and **Roby Poteau*** (rpoteau2010@my.fit.edu). *Identification of Parameters in Systems Biology.* Preliminary report.

We analyze class of inverse problems in systems biology on the identification of parameters for the system of nonlinear ODEs with the given solution in particular time interval. We apply numerical method suggested in *U.G.Abdulla, Journal of Optimization Theory and Applications, 85, 3(1995), 509-526*, which combines quasi-linearization, sensitivity analysis and Tikhonov regularization. Numerical simulations with and without noise are performed in Lotka-Volterra model, Lorenz system in chaotic regime, bistable switch model, gene regulation and repressilator models from synthetic biology, and a canonical genetic regulatory network model. Numerical results demonstrate quadratic convergence. We pursue Tikhonov regularization with optimal choice of the regularization parameter, which significantly increases the convergence range of the initial guess, and computational time. (Received July 31, 2017)

94 ► Information and communication, circuits

1133-94-52 **John J. Benedetto** and **Weilin Li*** (wl298@math.umd.edu). *Super-resolution by means of Beurling minimal extrapolation.*

We address the super-resolution question: Given spectral data defined on a finite set of d-dimensional multi-integers, of all complex Radon measures on the d-dimensional torus whose Fourier transform equals this data,

does there exist exactly one with minimal total variation? We first note that this is a mathematical formulation of a large class of super-resolution problems that arise in image processing. We prove a theorem that has quantitative implications about the possibility and impossibility of constructing such a unique measure. Our method introduces the notion of an admissibility range that fundamentally connects Beurling's theory of minimal extrapolation with the Candes and Fernndez-Granda theory of super-resolution. The method is also well-suited for the construction of explicit examples. (Received July 03, 2017)

1133-94-257 **Umberto Mosco*** (mosco@wpi.edu), Prof. Umberto Mosco, Department of Mathematics - WPI, 100 Institute Road, Worcester, MA 01609. *On a* $1D$ *approximation of the* $2D$ *Laplacian.*

On a $1D$ *approximation of the* $2D$ *Laplacian*

Abstract

We describe how the $2-$dimensional Laplacian can be approximated on a square by a sequence of $1-$dimensional Laplacians. This result shows that $1D$ particle dynamics can generate asymptotically a distributed $2D$ interaction. The construction is based on convergence properties of filling-space fractal curves and Sobolev spaces. (Received July 28, 2017)

00 ► General

1134-00-2 **Pavel Etingof** (aba@ams.org), Massachusetts Institute of Technology. *Double affine Hecke algebras and their applications.*

Double affine Hecke algebras (DAHAs) were introduced by I. Cherednik 25 years ago to prove Macdonald's conjectures. A DAHA is the quotient of the group algebra of the elliptic braid group attached to a root system by Hecke relations. DAHAs and their degenerations are now central objects of representation theory. They also have numerous connections to many other fields – integrable systems, quantum groups, knot theory, algebraic geometry, combinatorics, and others. In my talk, I will discuss the basic properties of double affine Hecke algebras and touch upon some applications.
(Received June 15, 2016)

1134-00-24 **Andrew M Stuart***, astuart@caltech.edu. *Ensemble Kalman Inversion.* Preliminary report.

The ensemble Kalman filter (EnKF) is a widely used methodology for state estimation in partial, noisily observed dynamical systems, and for parameter estimation in inverse problems. Despite its widespread use in the geophysical sciences, and its gradual adoption in many other areas of application, analysis of the method is in its infancy. Furthermore, much of the existing analysis deals with the large ensemble limit, far from the regime in which the method is typically used. In this talk we analyze the method when applied to inverse problems with fixed ensemble size. A continuous-time limit is derived and the long-time behavior of the resulting interacting particle dynamical system is studied. Hierarchical inversion is considered, along with the basic form of ensemble inversion.

For linear inverse problem we demonstrate that the continuous time limit of the EnKF corresponds to a set of gradient flows for the data misfit in each ensemble member, coupled through a common pre-conditioner, the empirical covariance matrix of the ensemble. Numerical results demonstrate that the conclusions of the analysis extend beyond the linear inverse problem setting. Applications are shown in geophysical inverse problems and in classification problems from machine learning. (Received June 12, 2017)

1134-00-110 **Alvin Kim*** (alvin.kim@live.com), 22529 Kent Ave, Torrance, CA 90505. *Considerations on problems with infinitely many solutions.*

A majority of the problems in the math community involves solving for all the solutions that satisfy a certain set of conditions. On the contrary, finding only some of the solutions can also be useful, especially for proving for infinitely many solutions. One of the most famous examples is Euclid's proof, showing the existence of infinitely many prime numbers. Looking through problems in the Gazeta Matematica, I have collected a group of problems involving proof for infinitely many solutions, and have categorized them into two main groups: proofs by general solutions and proofs by induction. Further, I have come up with my own problems to add on to each of the two categories. (Received August 27, 2017)

1134-00-206 **Murray Schacher*** (mms@math.ucla.edu), 3203 Wellesly Ave, San Diego, CA 92122. *Norms in central simple algebras.*

We give a ring theoretic proof of a theorem about products of supersingular elliptic curves. (Received September 05, 2017)

1134-00-378 **Abror Khudoyberdiyev**, **Bennett Rennier**, **James Francese** and **Anastasia Voloshinov***, avoloshi@usc.edu. *On the Classification of Leibniz and Nilpotent Algebras of Level Two.*

In this paper, we give a classification of all non-Lie Leibniz algebras, up to isomorphism, which degenerate directly to an algebra of level one. Two of these are nilpotent. We then show that all nilpotent algebras of level two are Leibniz, and isomorphic to one of these two non-Lie Leibniz algebras, or one of the nilpotent level two Lie algebras already identified by Khudoyberdiyev. Thus, we provide a classification of all nilpotent algebras of level two. (Received September 11, 2017)

03 ► Mathematical logic and foundations

1134-03-84 **Nicholas Ramsey*** (nramsey@math.berkeley.edu), 970 Evans Hall, Berkeley, CA 94703. *Around exact saturation.*

Given a singular cardinal κ and a complete theory T, we say T has exact saturation at κ if there is a κ-saturated model of T that is not κ^+-saturated. It is easy to see that stable theories and the random graph have exact saturation at every singular cardinal, while a dense linear order has exact saturation at no singular cardinal– accordingly, failure of exact saturation may be regarded as an avatar of linear order and one might attempt to classify theories according to whether they do or do not have exact saturation. We will describe recent work, joint with Itay Kaplan and Saharon Shelah, which offers several variations on this theme. (Received August 22, 2017)

1134-03-228 **Allen Gehret*** (allen@math.ucla.edu), 520 Portola Plaza MSB 6363, Los Angeles, CA 90095. *Distal and non-distal ordered abelian groups.*

It is a classical result of Gurevich and Schmitt (1984) that ordered abelian groups have NIP (the *non-independence property*). Two refinements of NIP theories that we wish to consider are distality (a notion of pure instability) and dp-minimality (a notion of tameness). We conjecture that for the class of ordered abelian groups, these two notions coincide. Janhke, Simon, and Walsberg (2017) proved that an ordered abelian group G is dp-minimal iff there is a prime p such G/pG is infinite; thus the job is to prove that this same property also characterizes the distal ordered abelian groups. In this talk I will report on progress towards resolving this conjecture. This is joint work with Matthias Aschenbrenner and Artem Chernikov. (Received September 06, 2017)

1134-03-282 **Matthias Aschenbrenner*** (matthias@math.ucla.edu), UCLA, Department of Mathematics, P.O. Box 951555, Los Angeles, CA 90095-1555. *Strong automorphisms of the differential field of transseries.* Preliminary report.

The differential field $\mathbb{T}$ of transseries comes with a natural notion of infinite summation. I plan to explain what we know about the the group of automorphisms of $\mathbb{T}$ which preserve infinite sums. This gives insight into definability in $\mathbb{T}$, and is motivated by our investigation of dimension for definable sets in $\mathbb{T}$. Joint work with Lou van den Dries and Joris van der Hoeven. (Received September 10, 2017)

1134-03-296 **Lynn Scow*** (lynn.scow@csusb.edu). *Transfer of the Ramsey property by semi-retractions.*

Given a class $\mathcal{K}$ of finite L-structures, say that a copy of A in B is any L-substructure of B isomorphic to A. We say that $\mathcal{K}$ has the Ramsey property if for all $A, B \in \mathcal{K}$ there is $C \in \mathcal{K}$ so that for all 2-colorings of copies of A in C, there is a copy B' of B in C, all of whose copies of A are colored the same color under this coloring.

In this talk we introduce a weaker form of bi-interpretability and see how it can be used to transfer the Ramsey property across classes in different first-order languages. This is a special case of a more general theorem about what we will call color-homogenizing embeddings. (Received September 10, 2017)

1134-03-303 **Aaron W Anderson*** (awanders@caltech.edu) and **Martino Lupini**. *The Fraïssé Limit of Finite Dimensional Matrix Algebras with the Rank Metric.*

We show that a certain ring, $M(\mathbb{F}_q)$, constructed by von Neumann and realized as the coordinate ring of a continuous geometry, can also be realized as the metric Fraïssé limit of the class of finite-dimensional matrix algebras over a finite field $\mathbb{F}_q$, equipped with the rank metric. Von Neumann constructed $M(\mathbb{F}_q)$ as the completion of the direct limit of an inductive sequence of matrix rings, and showed that the resulting ring does not depend on the choice of sequence. We provide an alternate proof of the latter by the uniqueness of the Fraïssé limit. We show that the automorphism group of this metric structure is extremely amenable, implying (by the metric Kechris-Pestov-Todorcevic correspondence) an approximate Ramsey Property. We also provide an explicit bound for the approximate Ramsey Property. Both the extreme amenability result and the Ramsey Property bound rely on work by Carderi and Thom, who proved that $M(\mathbb{F}_q)$'s unit group is extremely amenable. (Received September 12, 2017)

1134-03-394 **Silvain Rideau***, silvain.rideau@berkeley.edu, and **Ehud Hrushovski**. *Groups and fields definable in algebraically closed valued fields.*

In this talk, our goal will be to study groups interpretable in algebraically closed valued fields and, in particular those groups that have an invariant stably dominated type as they play a central role.

We will, first, show that all Abelian groups are extensions of groups internal to the residue field by groups that are unions of stably dominated groups. We will then show how stably dominated groups can be described in terms of group schemes over the valuation ring. Finally we will use those results to show that any field

interpretable in an algebraically closed is either the valued fields itself or its residue field. (Received September 12, 2017)

1134-03-403 **C Ward Henson*** (henson@math.uiuc.edu), 1409 W. Green St., Urbana, IL 61801. *Axiomatizable classes of Banach spaces via disjointness preserving automorphisms.* Preliminary report.

Here $\mathcal{C}$ is a class of Banach lattices and $\mathcal{C}^{\mathcal{B}}$ is the class of underlying Banach spaces of members of $\mathcal{C}$. Both are considered as classes of metric structures, using continuous model theory with appropriate signatures. Recently Yves Raynaud published the following result [Thm 3.7, in *Positivity*, 2017]:

Theorem 1: Assume $\mathcal{C}$ is axiomatizable, and every $X \in \mathcal{C}$ satisfies: (a) X is order continuous; and (b) every linear isometric embedding from X into an ultrapower of X is disjointness preserving. Then $\mathcal{C}^{\mathcal{B}}$ is axiomatizable.

Using model theory more explicitly (especially definability in continuous model theory), one can improve Theorem 1 by weakening assumption (b):

Theorem 2: Assume $\mathcal{C}$ is axiomatizable, and every $X \in \mathcal{C}$ satisfies: (a) X is order continuous; and (b) every surjective linear isometric map from X onto X is disjointness preserving. Then $\mathcal{C}^{\mathcal{B}}$ is axiomatizable.

These theorems yield new examples and simpler proofs of known examples. (Received September 12, 2017)

1134-03-423 **Charles Steinhorn*** (steinhorn@vassar.edu), Department of Mathematics and Statistics, Vassar College, 124 Raymond Ave., Poughkeepsie, NY 12604. *Asymptotic and multidimensional asymptotic classes of finite structures: a survey.* Preliminary report.

Asymptotic classes of finite structures and *measurable structures* were introduced by D. Macpherson and the author in an effort to develop a model theory for classes of finite structures that reflects contemporary infinite model theoretic themes. The subject has been further developed by Macpherson's Ph.D. students. Some of this work is reviewed in this talk, following which current research that generalizes these concepts to what are called *multidimensional asymptotic classes* and *generalized measurable structures* will be discussed. This most recent work is joint with Macpherson, S. Anscombe, and D. Wolf.

(Received September 12, 2017)

1134-03-455 **Samuel Birns*** (sbirns@hawaii.edu), Department of Mathematics, University of Hawaii at Manoa, 2565 McCarthy Mall (Keller Hall 401A), Honolulu, HI 96822. *On Maximally Complex Binary Words.* Preliminary report.

We provide results relating to the conjecture that there exist arbitrarily long binary words of maximal complexity, where a word is maximally complex if its automatic complexity is equal to the upper bound described by Hyde and Kjos-Hanssen. We additionally investigate open questions about basic properties of maximal complexity, specifically relating to the conditions that force maximal complexity to respect concantenation and restriction, and describe results that suggest characterizations of both of these. Finally, we provide evidence in favor of the equivalence of two distinct definitions of automatic complexity and state a conjecture regarding the growth of the automatic complexity function. (Received September 12, 2017)

05 ► Combinatorics

1134-05-33 **Vladimir D Tonchev*** (tonchev@mtu.edu), Department of Mathematical Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931. *Resolvable Steiner designs and maximal arcs in finite projective planes.*

Let $D = \{X, \mathcal{B}\}$ be a Steiner 2-$(v, k, 1)$ design with point set X, collection of blocks $\mathcal{B}$, and let v be a multiple of k, $v = nk$. A *parallel class* is a set of $v/k = n$ pairwise disjoint blocks, and a *resolution* is a partition R of $\mathcal{B}$ into $r = (v-1)/(k-1)$ disjoint parallel classes. A design is *resolvable* if it admits a resolution. Two resolutions R_1, R_2,

$$R_1 = P_1^{(1)} \cup P_2^{(1)} \cup \cdots P_r^{(1)},\ R_2 = P_1^{(2)} \cup P_2^{(2)} \cup \cdots P_r^{(2)}$$

are *compatible* if they share one parallel class, $P_i^{(1)} = P_j^{(2)}$, and $|P_{i'}^{(1)} \cap P_{j'}^{(2)}| \leq 1$ for $i' \neq i$ and $j' \neq j$.

In this talk, we discuss an upper bound on the maximum number of mutually compatible resolutions of a resolvable 2-$(nk, k, 1)$ design D. The bound is attainable if and only if D is embeddable as a maximal $(kq - q + k, k)$-arc in a projective plane of order $q = (v-k)/(k-1)$.

The maximal sets of mutually compatible resolutions of 2-$(52, 4, 1)$ designs associated with maximal $(52, 4)$-arcs in the known projective planes of order 16 have been computed recently. The results of these computations show that some 2-$(52, 4, 1)$ designs are embeddable as maximal arcs in two different planes. (Received June 28, 2017)

1134-05-43 **Joshua P Swanson*** (jps314@uw.edu). *Major Index Asymptotics.*

We discuss the representation theory and asymptotic behavior of major index statistics for words and tableaux.

Classic work of MacMahon gave a succinct expression for the major index generating function on words of fixed content. Canfield-Janson-Zeilberger (2011) gave precise asymptotic estimates for the number of such words with a given major index. In another direction, Lusztig and Stanley related the major index statistic on standard tableaux to the graded irreducible decomposition of the type A coinvariant algebra. Kraskiewicz-Weyman connected the major index modulo n to the Lusztig-Stanley decomposition and certain induced representations. We will describe recent work giving precise estimates for the number of standard tableaux with a given major index, modulo n. A key step involves certain normalized symmetric group character estimates. Time permitting, we will also describe ongoing joint work with Sara Billey and Matjaž Konvalinka generalizing Canfield-Janson-Zeilberger's investigations to skew shape tableaux. (Received July 12, 2017)

1134-05-60 **Georgia Benkart**, **Laura Colmenarejo**, **Pamela E Harris**, **Rosa Orellana**, **Greta Panova** and **Anne Schilling*** (anne@math.ucdavis.edu), Department of Mathematics, University of California, One Shields Avenue, Davis, CA 95616, and **Martha Yip**. *A minimaj-preserving crystal on ordered multiset partitions.*

We provide a crystal structure on the set of ordered multiset partitions, which recently arose in the pursuit of the Delta Conjecture. This conjecture was stated by Haglund, Remmel and Wilson as a generalization of the Shuffle Conjecture. Various statistics on ordered multiset partitions arise in the combinatorial analysis of the Delta Conjecture, one of them being the minimaj statistic, which is a variant of the major index statistic on words. Our crystal has the property that the minimaj statistic is constant on connected components of the crystal. In particular, this yields another proof of the Schur positivity of the graded Frobenius series of the generalization $R_{n,k}$ due to Haglund, Rhoades and Shimozono of the coinvariant algebra R_n. The crystal structure also enables us to demonstrate the equidistributivity of the minimaj statistic with the major index statistic on ordered multiset partitions. (Received August 07, 2017)

1134-05-65 **Alexander Garver**, **Rebecca Patrias** and **Hugh Thomas*** (hugh.ross.thomas@gmail.com). *Robinson-Schensted-Knuth for minuscule posets.* Preliminary report.

Let P be a minuscule poset. I will discuss a version of the Robinson-Schensted-Knuth correspondence which bijects arbitrary functions from P to $\mathbb{N}$ to functions from P to $\mathbb{N}$ which are order-preserving. In type A this is a rather general form of RSK which has been studied by Pak, among others. In other types it seems to be new. We define the correspondence using nilpotent endomorphisms of quiver representations. By relating piecewise-linear rowmotion to Auslander-Reiten translation in the derived category of quiver representations, we give a uniform proof of the periodicity of the former. (Received August 11, 2017)

1134-05-67 **Sami Assaf*** (shassaf@usc.edu), 3620 S. Vermont Ave, Los Angeles, CA 90089. *Nonsymmetric Macdonald polynomials and Demazure characters.*

We prove that nonsymmetric Macdonald polynomials specialized at t=0 expand as a positive graded sum of Demazure characters, and that the coefficients in the expansion give a refinement of the Kostka–Foulkes polynomials. (Received August 14, 2017)

1134-05-93 **Jeffrey B. Remmel*** (jremmel@ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gillman Drive, La Jolla, CA 92093-0112, and **Mahir B. Can** (mahirbilencan@gmail.com), Department of Mathematics, Tulane University, 6823 St. Charles Ave, New Orleans, LA 70118. *Loop-augmented forests and a variant of Foulkes' conjecture.* Preliminary report.

A loop-augmented forest is a labeled rooted forest with loops on some of its roots. By exploiting the interplay between nilpotent partial functions and labeled rooted forests, we investigate the permutation action of the symmetric group on loop-augmented forests. Our work led us to conjecture a variant of Foulkes conjecture on plethsyms of symmetric functions of which we can prove a special case. Other important outcomes of our analysis are a complete description of the stabilizer subgroup of an idempotent in the semigroup of partial transformations and a generalization of the Knuth-Sagan hook length formula. (Received August 23, 2017)

1134-05-120 **Kyungyong Lee*** (klee24@unl.edu). *The Laurent expressions for cluster variables associated to acyclic quivers.* Preliminary report.

It has been an open problem to find a combinatorial formula for the Laurent expressions of cluster variables associated to mutation-infinite quivers. We make first progress toward this problem. We propose a manifestly

positive and directly computable formula for cluster variables associated to acyclic quivers. (Received August 28, 2017)

1134-05-130 **Connor Thomas Ahlbach*** (c_ahlbach@yahoo.com), 1901 NE 85th St., Apt. #311, Seattle, WA 98115, and **Josh Swanson**. *Refined Cyclic Sieving on Words for the Major Index Statistic.*

Reiner-Stanton-White defined the cyclic sieving phenomenon (CSP) associated to a finite cyclic group action and a polynomial. A key example arises from the length generating function for minimal length coset representatives of a parabolic quotient of a finite Coxeter group. In type A, this result can be phrased in terms of the natural cyclic action on words of fixed content. There is a natural notion of refinement for many CSP's. We formulate and prove a refinement, with respect to the major index statistic, of this CSP on words of fixed content by also fixing the cyclic descent type. The argument presented is completely different from Reiner-Stanton-White's representation-theoretic approach. It is combinatorial and largely, though not entirely, bijective in a sense we make precise with a "universal" sieving statistic on words, "flex". A building block of our argument involves cyclic sieving for shifted subset sums, which also appeared in Reiner-Stanton-White. We give an alternate, largely bijective proof of a refinement of this result by extending some ideas of Wagon-Wilf. (Received August 29, 2017)

1134-05-136 **Ed Allen**, **Joshua Hallam** and **Sarah Mason*** (masonsk@wfu.edu), 127 Manchester Hall, Winston Salem, NC 27109. *Dual immaculate quasisymmetric functions expand positively into quasisymmetric Schur functions.*

We discuss the connection between two recently introduced bases for quasisymmetric functions, both of which are natural quasisymmetric analogs of Schur functions due to the combinatorial properties they exhibit. The quasisymmetric Schur functions are obtained through specializations of Macdonald polynomials. The dual immaculate basis is dual to a basis for non-commutative symmetric functions constructed through non-commutative Berenstein creation operators. Both bases can be defined using tableaux-like objects. We describe a Remmel-Whitney-style algorithm for writing a dual immaculate quasisymmetric function as a positive sum of quasisymmetric Schur functions. We also explore properties of the insertion algorithm used to prove this decomposition. (Received August 30, 2017)

1134-05-153 **Jake Levinson*** (jlev@uw.edu) and **Maria Gillespie**. *Axioms for shifted tableau crystals.* Preliminary report.

We give a combinatorially-local characterization of the crystal-like structure on shifted semistandard tableaux. This crystal structure is formed by two pairs of raising and lowering operators, each of which are coplactic for shifted jeu de taquin. Our description is in terms of local axioms satisfied by these operators. The axioms turn out to resemble those discovered by Stembridge for regular $\mathfrak{gl}_n$ crystals. This is joint work with Maria Gillespie. (Received September 01, 2017)

1134-05-154 **Maria M Gillespie*** (mgillespie@math.ucdavis.edu), **Jake Levinson** and **Kevin Purbhoo**. *A crystal-like structure on shifted tableaux.*

We describe operators on (skew) shifted semistandard tableaux which are coplactic for (Type B) shifted jeu de taquin. These operators give rise to a crystal-like structure on such tableaux, recovering the combinatorics of Schur Q-functions and the Littlewood-Richardson rule for the odd orthogonal Grassmannian. This is joint work with Jake Levinson and Kevin Purbhoo. (Received September 01, 2017)

1134-05-178 **Monica Vazirani*** (vazirani@math.ucdavis.edu), Mathematics Department, One Shields Ave, Davis, CA 95616. *Combinatorics, Categorification, and Crystals.*

Categorification attempts to replace algebraic and geometric structures with more general categories. It has enjoyed amazing successes, such as Khovanov homology categorifying the Jones polynomial, KLR algebras categorifying quantum groups, or Soergel bimodules categorifying Hecke algebras. The payoffs to finding these richer, higher categorical structures include applications like constructing finer knot invariants, as well as proving positivity results and producing some fantastic mathematics. In this talk, I will focus on quantum groups. Their crystal bases or canonical bases exhibit the positivity and integrality that is a trademark feature of a decategorified structure. My launch point is the type A combinatorics of Young diagrams, which encode the representation theory of the symmetric group and also form a crystal–the crystal graph of the basic representation of $\mathfrak{sl}_\infty$. This is not a coincidence. The symmetric groups categorify the basic representation, with induction and restriction functors descending to raising and lowering operators. This phenomenon generalizes to all symmetrizable types, replacing the symmetric groups with cyclotomic Khovanov-Lauda-Rouquier (KLR) algebras. See http://dx.doi.org/10.1090/noti1593 to read more. (Received September 12, 2017)

1134-05-208 **Anna Weigandt*** (weigndt2@illinois.edu). *Prism Tableaux and Alternating Sign Matrices.*

A prism tableau is an overlay of semistandard tableaux. In joint work with A. Yong, prism tableaux were used to provide a formula for Schubert polynomials. This expression directly generalizes the tableau rule for Schur polynomials. We study fillings of more general prism shapes. The resulting polynomials are multiplicity free sums of Schubert polynomials. Each prism shape determines an alternating sign matrix. This allows us to give a prism formula for the multidegree of an alternating sign matrix variety. (Received September 05, 2017)

1134-05-222 **Marko Thiel*** (markth@math.uzh.ch). *From Anderson to Zeta.*

In the study of the Hilbert series of the space of diagonal harmonics, many new combinatorial bijections were introduced, such as the Zeta map of Haglund and Loehr and the Anderson map of Gorsky, Mazin and Vazirani. We interpret both of these bijections in the language of affine reflection groups, thereby generalizing them from the symmetric group case to all Weyl groups. (Received September 06, 2017)

1134-05-234 **Anna, Ying Pun*** (annapunying@gmail.com), **Jonah Blasiak**, **Jennifer Morse** and **Daniel Summers**. *Generalized Kostka-Foulkes polynomials and k-Schur functions.*

In the late 1990's, Shimozono and Weyman conjectured a formula for a generalization of the Kostka-Foulkes polynomials in terms of catabolizable tableaux and charge. Li-Chung Chen generalized this conjecture to a much larger class of polynomials and further conjectured that a certain subset of these are the coefficients in the Schur expansions of k-Schur functions. We will give some of the background surrounding these conjectures and then discuss recent progress. This is joint work with Jonah Blasiak, Jennifer Morse, and Dan Summers. (Received September 07, 2017)

1134-05-268 **Damir Yeliussizov*** (damir@math.ucla.edu), 520 Portola Plaza Math Science room 6363 UCLA, Los Angeles, CA 90095. *Schur operators and identities for skew stable Grothendieck polynomials.*

Stable Grothendieck polynomials are certain symmetric powers series that can be viewed as a K-theoretic analog of Schur polynomials. Using noncommutative Schur operators we prove skew Cauchy identity for families of dual Grothendieck polynomials. We then derive various formulas that generalize properties of Schur functions. This approach gives new natural instances of dual filtered Young graphs. (Received September 09, 2017)

1134-05-279 **Dylan C Rupel*** (drupel@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556. *On Kontsevich Automorphisms and Quiver Representations.*

In this talk I will describe a combinatorial construction of non-commutative Laurent polynomials arising from iterations of polynomial Kontsevich automorphisms acting on the skew-field of rational functions in two non-commutative variables. Using these foundational results I will discuss implications on the geometry of quiver Grassmannians, this part of the talk is based upon joint work with Thorsten Weist. (Received September 09, 2017)

1134-05-316 **Jon McCammond**, **Hugh Thomas*** (hugh.ross.thomas@gmail.com) and **Nathan Williams**. *Fixed points of parking functions.* Preliminary report.

We define an action of words in $\{0, 1, \ldots, m-1\}^n$ on $\mathbb{R}^m$, and use it to give a new characterization of rational parking functions: they are exactly those words whose action has at least one fixed point. From this viewpoint, we give an equivalent definition of Gorsky, Mazin, and Vazirani's zeta map on rational parking functions with m and n coprime, and we prove that it is invertible. (Received September 11, 2017)

1134-05-325 **E Richmond** and **V Tewari*** (vasut@math.washington.edu). *Noncommutative LR coefficients.* Preliminary report.

In this talk, I will present two different perspectives on computing the structure coefficients that arise when multiplying two noncommutative Schur functions. One concerns Lascoux-Schützenberger's frank words and crystals operators on composition tableaux, while the other concerns a polyhedral decomposition of the Pak-Vallejo's Littlewood-Richardson cone.

This is joint work with Ed Richmond. (Received September 11, 2017)

1134-05-326 **Susanna Fishel*** (sfishel1@asu.edu), **Luc Lapointe** and **Maria-Elena Pinto**. *Quasisymmetric functions in superspace.* Preliminary report.

Symmetric functions in superspace were developed to study the supersymmetric version of the quantum Calogero-Sutherland model of identical particles on a circle. They are a generalization of symmetric functions: we still have the variables $x_1, x_2, \ldots$ and additionally we have anticommuting variables $\theta_1, \theta_2, \ldots$. Superspace analogues

of Macdonald, Jack, and Schur polynomials have been defined in a series of papers by Desrosiers and others. I will discuss quasisymmetric functions in superspace. This is work in progress, joint with Luc Lapointe and Maria-Elena Pinto. (Received September 11, 2017)

1134-05-361 **Reuven Hodges*** (hodges.r@husky.neu.edu). *Levi subgroup actions on Schubert varieties in the Grassmannian.*

There is a natural action of certain Levi subgroups on a Schubert variety in the Grassmannian. I will describe the decomposition of the homogeneous coordinate ring of such a Schubert variety into irreducible representations for the induced actions of these Levi subgroups. One nice application of these decomposition results is the ability to show that many classes of Schubert varieties are spherical varieties under these Levi subgroup actions. (Received September 11, 2017)

1134-05-377 **Brendan Pawlowski** and **Brendon Rhoades*** (bprhoades@math.ucsd.edu). *Line configurations, ordered set partitions, and the Delta Conjecture.*

The *coinvariant ring* R_n is a graded S_n-module whose algebraic properties are deeply tied to permutations in S_n. Motivated by the *Delta Conjecture* of Macdonald theory, Haglund, Rhoades, and Shimozono recently defined a *generalized coinvariant ring* $R_{n,k}$ whose algebraic properties are governed by k-block ordered set partitions of size n. We define a variety $X_{n,k}$ whose cohomology is given by $R_{n,k}$; in the case $k = n$ this reduces to Borel's result that R_n is the cohomology of the flag manifold. (Received September 11, 2017)

1134-05-395 **Megan Ly*** (megan.ly@colorado.edu). *Schur–Weyl Duality for Unipotent Upper Triangular Matrices.*

Schur–Weyl duality is a fundamental framework in combinatorial representation theory. It intimately relates the irreducible characters of the symmetric group to the irreducible characters of the general linear group via their commuting actions on tensor space. We investigate the analog of Schur-Weyl duality for the group of unipotent upper triangular matrices over a finite field. In this case, the character theory of these upper triangular matrices is unattainable. Thus we employ a generalization, known as supercharacter theory, to create a striking variation on the character theory of the symmetric group with combinatorics based on set partitions. We present a combinatorial structure that encodes the decomposition of a tensor space into supercharacters in order to describe the maps that centralize the action of the group of unipotent upper triangular matrices. (Received September 12, 2017)

1134-05-396 **Nathaniel Thiem*** (thiemn@colorado.edu). *Superclass walks on unipotent polytopes.* Preliminary report.

One of the nice applications of combinatorial representation theory is the use of characters in bounding mixing times of random walks. This talk examines a family of random walks coming from finite unipotent groups that are in fact walks on a family of polytopes (including hypercubes, and generalizations of both transportation and Birkhoff polytopes). I will introduce these walks, the underlying representation theory, and their associated combinatorics with a particular emphasis on the polytopes built out of placements of non-attacking rooks. (Received September 12, 2017)

1134-05-401 **Cara Monical*** (cmonica2@illinois.edu), 1409 W. Green Street, Urbana, IL 61801, and **Neriman Tokcan** and **Alexander Yong**. *Newton Polytopes in Algebraic Combinatorics.*

A polynomial has saturated Newton polytope (SNP) if every lattice point in the convex hull of its exponent vectors corresponds to a monomial. We compile instances of SNP in algebraic combinatorics, and show the phenomenon is widespread in many of the polynomial families of interest. We also give explicit inequalities for the Newton polytope of the Schubert polynomials based on the diagram of the permutation. (Received September 12, 2017)

1134-05-409 **Eugene Gorsky** and **Mikhail Mazin***, mmazin@math.ksu.edu, and **Monica Vazirani**. *Rational Slope Dyck Paths in the Non-Relatively Prime Case.*

In the relatively prime case, the rational (n, m)-Dyck paths are in bijection with the (n, m)-invariant subsets of integers, considered up to shifts. This bijection provides a connection between rational Catalan combinatorics and the geometry of certain algebraic varieties. In particular, it allows one to reinterpret the dinv statistic as the dimension of the corresponding complex affine cell in an affine Springer fiber. The non-relatively prime case is more complicated. Although on the combinatorial side many things can be generalized, including the dinv statistic and even Shuffle conjecture (theorem), there is no known generalization of the geometric interpretation of the dinv statistic. In this talk, I will explain how one can extend the bijection between rational Dyck paths and the invariant subsets in Z to the non-relatively prime case. The natural obstacle is that the set of invariant subsets

is not finite in the non-relatively prime case. One has to consider certain equivalence relation on the invariant subsets to make the bijection work. The hope is that this construction will lead to a geometric or representation theoretic interpretation of the dinv statistic in the non-relatively prime case. (Received September 12, 2017)

1134-05-411 **Matthew T Hogancamp*** (hogancam@usc.edu). *Torus links and Catalan combinatorics.*
I will present on recent progress in understanding the q,t Catalan polynomials (and generalizations) and their relation to the Khovanov-Rozansky homology of torus links. Specifically, I will present a simple new recursion, motivated by connections to topology, for the q,t Fuss-Catalan polynomials. One can also generalize these recursions to give (conjectural) formulas for the anti-invariant part of Haiman's polygraph rings, in terms of the Khovanov-Rozansky homology of the (n, nk) torus links, via a conjecture communicated to me by Gorsky. (Received September 12, 2017)

1134-05-439 **Ezgi Kantarcı Oğuz*** (kantarci@usc.edu), **Sami Assaf** and **Danjoseph Keeny Quijada**. *Fundamental Slide Polynomials and Generalized Lattice Paths.* Preliminary report.
The fundamental slide polynomials are a lifting of the fundamental quasisymmetric polynomials to the full polynomial ring, with interesting connections to Schubert polynomials and Demazure characters. We consider the principal specialization given by substituting $x_i = q^i$ and give a combinatorial interpretation in terms of lattice paths that stay under a fixed path dependent on the indexing composition. This is joint work with Sami Assaf and Danjoseph Quijada. (Received September 12, 2017)

1134-05-442 **Chris Roman Miller*** (crmiller@math.berkeley.edu). *Catabolism and Littlewood-Richardson Coefficients.*
We state a conjecture that generalized Littlewood-Richardson coefficients can be computed by counting certain catabolizable tableaux. We motivate the conjecture, and outline a proof for certain cases. (Received September 12, 2017)

1134-05-451 **Ira M Gessel** (gessel@brandeis.edu), **Sean Griffin*** (stgriff@uw.edu) and **Vasu Tewari** (vasut@math.washington.edu). *A representation-theoretic interpretation of Gessel's tree symmetric function.*
The first author introduced a multivariate formal power series tracking the distribution of ascents and descents in labeled binary trees. In addition to showing that it was a symmetric function, he conjectured it was Schur-positive. In this talk, we show how to expand this symmetric function positively in terms of ribbon Schur functions. In fact, a refinement of this conjecture holds; we get a family of Schur-positive functions indexed by certain intervals in the Tamari lattice. I will also present our progress in constructing the corresponding symmetric group representations and how certain specializations of the symmetric function relate to actions on hyperplane arrangements. (Received September 12, 2017)

1134-05-454 **Matthew T Hogancamp*** (hogancam@usc.edu). *Braids, symmetric functions, and shuffle conjectures.*
A recent conjecture of Gorsky-Negut-Rasmussen has the following combinatorial consequence: to each braid β there should be a "character" $\chi(\beta) \in \Lambda_{q,t}$ satisfying a number of properties, where $\Lambda_{q,t}$ is the ring of q, t symmetric functions. This character should be a q, t deformation of a classical character map for permutations (send a permutation to $e_{\lambda_1} \cdots e_{\lambda_r}$, where $\lambda = (\lambda_1, \ldots, \lambda_r)$ is the cycle type). In this talk I will discuss some expected properties of such a character map; for instance the operation of inserting a positive 360 degree twist in a braid should correspond to the Bergeron-Garsia ∇ operator on symmetric functions. I will also discuss how an analogy with recent computations of torus link homology informs aspects of the shuffle conjecture and its generalizations. In particular, we present a new conjectural refinement of the $(n, nk + 1)$ rational shuffle conjecture. (Received September 12, 2017)

08 ► General algebraic systems

1134-08-329 **Karl Schmidt*** (karls@uoregon.edu). *Factorizable Module Algebras.*
The aim of this talk is to introduce and study a large class of $\mathfrak{g}$-module algebras which we call *factorizable*, generalizing the Gauss factorization of (square or rectangular) matrices. This class includes appropriate localizations of coordinate algebras of corresponding reductive groups G, their parabolic subgroups, basic affine spaces and many others. It turns out that tensor products of certain factorizable algebras are also factorizable. We also have quantum versions of all these constructions in the category of $U_q(\mathfrak{g})$-module algebras. Quite surprisingly,

our quantum factorizable algebras are naturally acted on by the quantized enveloping algebra $U_q(\mathfrak{g}^*)$ of the dual Lie bialgebra $\mathfrak{g}^*$ of $\mathfrak{g}$. (Received September 11, 2017)

11 ► Number theory

1134-11-22 **Sally Moite*** (smoite@yahoo.com). *First Open Numbers And Goldbach's Conjecture.* Preliminary report.

Choose arbitrary remainders, one for each prime up to a last prime (LP). From the numbers 1,2,3,4,5, . . . eliminate numbers congruent to + or - any of these remainders mod the respective prime leaving a first open number (FON). A problem is to find the maximum first open number (MFON) for any choice of remainders. Some computed results are presented for last primes up to 43, as well as a conjecture on an upper limit for the MFON as a function of LP. If this conjecture is true, it would prove Goldbach's Theorem. Some elements of the computations are presented, along with some results for partial computations for last primes up to 2753. (Received August 25, 2017)

1134-11-309 **Abhinav R Ganesh*** (montuganesh@yahoo.com). *Investigations in Number Theory and Calculus.*

In our presentation we discuss the solutions to several problems published in American Regions Mathematics League (ARML) and the Romanian monthly Mathematical Gazette. The inspirations for the solutions comes from the Fullerton Mathematical Circle, the outreach program of the Department of Mathematics at Cal State Fullerton. The solutions explore interesting properties of equations and roots, functions, and exponents along with polynomials. The content of our presentation is accessible to undergraduate students. (Received September 10, 2017)

1134-11-310 **Dong Dong***, Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801, and **Xiaochun Li** and **Will Sawin**. *Roth theorem in finite fields and its connection to algebraic geometry.*

Recently, Bourgain and Chang initiated the study of the existence of 3-term polynomial progressions in subsets of a finite field. Their theorem is a natural analogue of Roth Theorem (1953). We will show how this problem is related with Deligne and Katz's work on exponential sums. This bridge between number theory and algebraic geometry is, very interestingly, harmonic analysis. (Received September 10, 2017)

1134-11-346 **Nicholas J. Newsome*** (nnews001@ucr.edu). *Symmetry of the Power Sum Polynomials.*

Sums of powers of integers have been studied extensively for many centuries. The Pythagoreans, Archimedes, Fermat, Pascal, Bernoulli, Faulhaber, and other mathematicians have discovered formulas for sums of powers of the first n natural numbers. Among these is Faulhaber's well-known formula which expresses the power sums as polynomials whose coefficients involve Bernoulli numbers.

In this talk, we give an elementary proof that for each natural number p, the sum of pth powers of the first n natural numbers can be expressed as a polynomial in n of degree $p+1$. We also prove a novel identity involving Bernoulli numbers and use it to show symmetry of these polynomials. In addition, we make a few conjectures regarding the roots of these polynomials, and speculate on the asymptotic behavior of their graphs. (Received September 11, 2017)

1134-11-386 **Matthias Flach*** (flach@caltech.edu), Caltech, Pasadena, CA 91125, and **Baptiste Morin**. *Higher class number formulas.*

We report on joint work with B. Morin in which we give a description of the vanishing order and leading Taylor coefficient of the Zeta function of a proper regular arithmetic scheme at any integer argument. This description generalizes ideas of Lichtenbaum and is compatible with the Tamagawa number conjecture of Bloch, Kato, Fontaine and Perrin-Riou. For the Dedekind Zeta function of a number field F it amounts to a higher class number formula., and it is completely proven if F is absolutely abelian. (Received September 12, 2017)

12 ► Field theory and polynomials

1134-12-218 **Hans Schoutens***, 365 Fifth Ave, Dept of Mathematics, NYC, NY 10016. *Defining affine space.*

It is a hard but important problem to distinguish affine space geometrically from other algebraic varieties (equivalently, to determine when an algebra is a polynomial ring), as the problem is linked to many long open

standing problems like the Jacobian Conjecture, Zariski Cancelation, etc. A more recent approach uses locally nilpotent derivations (or an equivalent version via additive group actions). I will propose a first-order version of this, and describe a theory whose Noetherian models are precisely the affine spaces (over some ground field). (Received September 05, 2017)

13 ► Commutative rings and algebras

1134-13-236 **Eleonore Faber** and **Greg Muller***, Department of Mathematics, University of Oklahoma, Norman, OK 73019, and **Karen E Smith**. *Non-commutative resolutions of toric rings (via conic modules).* Preliminary report.

Toric rings (and the associated toric varieties) are typically singular. Resolutions of these singularities are well-known, and can be defined in terms of the associated polyhedral objects. However, this requires making choices, and so these resolutions are not unique.

In this talk, I will describe a non-commutative resolution of any toric ring which is canonical (up to Morita equivalence). This non-commutative resolution may be given as the endomorphism algebra of a sum of 'conic modules', which maybe be classified in terms of a certain periodic hyperplane arrangement. In fact, the combinatorics of this hyperplane arrangement gives special resolutions of these conic modules.

As an application, we deduce that the ring of differential operators of a toric ring with positive characteristic has finite global dimension. (Received September 07, 2017)

1134-13-383 **Pavel Etingof**, **Victor Ostrik** and **Siddharth Venkatesh*** (sidnv@mit.edu). *Commutative Algebra in the Verlinde Category.*

A classical theorem of Deligne states that symmetric tensor categories in characteristic zero with subexponential growth are almost Tannakian in that they are fibered over supervector spaces. For fusion categories, Ostrik extended this theorem to positive characteristic by replacing supervector spaces with the Verlinde category. Consequently, every symmetric fusion category is the representation category of a commutative Hopf algebra in Verlinde.

I will begin by introducing the Verlinde category and showing that finitely generated algebras in it are Noetherian and have finitely generated invariants. The proof uses the connection between the Verlinde category and tilting modules for SL_2 to show that any such algebra is a nilpotent thickening of its invariants. Subsequently, I will use this idea to strengthen Ostrik's theorem and show that fiber functors from a symmetric fusion category to the Verlinde category are unique up to isomorphism. I will end by introducing the notion of super Frobenius-Perron dimension and use it to provide decomposition formulas for images of objects under the Verlinde fiber functor and for symmetric powers of simples in Verlinde. The latter formulas generalize the Cayley-Sylvester formula for the number of invariants of binary forms. (Received September 12, 2017)

14 ► Algebraic geometry

1134-14-68 **Wenhao Ou*** (wenhaoou@math.ucla.edu), 520 Portola Plaza, Los Angeles, CA 90095. *Positivity of tangent bundles.*

During the last few decades, much progress has been made in classification of complex algebraic varieties. From the viewpoint of Minimal Model Program, projective manifolds should be classified according to "sign" of their canonical class K_X. It is then natural to ask how far we can lift the positivity or the negativity of K_X to the cotangent bundle. In the positive case, Miyaoka showed that if K_X is pseudoeffective, then the cotangent bundle is generically nef, that is, its restriction to a curve cut out by general sufficiently ample divisors is a nef vector bundle. If moreover K_X is nef, he also showed that the second Chern class of X has non-negative intersection numbers with ample divisors in this case. We are interested in the negative case. We show that if $-K_X$ is nef, then the tangent bundle is generically nef, and the second Chern class of X has the same positivity as before. We also investigate under which conditions the postivities would be strict. (Received September 08, 2017)

1134-14-88 **Humberto A. Diaz*** (humbertd@ucr.edu). *SOME NILPOTENCE THEOREMS FOR CHOW MOTIVES.*

Using fundamental results of Deligne, we prove (under a suitable hypothesis) a nilpotence theorem for Chow motives with rational coefficients and give some applications of it (e.g., show how it may be used to prove the Chow-Künneth conjecture for certain varieties). We also prove a torsion nilpotence result for surfaces, using the same strategy. (Received August 22, 2017)

1134-14-94 **Emily Clader*** (eclader@sfsu.edu). *Wall-crossing in Gromov-Witten and Landau-Ginzburg theory.*

The theory of quasi-maps, developed in recent work of Ciocan-Fontanine and Kim, is a generalization of Gromov-Witten theory that depends on an additional stability parameter varying over positive rational numbers. When that parameter tends to infinity, Gromov-Witten theory is recovered, while when it tends to zero, the resulting theory encodes information related to the "B-model". Ciocan-Fontanine and Kim proved a wall-crossing formula exhibiting how the theory changes with the stability parameter, and in this talk, we discuss an alternative proof of their result as well as a generalization to other gauged linear sigma models. This is joint work with Felix Janda and Yongbin Ruan. (Received August 23, 2017)

1134-14-114 **Martin Gallauer*** (gallauer@math.ucla.edu). *Tensor triangular geometry of Tate motives.*

We study Tate motives with integral coefficients through the lens of tensor triangular geometry. For some base fields, including the field of algebraic numbers, we arrive at a complete description of the tensor triangular spectrum and a classification of thick tensor ideals. (Received August 27, 2017)

1134-14-149 **Burt Totaro*** (totaro@math.ucla.edu). *Rationality in families.*

We discuss the recent proof by Kontsevich and Tschinkel, inspired by work of Nicaise and Shinder, that rationality specializes in families of smooth projective varieties. That is, if most varieties in the family are rational, then all are rational. By contrast, we give an example to show that rationality does not specialize among projective varieties with terminal singularities. (Received September 01, 2017)

1134-14-184 **Daping Weng*** (daping.weng@yale.edu), 3 Trumbull St, New Haven, CT 06511. *Donaldson-Thomas Transformation of Grassmannian.*

On the one hand, there is a 3d Calabi Yau category with stability conditions associated to a quiver without loops or 2-cycles with generic potential, and one can study its Donaldson-Thomas invariants. On the other hand, such a quiver also defines a cluster Poisson variety, which often has geometric realizations. In certain cases, the Donaldson-Thomas invariants of the former can be captured by a birational automorphism of the latter. In this talk, I will describe the cluster Poisson structure on the moduli space of configurations of points in a projective space, and state my result on the geometric realization of the corresponding cluster Donaldson-Thomas transformation. (Received September 04, 2017)

1134-14-250 **James McKernan*** (jmckernan@math.ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gilman Drive # 0112, La Jolla, CA 92093-0112. *Broken Arrows.*

We describe recent work with Morgan Brown to do with unstable vector bundles and zero dimensional schemes. (Received September 08, 2017)

1134-14-252 **Elden Elmanto*** (eldenelmanto@gmail.com), 2033 Sheridan Road, Evanston, IL 60208, and **Marc Hoyois**, **Adeel Khan**, **Maria Yakerson** and **Vladimir Sosnilo**. *Motivic Infinite Loop Spaces.*

I will describe a resolution to the problem of recognizing an infinite $\mathbb{P}^1$-loop space in motivic homotopy theory. This uses an $(\infty-)$category $\mathrm{Corr}^{\mathrm{fr}}$ whose objects are smooth schemes and morphisms are spans where the left legs are finite, flat, local complete intersections equipped with a trivialization of its cotangent complex.

This is joint work with Marc Hoyois, Adeel Khan, Vladimir Sosnilo and Maria Yakerson. (Received September 08, 2017)

1134-14-301 **Roman Fedorov**, **Alexander Soibelman*** (asoibelm@usc.edu) and **Yan Soibelman**. *Motivic classes for moduli of Higgs bundles and moduli of connections on a curve.*

In their paper, "On the motivic class of the stack of bundles", Behrend and Dhillon derive a formula for the class of the stack of vector bundles on a curve in a completion of the Grothendieck ring of varieties. Later, Mozgovoy and Schiffmann performed a similar computation in order to obtain the number of points over a finite field for the moduli stack of semistable twisted Higgs bundles. We will briefly introduce motivic classes. Then, following Mozgovoy and Schiffmann's approach, we will outline an argument for computing motivic classes for the moduli stack of Higgs bundles on a curve and use it to compute the class of the stack of vector bundles with connections. (Received September 10, 2017)

1134-14-343 **Omprokash Das*** (das@math.ucla.edu), UCLA Mathematics Department, MS Building 6363, 520 Portola Plaza, Los Angeles, CA 90095. *Kawamata-Viehweg Vanishing Theorem for regular del Pezzo Surfaces over imperfect fields in characteristic $p > 3$.*

The Kawamata-Viehweg vanishing theorem, which is a generalization of the Kodaira vanishing theorem, is one of the fundamental tools used in the higher dimensional minimal model program in characteristic zero. However, this powerful theorem fails in positive characteristic, counterexamples are known to exist. Despite this negative result, it has long been believed that the Kawamata-Viehweg vanishing theorem should still hold for smooth del Pezzo surfaces in positive characteristic. Recently Cascini, Tanaka and Witaszek showed that indeed it holds for smooth del Pezzo surfaces, they also showed that the same vanishing theorem more generally holds for KLT log del Pezzo surfaces over algebraically closed field of sufficiently high characteristic. On the other side of the spectrum, in 2016 Maddock constructed an example of a regular del Pezzo surface over an imperfect field of characteristic 2 violating the Kodaira vanishing theorem. More recently, Patakfalvi and Waldron showed that the Kodaira vanishing holds for del Pezzo surfaces over imperfect fields of characteristic $p > 3$. In this talk, I will show that the Kawamata-Viehweg vanishing theorem holds for regular del Pezzo surfaces over imperfect fields of characteristic $p > 3$. (Received September 11, 2017)

1134-14-397 **Shuai Guo** and **Dustin Ross*** (rossd@sfsu.edu), Department of Mathematics, San Francisco State University, 1600 Holloway Avenue, San Francisco, CA 94132. *Genus-One Global Mirror Symmetry.*

Global mirror symmetry is a physical phenomenon wherein two sigma models share a common family of mirror manifolds, resulting in two descriptions of the same physical system. In the mathematical context, global mirror symmetry suggests a relationship between virtual counts of curves in a degree-d hypersurface and virtual counts of abstract curves with dth roots of their canonical line bundle. I'll briefly describe this correspondence and recent work that verifies the global mirror symmetry predictions for genus-one curves. (Received September 12, 2017)

1134-14-404 **Yordanka Aleksandrova Kovacheva*** (ykovacheva12@gmail.com), 1401 E 55 Str Apt 807N, Chicago, IL 60615. *Height Pairing for Cycles and Determinant Line Bundle.*

I present my work on height pairing of cycles modulo relations and the corresponding determinant line bundle and point directions for future research. More specifically, I consider the map $CH^p(X) \times CH^q(X) \to Pic(S)$ of Chow groups of a variety X over a base S. Here $p+q = d+1$, where d is the relative dimension of the morphism $X \to S$. I treat the Chow groups $CH^p(X)$ as categories with the obvious objects and morphisms arising from the $Z^p(X, 1)$ term in Bloch's complex modulo the image of Tame symbols of $K2$-chains. This pairing coincides with the Knudsen-Mumford determinant line bundle using the structure sheaves of the cycles on X.

Restricting to cycles that are algebraically trivial on the generic fiber X_η, I show that the image in $Pic(S)$ does not depend on the rational equivalence of the cycles. Nevertheless, when working with numerically trivial divisors, the image does depend on the rational equivalence of the zero cycles. Based on this, I construct a line bundle on $CH^p_{alg}(X) \times CH^q_{alg}(X)$, which I want to prove is canonically isomorphic to the pull-back via the Abel-Jacobi map of the Poincare line bundle on the Intermediate Jacobians $J^p(X) \times J^q(X)$. I hope to extend the pairing to Suslin homology and in motivic setting. (Received September 12, 2017)

1134-14-412 **Aravind Asok*** (asok@usc.edu), 3620 S. Vermont Ave KAP 104, Los Angeles, CA 90089, and **Jean Fasel** and **Michael J Hopkins**. *Counting vector bundles.*

It is well-known that the Picard group of the ring of integers in a number field or of a smooth affine curve over a finite field is a finite group. I will discuss some "higher rank" and "higher dimensional" variants of this result. For example, I will discuss the question: given a smooth affine arithmetic scheme, when are there finitely many isomorphism classes of vector bundles with fixed rank and determinant? (Received September 12, 2017)

1134-14-447 **Erik Carlsson*** (ecarlsson@math.ucdavis.edu), Renaissance apartments, 3000 Lillard apt. 210, Davis, CA 95618. *Geometric representation theory and the shuffle conjectures.*

I will explain a new geometric construction due to E. Gorsky, A. Mellit for the representation of the algebra that appears in my proof of the shuffle conjecture with Mellit. We have discovered that the algebras act on the equivariant K-theory of a certain smooth subscheme of the flag Hilbert scheme, which breaks the q,t-symmetry. This is the first step towards categorifying these actions, and we hope to find applications to refined knot invariants and other conjectures. (Received September 12, 2017)

1134-14-461 **Ajay Menon Manneth*** (thekingofnothingda1@gmail.com), 10549 Lynrose St, Temple City, CA 91780. *Problems of Interest Related to AMC Mathematical Content.*

In our presentation we discuss the solutions to several problems published in the in the College Mathematical Journals and the Romanian monthly Mathematical Gazette. The solutions explore a variety of ideas, from interesting properties in the arithmetic of integers to advanced Euclidean geometry. The content of our presentation is accessible to undergraduate students. (Received September 13, 2017)

15 ► Linear and multilinear algebra; matrix theory

1134-15-51 **Sk Safique Ahmad*** (safique@iiti.ac.in), Indian Institute of Technology Indore, Simrol, Khandwa Road, Indore, 453552, India. *Structured Perturbation of two-parameter Eigenvalue Problems and their Backward Error with Sparsity.*

We study the structured backward error analysis of two- parameter eigenvalue problems with co-efficient matrices having structures like symmetric, skew symmetric, Hermitian, skew Hermitian, T-even, T-odd, H-even, H-odd. Minimal norm structured perturbations are given such that an approximate eigenpair becomes an exact eigenpair of an appropriately perturbed two parameter problems which also preserves sparsity.

This is a joint work with Prince Kanhya. (Received July 26, 2017)

1134-15-174 **Diego G. A. Avalos Galvez*** (avalosgalvez@cpp.edu), 21622 Marguerite Pkwy, Apt. 444, Mission Viejo, CA 92692.

Calculating Exponentials of Real Skew-Symmetric Matrices in Terms of Their Eigenvalues

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The eigenvalues of a real nonzero n-by-n skew-symmetric matrix S are purely imaginary or zero. If we denote the nonzero eigenvalues of S by $\pm\theta_1 i, \ldots, \pm\theta_p i$ such that each θ_j is positive, then e^S can be expressed as a polynomial in S of degree at most $n-1$, whose coefficients are functions of the θ_js. In this paper, we algebraically calculate the formulas of such exponentials of skew-symmetric matrices up to size $n = 9$ by using the method described by J. Gallier and D. Xu [1]. Furthermore, the formulas of e^S depend solely on the number of distinct eigenpairs $\pm\theta_j i$ of S and not on their algebraic multiplicity, which allows us to classify each exponential of S based on its number of distinct eigenpairs, rather than its size. (Received September 03, 2017)

1134-15-216 **Kourosh Modarresi** and **Abdurrahman Munir*** (mannya897@gmail.com), 2619 S. Catalina St, Los Angeles, CA 90007, and **Jamie Diner**. *A Comprehensive Evaluation of the Models for Matrix Imputation.*

In applied linear algebra, most of the matrices under study have missing entries. These missing entries are the result of many practical shortcomings such as measurement errors, technical mishap and the lack of the possibility of observing or collecting a comprehensive set of data for many events. Before any further analysis of the data matrix, one needs to deal with the problem of missing data or missing entries in the matrix. Modern data sets have high sparsity and thus we can't simply eliminate the rows and columns with missing entries. Imputation of the missing entries of data matrices have been an important area of studies in the field of random matrices. Variety of models from many areas such as data mining, machine learning and statistical analysis have been deployed to impute or estimate the unknown entries. Though many of these models have been applied to very specific data sets and their performances for any other type of data sets may not be known. In this study, we have used many different data sets containing various data features such as data sparsity, data type, data domain, and data dimensions. Then, we have evaluated the different models based on two metrics of accuracy and computational complexity. (Received September 05, 2017)

16 ► Associative rings and algebras

1134-16-55 **Mustafa Hajij**, Department of Computer Science, University of South Florida, Tampa, FL 33647, and **Jesse S F Levitt***, USC Dornsife, Department of Mathematics, Los Angeles, CA 90089. *An Algorithm for Computing the Colored Jones Polynomial.*

The colored Jones polynomial is a knot invariant that plays a central role in low dimensional topology. We give a simple and explicit algorithm to compute the colored Jones polynomial of any knot. Our algorithm utilizes a walks along a braid model of the colored Jones polynomial that was developed by Armond, Huynh and Lê.

The walk model gives rise to ordering a word in a q-Weyl algebra which is addressed and studied from multiple perspectives. (Received August 05, 2017)

1134-16-79 **Erik Carlsson** and **Eugene Gorsky***, Department of Mathematics, One Shields Avenue, Davis, CA 95616, and **Anton Mellit**. *Dyck path algebra and Hilbert schemes.*

The earlier work of Carlsson and Mellit introduced the Dyck path algebra and its polynomial representation, which was used to prove some important conjectures in algebraic combinatorics. In this paper we construct an action of this algebra on the equivariant K-theory of certain smooth strata in the flag Hilbert schemes of points on the plane. In this presentation, the fixed points of torus action correspond to generalized Macdonald polynomials and the the matrix elements of the operators have explicit combinatorial presentation (Received August 19, 2017)

1134-16-81 **James J Zhang*** (zhang@math.washington.edu), Department of Mathematics, Box 354530, University of Washington, Seattle, WA 98195. *An operadic Small-Stafford-Warfield theorem.*

The Small-Stafford-Warfield theorem states that, if an affine algebra over a base field has Gelfand-Kirillov dimension one, then it satisfies a polynomial identity. In this talk we will try to understand a version of Small-Stafford-Warfield theorem for unitary operads. Joint work with Yu Ye and Yanhong Bao. (Received August 21, 2017)

1134-16-82 **Louis H Rowen*** (rowen@math.biu.ac.il), Mathematics Department, Bar-Ilan University, Ramat-Gan, Israel. *Hopfian and Bassian algebras.*

(Joint work with Lance Small) A ring A is **Hopfian** if A cannot be isomorphic to a proper factor ring A/J. A is **Bassian**, if there cannot be an injection of A into a proper homomorphic image A/J. We consider classes of Hopfian and Bassian rings, and tie representability of algebras and chain conditions on ideals to these properties. In particular, any semiprime algebra satisfying the ACC on semiprime ideals is Hopfian, and any semiprime affine PI-algebra over a field is Bassian.
(Received September 10, 2017)

1134-16-95 **Aaron D Lauda*** (lauda@usc.edu), Department of Mathematics, University of Southern California, 3620 S. Vermont, Los Angeles, CA 90089. *The elliptic Hall algebra and categorified Heisenberg algebras.*

Khovanov defined a categorification of the Heisenberg algebra via a monoidal category conveniently encoded in a calculus of planar diagrams. This monoidal category is intimately related to the category of representations of all symmetric groups together with induction and restriction functors between them. Deforming the symmetric group to the Hecke algebra, Licata and Savage defined a q-deformation of Khovanov's Heisenberg category, again using planar diagrammatics. In this talk we will describe a connection between a specialization of the the elliptic Hall algebra of Burban and Schiffmann and the annular q-deformed Heisenberg category. This project is joint work with Sabin Cautis, Anthony Licata, Peter Samuelson, Joshua Sussan. (Received August 23, 2017)

1134-16-100 **David J Saltman*** (saltman@idaccr.org), 805 Bunn Dr, Princeton, NJ 08540. *Genus one curves in Severi-Brauer Varieties.*

Let A/F be a division algebra of degree 3, and X its Severi-Brauer variety which is a form of the projective plane. The linear system of cubic curves is defined on X, and so we can let $C \subset X$ be one such. If C is a nonsingular such curve, then C is a genus one curve with Jacobian E, an elliptic curve. The question we address is the one asked by Asher Auel, namely, which E arise. We give an answer that depends on the structure of A. (Received August 24, 2017)

1134-16-116 **Ivan Loseu***, 360 Huntington Avenue, Boston, MA 02115. *Modular categories O for type A rational Cherednik algebras.*

We will discuss modular analogs of categories O for type A rational Cherednik algebras (over fields of very large positive characteristic). These categories consist of finitely generated graded modules and are highest weight in a suitable sense. The main result of the talk is the existence of two standardly stratified structures on the modular category O (with regular integral parameter) whose associated graded categories are reductions to characteristic p of the usual categories O (with positive and negative rational parameters). (Received August 27, 2017)

1134-16-117 **Ben Elias** and **Ivan Loseu***, 360 Huntington Avenue, Boston, MA 02115. *Character formulas for modular representation theoretic categories of type A.*

We show that the characters of simple objects in various modular representation theoretic categories of type A (representations of symmetric groups, Hecke algebras or their higher level generalizations, rational representations of GL_n or its quantum analogs) can be expressed via p-Kazhdan-Lusztig polynomials of Elias and Williamson. (Received August 27, 2017)

1134-16-118 **Seth Shelley-Abrahamson*** (sethsa@mit.edu), 77 Massachusetts Avenue, Room 2-333B, Cambridge, MA 02139, and **Ivan Losev**. *Refined Filtration by Supports for Rational Cherednik Categories $\mathcal{O}$.*

Given a finite complex reflection group W with reflection representation $\mathfrak{h}$, one can consider the associated rational Cherednik algebra $H_c(W,\mathfrak{h})$ and its representation category $O_c(W,\mathfrak{h})$, depending on a parameter c. The irreducible representations in $O_c(W,\mathfrak{h})$ are in natural bijection with the irreducible representations of W, and each representation M in $O_c(W,\mathfrak{h})$ has an associated support, a closed subvariety of $\mathfrak{h}$. Via the KZ functor, the irreducible representations in $O_c(W,\mathfrak{h})$ of full support are in bijection with the irreducible representations of the Hecke algebra $H_q(W)$. In the case that W is a finite Coxeter group, I will explain how to count irreducible representations in $O_c(W,\mathfrak{h})$ of arbitrary given support by introducing a functor KZ_L, generalizing the KZ functor and depending on a finite-dimensional representation L of a rational Cherednik algebra attached to a parabolic subgroup of W. This is joint work with Ivan Losev. (Received August 27, 2017)

1134-16-123 **Frauke Bleher**, **Ted Chinburg** and **Birge Huisgen-Zimmermann***, Dept. of Mathematics, University of California, Santa Barbara, CA 93106. *Generic representations of algebras with low Loewy length.* Preliminary report.

The geometric understanding of finite dimensional algebras with vanishing radical square ($J^2 = 0$) is essentially as far advanced as that of hereditary algebras. We start with a brief survey and follow with a discussion of the quantum leap that occurs on passage from the case $J^2 = 0$ to $J^3 = 0$. (Received September 08, 2017)

1134-16-127 **Richard M. Green*** (rmg@euclid.colorado.edu), Department of Mathematics, University of Colorado Boulder, Campus Box 395, Boulder, CO 80309-0395. *The nil Temperley–Lieb algebra of type affine C.*

The nil Temperley–Lieb algebra of type affine C is a certain infinite-dimensional associative algebra. It can be defined either in terms of generators and relations, or as an algebra of creation and annihilation operators on certain particle configurations. The algebra turns out to have an interesting combinatorial structure, and I will discuss the extent to which this can be used to understand the representation theory of the algebra. (Received August 29, 2017)

1134-16-135 **Donald S. Passman***, passman@math.wisc.edu. *Trace Methods in Twisted Group Algebras.*

The trace map in a group algebra or a twisted group algebra picks off the identity coefficient of an element. One can use Brauer's identity to prove results about traces of idempotents and nilpotent elements in characteristic $p > 0$ and then try to lift these results to characteristic 0. This lifting is routine for ordinary group rings, but requires a trick in the twisted case which we discuss here. (Received August 30, 2017)

1134-16-157 **Bach Nguyen** (bnguy38@tigers.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, **Kurt Trampel** (ktramp2@lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Milen Yakimov*** (yakimov@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Noncommutative discriminants via Poisson primes and cluster algebras.*

Discriminants play a key role in various settings in algebraic number theory, algebraic geometry, combinatorics, and noncommutative algebra. In the last case, they have been computed for very few algebras. We will present a general method for computing discriminants of noncommutative algebras which is applicable to algebras obtained by specialization from families, such as quantum algebras at roots of unity. It builds a connection with Poisson geometry and expresses the discriminants as products of Poisson primes. From a different perspective it relates noncommutative discriminants to frozen variables of quantum cluster algebras. (Received September 01, 2017)

1134-16-170 **Gail Letzter*** (gletzter@verizon.net), 9800 Savage Road, Fort Meade, MD 20755-6844. *Quantum Coideals and their Representations.* Preliminary report.

Quantum symmetric pair coideal subalgebras can be viewed as a family of nonstandard quantum analogs of enveloping algebras of certain semisimple and reductive Lie algebras. In this talk, we discuss what is known

about finite-dimensional representations of these quantum coideals and connect this to the theory of FCR algebras as studied by Lance Small and others. (Received September 03, 2017)

1134-16-172 **Ken Goodearl***, Dept. of Mathematics, University of California, Santa Barbara, CA 93111. *Algebraic Structure of Cluster and Quantum Cluster Algebras.* Preliminary report.

I will discuss the algebras of the title from a ring-theoretic point of view. Since their algebraic structure has not been investigated much so far, the main point of the talk will be to propose a cluster of open problems and questions. (Received September 03, 2017)

1134-16-185 **Efim I Zelmanov*** (ezelmano@math.ucsd.edu). *Polynomial Identities in Groups.* Preliminary report.

We will discuss possible extensions of PI-theory to prounipotent and pro-p groups. (Received September 04, 2017)

1134-16-191 **Susan Sierra**, Edinburgh, EH9 3FD, United Kingdom, and **Chelsea Walton*** (notlaw@temple.edu), Philadelphia, PA 19122. *Maps from the enveloping algebra of the positive Witt algebra to regular algebras.*

In honor of Lance Small's 75th birthday, I will speak about joint with Susan Sierra on the Noetherian property of the universal enveloping algebra of the Witt algebra. In this talk, I will provide an elementary proof that the universal enveloping algebras of the Virasoro algebra, the Witt algebra, and the positive Witt algebra are neither left nor right Noetherian. If time permits, I will also highlight recent progress on related projects and further questions for consideration. (Received September 04, 2017)

1134-16-221 **Harold Williams*** (hwilliams@math.ucdavis.edu), **Dylan Rupel** and **Salvatore Stella**. *Quiver Representations and Generalized Minors.*

The representation theories of quivers and of Kac-Moody groups are described by parallel ternary classifications. Quiver representations are classified as preprojective, preinjective, or regular while representations of Kac-Moody groups are classified as highest-weight, lowest-weight, or level zero. In both settings the first two classes are well understood and dual to each other in a suitable sense, while the third is much less tractable. The goal of the talk is to explain a direct relationship between these two kinds of representation theory, of which the superficial parallels between their classifications are reflections. The meeting ground between the two sides is their mutual relationship to the theory of cluster algebras – these are at once repositories for generating functions (cluster characters) associated to quiver representations, and also coordinate rings of certain subvarieties of Kac-Moody groups (double Bruhat cells). The main result (proved in affine type and partially in general type) is that the cluster character of a rigid quiver representation can be computed as the restriction of a generalized minor of a corresponding Kac-Moody representation, and that this relationship intertwines the classifications described above. (Received September 06, 2017)

1134-16-239 **Surjeet Singh** and **S. K. Jain*** (jain@ohio.edu). *Structure of right Noetherian rings over which each cyclic is almost injective.* Preliminary report.

1. Theorem. Any right Noetherian ring R with the property that each cyclic right module is almost injective is right serial (This ring happens to be a piecewise-domain in the sense of Gordon-Small). 2. Theorem. For a semi-prime right Noetherian ring R, each cyclic right module is almost injective if and only if R is a direct sum of right and left uniserial ideals and simple Artinian rings. 3. Example: Let R be a 2×2 upper triangular matrix ring

D K ( ), 0 K

where D is a local PID and K is the quotient field of D. Then R is a right Noetherian right serial and has the property that each cyclic right module is almost injective. (Received September 07, 2017)

1134-16-256 **Martin Lorenz*** (lorenz@temple.edu), Philadelphia, PA 19122. *On the noncommutative Nullstellensatz.* Preliminary report.

I will make some remarks on a possible version of the noncommutative Nullstellensatz (a.k.a the Dixmier-Moeglin equivalence) with Hopf actions. (Received September 08, 2017)

1134-16-283 **Natalia K. Iyudu***, Niyudu@exseed.ed.ac.uk. *Sklyanin algebras via Groebner bases and finiteness conditions for potential algebras.*

I will discuss how some questions on Sklyanin algebras can be solved using combinatorial techniques, namely, the theory of Groebner bases, and elements of homological algebra. We calculate the Poincaré series, prove Koszulity, PBW, Calabi-Yau, etc., depending on the parameters of the Sklyanin algebras. There was a gap in

the Artin-Schelter classification of algebras of global dimension 3, where Koszulity and the Poincaré series for Sklyanin algebras were proved only generically. It was filled in the Grothendieck Festschrift paper of Artin, Tate and Van den Bergh, using the geometry of elliptic curves. Our point is that we recover these results by purely algebraic, combinatorial means. We use similar methods for generalized Sklyanin algebras, and for other potential algebras, appearing in noncommutative resolution of singularities. This is a joint work with A.Smoktunowicz and S.Shkarin. (Received September 10, 2017)

1134-16-294 **Daniel Rogalski*** (drogalski@ucsd.edu). *The noetherian property and base ring extension.*

Given a noetherian algebra over a field, a longstanding interesting question is to understand under what conditions the algebra remains noetherian when the base field is extended to a larger field or a larger commutative ring. We survey some of what is known about this topic, including the important contributions of Lance Small. (Received September 10, 2017)

1134-16-302 **Yuri Bazlov*** (yuri.bazlov@manchester.ac.uk), School of Mathematics, University of Manchester, Manchester, M13 9PL, United Kingdom, and **Arkady Berenstein**, Department of Mathematics, University of Oregon, Eugene, OR 97403. *H-cross products.*

It frequently happens that an algebra C *factors* as $C = A \cdot B$, meaning a vector space isomorphism between C and the tensor product $A \otimes B$ of its subalgebras A and B. The classical PBW theorem and its more recent incarnations – think quantum groups and affine Hecke algebras – are statements about algebra factorizations. Conversely, an algebra structure on the vector space $A \otimes B$ can be established in many cases: semidirect product, braided tensor product, etc, which all fit the situation when A is an H-module algebra and B is an H-comodule algebra for some bialgebra H.

We show that, quite surprisingly, any algebra factorization $C = A \cdot B$ can be realized in this way for a suitable H: an ordinary bialgebra if the factorization is *tame* (which is typically the case), or a topological bialgebra in general.

In particular, when C is a rational Cherednik algebra or a Kostant-Kumar nilHecke algebra, reconstructing H leads us to a Nichols algebra. DAHA and its generalizations correspond to the Hecke-Hopf algebras H, recently found by Berenstein and Kazhdan. Even in more straightforward examples of algebra factorisations, H can be a new and interesting Hopf algebra the representation theory of which begs to be explored. (Received September 10, 2017)

1134-16-306 **Yuri Bazlov** and **Arkady Berenstein*** (arkadiy@math.uoregon.edu), 1222 University of Oregon, Eugene, OR 97403-1222. *Noncommutative Dunkl operators and braided Cherednik algebras.*

In my talk (based on joint work with Yuri Bazlov) I introduce a version of Dunkl operators $\underline{\nabla}_1, \dots, \underline{\nabla}_n$ that act on the algebra $\mathbb{C}_{-1}[x_1, \dots, x_n]$ of anticommuting polynomials and anticommute. The anticommutation phenomenon can be explained by constructing *braided Cherednik algebras* $\underline{\mathcal{H}}(W_+)$ for *mystic reflection groups* W_+ which are companions of classical reflection groups $G(m, p, n)$, so that the $\underline{\nabla}_i$ form a representation of $\underline{\mathcal{H}}(W_+)$. The operators are expressed in terms of braided partial derivatives, which act on $\mathbb{C}_{-1}[x_1, \dots, x_n]$ via odd versions of Demazure divided difference operators. We expect the latter operators to form a representation of an *odd Hecke-Hopf algebra* attached to W_+. (Received September 10, 2017)

1134-16-313 **Xinli Xiao*** (xinlix@math.ucr.edu), Surge 262A, University of California, Riverside, Riverside, CA 92521. *A representation of Double COHA involving two quivers.*

A moduli space involving representations of a quiver $\mathcal{Q}$ and its sub-quiver $\mathcal{Q}_1$ is constructed. Using this moduli space we construct representations of the Cohomological Hall algebra of $\mathcal{Q}$ on the cohomology of the smooth model of$\mathcal{Q}_1$, and form the Nakajima type double construction of the representations. With these representations the motivic Donaldson-Thomas invariants of this model is discussed. (Received September 11, 2017)

1134-16-339 **Andy R. Magid*** (txmagid@yahoo.com), Department of Mathematics, University of Oklahoma, 601 Elm, Room 423, Norman, OK 73019, and **Lourdes Juan**. *Idempotents in Differential Algebras and Differential Projective Modules.*

Let R be a differential commutative ring, let A be a differential R algebra, and let E be an idempotent of A. Elementary calculations show that the derivation of A may be modified by an inner derivation so as to vanish on E. Applied to the case $A = M_n(R)$ with entry–wise differentiation, this provides a constructive proof that finitely generated projective R modules carry an R–compatible differential structure; that is, are differential projective modules. We study such modules. Among other results, we obtain that differential projective modules

are differential direct summands of free$R$ modules with coordinate–wise differentiation if and only if they are defined over constants of R. (Received September 11, 2017)

1134-16-344 **Manuel L. Reyes*** (reyes@bowdoin.edu), Department of Mathematics, Bowdoin College, Brunswick, ME 04011. *Recent progress with the Prime Ideal Principle.*

The Prime Ideal Principle (PIP) for commutative rings (due to T.Y. Lam and the speaker) is a theorem unifying many results in commutative algebra which state that an ideal maximal with respect to *not* possessing certain properties (such as "being proper," "being finitely generated," or "being principal") must be prime. This has subsequently been generalized to a Prime Ideal Principle for right ideals in noncommutative rings, and more recently for two-sided ideals in noncommutative rings.

In this talk, I will survey the various forms of the PIP, including some open questions about the PIP for two-sided ideals. I will also discuss recent applications of the PIP for right ideals when generalizing the notion of "S-finiteness" for a multiplicative set S from commutative to noncommutative algebra. (Received September 11, 2017)

1134-16-357 **Alexei Davydov**, **Pavel Etingof** and **Dmitri Nikshych*** (dmitri.nikshych@unh.edu), University of New Hampshire, Department of Mathematics and Statistics, Durham, NH 03824. *Autoequivalences of tensor categories attached to quantum groups at roots of* 1.

We compute the group of braided tensor autoequivalences and the Brauer-Picard group of the representation category of the small quantum group $u_q(\mathfrak{g})$, where q is a root of unity. (Received September 11, 2017)

1134-16-360 **Semeon Artamonov*** (semeon.artamonov@rutgers.edu), Department of Mathematics, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Noncommutative Integrable Systems and Kontsevich map.*

Kontsevich map is a birational automorphism of the group algebra of the free group parameterized by some integer r. For nonnegative values of r this automorphism satisfies the celebrated Laurent property and for r=-1 it appears to be a symmetry of certain noncommutative system of ODE. In my talk I will present this system of ODE as a Hamilton flow and discuss relations with the geometry of character varieties of the fundamental group of a once punctured torus. (Received September 11, 2017)

1134-16-366 **Yiby Morales*** (yk.morales964@uniandes.edu.co) and **César Galindo**. *The five-term exact sequence for Kac cohomology.* Preliminary report.

The group of equivalence classes of abelian extensions of Hopf algebras associated to a matched pair of finite groups was described by Kac in the 60's as the first cohomology group of a double complex, whose total cohomology is known as the Kac cohomology. Masuoka generalized this result and used it to construct semisimple Hopf algebra extensions. Since Kac cohomology is defined as the total cohomology of a double complex, there is an associated spectral sequence. We compute the second page of this spectral sequence and the associated five-term exact sequence. Through some examples we show the usefulness of this new exact sequence for computing groups of abelian extensions. This is joint work with César Galindo. (Received September 11, 2017)

1134-16-370 **Tom Braden** and **Carl Mautner*** (mautner@math.ucr.edu). *From the general linear group to matroids.*

The Schur algebra is a finite-dimensional algebra that encodes the rich representation theory of the general linear group. Motivated by geometry, Tom Braden and I have defined a similar algebra associated to any graph or, more generally, matroid. After introducing the various objects involved, I will discuss how our work 'categorifies' some combinatorial results about matroids and discuss some new combinatorial questions that it raises. (Received September 11, 2017)

1134-16-405 **Ellen E. Kirkman*** (kirkman@wfu.edu), Department of Mathematics and Statistics, Wake Forest University, Box 7388, Winston-Salem, NC 27109. *Reflection Hopf Algebras.* Preliminary report.

The Shephard-Todd-Chevalley Theorem states that when a finite group G acts linearly on a commutative polynomial ring $A = k[x_1, \ldots, x_n]$ over a field k of characteristic zero, the invariant subring A^G is a commutative polynomial ring if and only if G is generated by reflections. More generally, let H be a semi-simple Hopf algebra that acts on an Artin-Schelter regular algebra A so that A is an H-module algebra, the grading on A is preserved, and the action of H on A is inner faithful. When A^H is Artin-Schelter regular, we call H a reflection Hopf algebra for A. We present some examples of such pairs (A, H). (Received September 12, 2017)

1134-16-417 **Hans Wenzl***, Dept of Mathematics, UC San Diego, La Jolla, CA 92014. *Reconstructing Spinor Categories.* Preliminary report.

We consider the problem of classifying all braided tensor categories whose fusion ring is the one of a Spin or Pin group. Such categories contain full subcategories whose fusion rules are the ones of a (special) orthogonal group. For the full orthogonal group, these categories have been classified in a paper by the author with Tuba; for the case of special orthogonal groups see the talk by Daniel Copeland in this section. Objects corresponding to representations of spin groups which do not factor to representations of orthogonal groups form a module category of the orthogonal category. As a first step, we classify all module categories satisfying these fusion rules, using BMW algebras of type B. It is expected that this can then be used to reconstruct the full tensor category. In the cases worked out so far, we again obtain that the categories are twists of the tensor categories of representations of quantum groups for q not a root of unity. (Received September 12, 2017)

1134-16-458 **Stefan Catoiu*** (scatoiu@depaul.edu), Department of Mathematics, DePaul University, 2320 N. Kenmore Avenue, Chicago, IL 60614, and **Paul Terwilliger** (terwilli@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, Madison, WI 53706. *On Generalized Weyl Enveloping Algebras.* Preliminary report.

There are two explicit methods for generating ideals of the enveloping algebra of the type A_1 semisimple Lie algebra sl_2: by highest weight elements relative to the adjoint module structure, introduced by the first author, and by homogenous elements relative to the canonical grading of the generalized Weyl algebra, introduced by V. V. Bavula. In addition, the enveloping algebra has an equitable presentation, introduced by the second author. We give a unitary treatment of these three methods in both the classical and quantum type A_1^n, that is for all enveloping algebras and quantized enveloping algebras of semisimple Lie algebras that are generalized Weyl algebras. (Received September 13, 2017)

17 ► Nonassociative rings and algebras

1134-17-158 **Matthew Lee*** (mlee@math.ucr.edu). *Global Weyl Modules for maximal parabolics of twisted affine Lie algebras.*

In this talk we will discuss the structure of non standard maximal parabolics of twisted affine Lie algebras, global Weyl modules and the associated commutative associative algebra, $\mathbf{A}_\lambda$. Since the global Weyl modules associated with the standard maximal parabolics have found many applications the hope is that these non-standard maximal parabolics will lead to different, but equally interesting applications. (Received September 02, 2017)

1134-17-168 **Jonathan Brundan***, Department of Mathematics, University of Oregon, Eugene, OR 97403. *Dual canonical bases arising from* $\mathfrak{gl}(m|n)$.

There are very few dual canonical bases that can be computed by a non-recursive formula. Perhaps the best known example is the dual canonical basis for the quantized coordinate algebra of $2 \times n$ matrices, which is the braided tensor product $S_q(V) \otimes S_q(V)$ of two copies of the quantum symmetric algebra of the natural $U_q(\mathfrak{sl}_n)$-module V. The dual canonical basis of the braided tensor product $S_q(V) \otimes S_q(V^*)$ also has such an explicit closed form. I will explain this and some consequences for the classification of blocks of category $\mathcal{O}$ for the Lie superalgebra $\mathfrak{gl}_{m|n}(\mathbb{C})$. (Received September 03, 2017)

1134-17-202 **McKay Sullivan*** (mckay.sullivan@dixie.edu) and **Bojko Bakalov**. *Twisted Modules and their Applications.*

We discuss twisted modules of free field and lattice vertex algebras and outline possible applications to integrable systems and hierarchies of partial differential equations. (Received September 05, 2017)

1134-17-391 **A. Hof*** (alexander.hof@pomona.edu), **J. Shade** and **W. Whiting**. *Classification of Solvable Leibniz Algebras with Naturally Graded, Quasifiliform Lie Nilradicals.* Preliminary report.

In this work, we examine Leibniz algebras with naturally graded quasi-filiform Lie nilradicals, building on the previous classification of quasi-filiform Lie algebras by Gómez and Jiménez-Merchán [2]. By examining derivations on the nilradical, we get a constraint [1] on the dimension of the complementary space, and in the case when this dimension is maximal, obtain a classification.

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(Received September 12, 2017)

18 ► Category theory; homological algebra

1134-18-10 **Marco Aldi*** (maldi2@vcu.edu) and **Alexander McCleary**. *Kan Extensions in Elementary Real Analysis.*

The goal of this talk is to demonstrate how left and right Kan extensions can be used as a fully self-contained conceptual alternative to the classical epsilon-delta approach to elementary real analysis. In particular, we show how familiar notions such as Dedekind cuts, convergence, continuity, integral etc. are all particular instances of a single construction which involves comparing left and right Kan extensions of order preserving maps between posets. (Received April 06, 2017)

1134-18-21 **Dmitry Vagner*** (dv@math.duke.edu), **David I. Spivak** and **Eugene Lerman**. *Algebras of Open Dynamical Systems on the Operad of Wiring Diagrams.*

In this paper, we use the language of operads to study open dynamical systems. More specifically, we study the algebraic nature of assembling complex dynamical systems from an interconnection of simpler ones. The syntactic architecture of such interconnections is encoded using the visual language of wiring diagrams. We define the symmetric monoidal category W, from which we may construct an operad O(W), whose objects are black boxes with input and output ports, and whose morphisms are wiring diagrams, thus prescribing the algebraic rules for interconnection. We then define two W-algebras, G and L, which associate semantic content to the structures in W. Respectively, they correspond to general and to linear systems of differential equations, in which an internal state is controlled by inputs and produces outputs. As an example, we use these algebras to formalize the classical problem of systems of tanks interconnected by pipes, and hence make explicit the algebraic relationships among systems at different levels of granularity. (Received June 07, 2017)

1134-18-26 **Daniel Michael Cicala*** (cicala@math.ucr.edu). *A bicategorical syntax for pure state qubit quantum mechanics.*

We begin by constructing a framework used to study open networks modeled by graphs and their rewritings. This consists of a symmetric monoidal compact closed bicategory built by combining spans and cospans inside a topos. Into this bicategorical framework, we fit Coecke and Duncan's zx-calculus, a graphical language used to reason about pure state qubit quantum mechanics. After viewing the zx-calculus through this lens, we highlight several benefits over the 1-categorical approach: the presence of a symmetric monoidal compact closed structure and a better representation of rewriting information. (Received June 22, 2017)

1134-18-27 **Brendan Fong*** (bfo@mit.edu). *Black boxes and decorated corelations.*

Consider an electric circuit. Suppose this circuit has chosen terminals, which we may connect with the terminals of another circuit. That is to say, consider that we may compose two circuits to obtain another circuit. This suggests we might model circuits as morphisms in a category.

Next, suppose I want to compose a circuit with a resistor of resistance 2 ohms. If I have no such resistors, I could substitute with a pair of 1 ohm resistors in series. This suggests a coarser representation of circuits, one that keeps track of only how the circuit *behaves*, and not their constituent components.

In this talk I shall introduce decorated corelations as a tool for constructing categories that model circuits, and constructing 'black box' functors that shift between these models. This framework is applicable not only to circuits, but to open systems in general. (Received June 23, 2017)

1134-18-30 **K Courser*** (kcour001@ucr.edu). *A bicategory of coarse-grained Markov processes.* Preliminary report.

If C is a category with finite colimits, D is a symmetric monoidal category and F is a lax symmetric monoidal functor from C to D, Fong has developed a theory of F-decorated cospans which are suitable for representing open dynamical systems. Indeed, Fong has shown the existence of a symmetric monoidal category consisting of objects of C and isomorphism classes of F-decorated cospans in C as morphisms. One application of this result is given by Baez, Fong and Pollard in which they construct a symmetric monoidal category whose morphisms are given

by isomorphism classes of open Markov processes. Using a result of Shulman, we present a symmetric monoidal bicategory consisting of finite sets as objects, open Markov processes as morphisms and coarse-grainings of open Markov processes as 2-morphisms. (Received June 25, 2017)

1134-18-31 **Adam Yassine*** (ayass002@ucr.edu). *Open Systems in Classical Mechanics.* Preliminary report.

Using the framework of category theory, we formalize the heuristic principles that physicists employ in constructing the Hamiltonians for open classical systems as sums of Hamiltonians of subsystems. First we construct a category where the objects are symplectic manifolds and the morphisms are spans whose legs are surjective Poisson maps. Using a slight variant of Fong's theory of "decorated" cospans, we then decorate the apices of our spans with Hamiltonians. This gives a category where morphisms are open classical systems, and composition allows us to build these systems from smaller pieces. (Received July 09, 2017)

1134-18-32 **David I. Spivak*** (dspivak@mit.edu). *A higher-order temporal logic for dynamical systems.*

We consider a very general class of dynamical systems—including discrete, continuous, hybrid, deterministic, non-deterministic, etc.—based on sheaves. We call these sheaves *behavior types*: they tell us the set of possible behaviors over any interval of time. A machine can be construed as a wide span of such sheaves, and these machines can be composed as morphisms in a hypergraph category. The topos of sheaves has an internal language, which we use as a new sort of higher-order internal logic for talking about behaviors. We can use this logic to prove properties about a composite system of systems from properties of the parts and how they are wired together. (Received June 28, 2017)

1134-18-34 **Christina Vasilakopoulou***, christie.vasi@gmail.com, and **David Spivak** and **Patrick Schultz**. *Abstract Dynamical Systems.*

We describe a categorical framework of modeling and analyzing systems in a broad sense. The latter can be thought of as 'machines' with inputs and outputs, carrying some sort of signal that occurs through some notion of time; special cases include discrete and continuous dynamical systems. Modeling them as algebras for the wiring diagram operad, a central goal is to understand the behavior of composite systems, formed as arbitrary interconnections of component subsystems. This shall be accomplished using lax monoidal functors, which provide a coherent formalization of systems, as well as sheaf theory, which captures the crucial notion of time. (Received June 29, 2017)

1134-18-35 **Evan Patterson*** (epatters@stanford.edu). *Knowledge Representation in Bicategories of Relations.*

We introduce the relational ontology log, or relational olog, a categorical framework for knowledge representation based on the category of sets and relations. It is inspired by Spivak and Kent's olog, a knowledge representation system based on the category of sets and functions. Relational ologs interpolate between ologs and description logic, the dominant formalism for knowledge representation today. On a practical level, we demonstrate that relational ologs have an intuitive yet fully precise graphical syntax, derived from the string diagrams of monoidal categories. We explain several other useful features of relational ologs not possessed by most description logics, such as a type system and a rich, flexible notion of instance data. In a more theoretical vein, we draw on categorical logic to show how relational ologs can be translated to and from logical theories in a fragment of first-order logic. (Received June 29, 2017)

1134-18-37 **Blake S Pollard***, bpoll002@ucr.edu, and **John C Baez**. *Compositional modelling of open reaction networks.*

Reaction networks, or equivalently Petri nets, are a general framework for describing processes in which entities of various kinds interact and turn into other entities. In chemistry, where the reactions are assigned 'rate constants', any reaction network gives rise to a nonlinear dynamical system called its 'rate equation'. In this talk, I'll describe 'open' reaction networks, which allow entities to flow in and out at certain designated inputs and outputs. We treat open reaction networks as morphisms in a category. Composing two such morphisms connects the outputs of the first to the inputs of the second. We construct a functor sending any open reaction network to its corresponding 'open dynamical system'. This provides a compositional framework for studying the dynamics of reaction networks. We then turn to statics: that is, steady state solutions of open dynamical systems. We construct a 'black-box' functor that sends any open dynamical system to the relation that it imposes between input and output variables in steady states. This extends our earlier work on black-boxing for Markov processes. (Received June 30, 2017)

1134-18-38 **Brandon Coya*** (bcoya001@ucr.edu). *Frobenius monoids, weak bimonoids, and corelations.*

In this talk we consider object 2 in the category FinCorel, whose objects are finite sets and whose morphisms are "corelations." The object 2 can be equipped with two different Frobenius monoid structures. We show that the two Frobenius monoids interact to form a "weak bimonoid" as defined by Pastro and Street. Baez and Fong have shown that FinCorel is useful for modeling circuits made of wire as morphisms in a category. In this analogy the object 1 is viewed as a single wire. We show how the two Frobenius monoids associated to the object 2 relate to placing pairs of wires into series and parallel connections. (Received July 06, 2017)

1134-18-47 **Steve Huntsman*** (steve.huntsman@baesystems.com). *The multiresolution analysis of flow graphs.*

We unify and formalize several natural concepts relevant to the decomposition and construction of digraphs that model control flow in programs, business processes, etc. In particular, we exhibit sequential and parallel tensor product operations and introduce the operad of flow graphs in light of a well-known algorithm that dovetails with the operadic structure. (Received July 18, 2017)

1134-18-74 **Jonathan Beardsley** (jbeards1@uw.edu) and **Liang Ze Wong*** (wonglz@uw.edu). *The enriched Grothendieck construction.* Preliminary report.

Fibrations, or fibered categories, were introduced by Grothendieck in order to define stacks and descent theory. They have since found numerous applications outside of algebraic geometry, such as to algebraic topology, logic, and type theory, and have been generalized to arbitrary 2-categories. The Grothendieck construction and its inverse show that the category of fibrations over a base category $\mathcal{B}$ is equivalent to the category of pseudofunctors $\mathcal{B}^{op} \to \mathbf{Cat}$. In this talk, we develop the theory of fibrations for categories enriched over a semi-cartesian monoidal category $\mathcal{V}$, along with enriched versions of the Grothendieck construction and its inverse. We then highlight some homotopical features that arise when $\mathcal{V}$ is the category **sSet** of simplicial sets. This is joint work with Jonathan Beardsley. (Received August 17, 2017)

1134-18-80 **Paul Balmer***, UCLA Mathematics Department, PO Box 951555, Los Angeles, CA 90095-1555. *An Invitation to Tensor-Triangular Geometry.*

Tensor Triangular Geometry (a.k.a. 'tt-geometry') is a general topic dedicated to the study of several, rather different, areas of mathematics through the lens of tensor-triangulated categories. Indeed, these structures appear in algebraic geometry, in representation theory, in topology, in the theory of motives, in the study of C^*-algebras, etc.

The talk will not be dedicated to abstract tt-geometry but will rather focus on one recent development in equivariant stable homotopy theory, in joint work with Beren Sanders. We shall begin with a review of non-topological results due to Dress, and of non-equivariant results due to Hopkins-Smith, before we describe the equivariant and topological situation in the form of the tt-spectrum of $\mathsf{SH}(G)$, the stable equivariant homotopy category of G-equivariant spectra over a finite group G. We shall try to illustrate general principles of tt-geometry along the way. (Received August 21, 2017)

1134-18-109 **John Min Zhang*** (jmzhang@math.ucla.edu), UCLA Department of Mathematics, 520 Portola Plaza, Math Sciences Building 6363, Los Angeles, CA 90095. *Localizations of Derivators.* Preliminary report.

This talk concerns derivators and their localizations. In particular, the left Kan extension morphism along the inclusion of a reasonable monoid into its Grothendieck group is a Bousfield localization of shifted derivators. This is akin to the result that the derived category of an open subscheme U of a scheme X is a Bousfield localization of the derived category of X. (Received August 26, 2017)

1134-18-115 **Martin Gallauer*** (gallauer@math.ucla.edu). *Tensor triangular geometry of filtered modules.*

We compute the tensor triangular spectrum of perfect complexes of filtered modules over a commutative ring, and deduce a classification of the thick tensor ideals. Some useful tools in tensor triangular geometry are developed along the way. (Received August 27, 2017)

1134-18-122 **Vin de Silva*** (vin.desilva@pomona.edu). *Reeb Graph Smoothing via Cosheaves.*

This talk concerns Reeb graphs and their category-theoretic interpretation as cosheaves over the real line. Following (de Silva, Munch, Patel; 2016), I will explain the correspondence between Reeb graphs and Reeb cosheaves, and use it to define a metric on the class of all Reeb graphs, as well as a 1-parameter semigroup of 'smoothing' operators that progressively simplify the topology of a given Reeb graph. These constructions are modelled,

following (Bubenik, Scott; 2014), on analogous constructions originating in the theory of topological persistence. Finally, I will present an algorithm (de Silva, Smirnov, Yu; unpublished) that produces, in a single calculation, the description of the smoothings of a given Reeb graph at all possible parameter values. The ideas in this talk are the result of collaborations with Peter Bubenik, Jonathan Scott, Elizabeth Munch, Amit Patel, Dmitriy Smirnov and Song Yu. (Received August 28, 2017)

1134-18-134 **Michael Shulman*** (shulman@sandiego.edu) and **Tom Leinster**. *Magnitude homology of enriched categories and metric spaces.* Preliminary report.

Magnitude is a numerical invariant of enriched categories introduced by Leinster, which generalizes the Euler characteristic of (the nerve of) an ordinary category. We show that just as the ordinary Euler characteristic is the alternating sum of ranks of ordinary homology, under suitable hypotheses the magnitude is the alternating sum of ranks of an appropriate sort of Hochschild homology. Applying this to metric spaces, regarded after Lawvere as categories enriched over the poset $[0, \infty]$, we obtain a new "magnitude homology" theory for metric spaces. Since magnitude detects invariants like cardinality, volume, and Minkowski dimension, so does magnitude homology. It also detects other geometric information; for instance, a closed subset $X \subseteq \mathbb{R}^n$ is convex if and only if $H_1^{\mathrm{mag}}(X) = 0$. But many other questions about magnitude homology remain open. (Received August 30, 2017)

1134-18-156 **Kent Vashaw** (kvasha1@lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70808, and **Milen Yakimov*** (yakimov@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 7808. *Prime spectra of 2-categories and categorification of open Richardson varieties.*

We will describe a general theory of prime, completely prime, semiprime, and primitive ideals of monoidal categories, and more generally of 2-categories. These notions extend Balmer's theory of spectra of tensor triangulated categories, which deals with the symmetric/braided case. The notions provide a bridge between prime spectra of noncommutative rings and total positivity. As an application we obtain categorications of the coordinate rings of Richardson varieties for arbitrary symmetric Kac-Moody algebras. (Received September 01, 2017)

1134-18-162 **Pavel Etingof*** (etingof@math.mit.edu). *Faithfulness of the lifting for fusion categories.*

We use a version of Haboush's theorem over complete local Noetherian rings to prove faithfulness of the lifting for semisimple cosemisimple Hopf algebras and separable (braided, symmetric) fusion categories from characteristic p to characteristic zero, showing that, moreover, any isomorphism between such structures can be reduced modulo p. We also show that lifting of semisimple cosemisimple Hopf algebras is a fully faithful functor, and prove that lifting induces an isomorphism on Picard and Brauer-Picard groups. Finally, we show that a subcategory or quotient category of a separable multifusion category is separable (resolving an open question raised by Etingof, Nikshych and Ostrik 15 years ago), and use this to show that certain classes of tensor functors between lifts of separable categories to characteristic zero can be reduced modulo p.The talk will be based on the paper arXiv:1704.07855. (Received September 02, 2017)

1134-18-166 **Jonathan Beardsley*** (jbeards1@uw.edu). *Toward Derived Hopf-Galois Extensions.*

I will describe how, in the derived setting, the quotient map $\hat{\mathbb{Z}}_2 \to \mathbb{Z}/2\mathbb{Z}$ is a Hopf-Galois extension, with associated Hopf-algebra $B\mathbb{Z} \simeq S^1$. Here, the algebra structure is the group structure on S^1 and the coalgebra structure is the diagonal map $\Delta\colon S^1 \to S^1 \times S^1$ (which makes S^1 into a bialgebra, since it is an algebra object in the category of topological coalgebras). In particular, we regard $\mathbb{Z}/2\mathbb{Z}$ as the quotient of the group action $\mathbb{Z} \to Aut(\mathbb{Z})$ given by $1 \mapsto -1$. Describing this in full detail requires methods from stable homotopy theory and the theory of operads, which I will omit. However, the above Hopf-Galois extension suggests that, more generally, given an action of a group G on a ring R, we can think of $R \to R/G$ as a Hopf-Galois extension with "Hopf-algebra" the space BG. This is a form of generalized Koszul duality. (Received September 02, 2017)

1134-18-181 **Robert Laugwitz***, Department of Mathematics, Rutgers University, Hill Center - Busch Campus, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, and **Vanessa Miemietz**. *2-Representation Theory for Categorified Quantum Groups at Prime Roots of Unity.*

Small quantum groups at prime roots of unity have been categorified in the work of Khovanov–Qi and Elias–Qi. This talk reports on how constructions of cell 2-representations, which were introduced in the work of Mazorchuk–Miemietz can be adapted to this setup. (Received September 04, 2017)

1134-18-182 **John C. Baez**, **John D. Foley*** (foley@metsci.com), **Joseph Moeller** and **Blake S. Pollard**. *Compositional design and tasking of networks.* Preliminary report.

Network models provide a flexible method to construct operads to compose networks: one specifies an appropriate functor. This talk explores the problem of matching the kind of network in some application to a specific network model. In particular, we give examples of different kinds of networks whose composition is modeled as an algebra of a suitable operad that is constructed from a network model. Remarkably this style of operad can provide a unified treatment of the structural design and behavioral tasking of dynamic networks. (Received September 05, 2017)

1134-18-244 **Kevin Carlson*** (carlskevin@gmail.com). *Higher Category Theory via Derivators.* Preliminary report.

The theory of derivators is intended, from one perspective, to give an approach to higher category theory that is as lightweight as possible. In particular, a derivator is built out of categories, rather than spaces, and so working with them recovers some of the simplicity of ordinary category theory. The general goal is to advance the program of developing a framework in which homotopical areas of mathematics are closer to being as easy to talk about as their classical counterparts. I'll talk about in what sense it's true that derivators model higher categories, and say a few words about ongoing work on using derivators to model approximations of fully coherent higher category theory. (Received September 07, 2017)

1134-18-345 **Eric Carson Rowell*** (rowell@math.tamu.edu). *Spin, super and fermionic modular categories.* Preliminary report.

While modular categories are well established as models for 2D bosonic topological phases of matter, a more nuanced theory is required to include fermions, due to their non-local behavior. I will discuss some recent results and open questions surrounding super modular categories, focusing on their minimal modular extensions, and fermionic quotients. This is based upon several different joint projects with 10+ collaborators. (Received September 11, 2017)

1134-18-348 **Marcel Bischoff*** (bischoff@ohio.edu). *On Generalized Metaplectic Modular Categories.* Preliminary report.

Metaplectic modular categories are modular tensor categories whose fusion rules are given by the Verlinde fusing rules of Spin(n) at level 2. One can generalize these fusion rules by replacing the cyclic group of order n with an arbitrary finite abelian group A. I will discuss the classification of modular categories with such fusion rules in the case that A is of odd order. I will also discuss the relation to twisted doubles of generalized dihedral groups. (Received September 11, 2017)

1134-18-362 **Victor Ostrik*** (vostrik@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Categorifications of some based rings.*

The Grothendieck ring of a semisimple tensor category is an example of based ring. In this talk we will discuss some known results for converse problem: given a based ring reconstruct tensor category. We will be particularly interested in based rings arising from semisimple Lie algebras and their quantum versions. (Received September 11, 2017)

1134-18-363 **Nicolas Escobar-Velasquez*** (n.escobar1726@uniandes.edu.co), Bogota, Colombia, **Cesar Galindo** (cn.galindo1116@uniandes.edu.co), Bogota, Colombia, and **Zhenghan Wang** (zhenghwa@microsoft.com), Santa Barbara, CA. *Braid Group Representations from Braiding Gapped Boundaries of Dijkgraaf-Witten Theories.*

We study representations of the braid groups from braiding gapped boundaries of Dijkgraaf-Witten theories and their twisted generalizations, which are (twisted) quantum doubled topological orders in two spatial dimensions. We show that the braid representations associated to Lagrangian algebras are all monomial with respect to some specific bases. We give explicit formulas for the monomial matrices and the ground state degeneracy of the Kitaev models that are Hamiltonian realizations of Dijkgraaf-Witten theories. Our results imply that braiding gapped boundaries alone cannot provide universal gate sets for topological quantum computing with gapped boundaries. (Received September 11, 2017)

1134-18-369 **Paul P Gustafson*** (pgustafs@math.tamu.edu). *Towards Property F for metaplectic modular categories.* Preliminary report.

A metaplectic modular category is a unitary modular category with the same fusion rules as $SO(N)_2$ for some odd $N > 1$. These categories are some of the simplest nontrivial examples of gauging: every metaplectic modular category is a gauging of the particle-hole symmetry of a $\mathbb{Z}_n$-cyclic modular category.

Recently, Rowell and Wenzl proved that the braid group representations associated to $SO(N)_2$ have finite image, i.e. $SO(N)_2$ has Property F. In this talk, I will outline progress on three approaches to extending this result to the more general metaplectic case: (i) directly comparing the metaplectic R-matrices to the $SO(N)_2$ ones, (ii) modifying the quantum group construction to change the Frobenius-Schur indicator of the fundamental spinor object, and (iii) analyzing the effects of gauging on R-matrices. (Received September 11, 2017)

1134-18-374 **Costel Gabriel Bontea*** (cgb1@unh.edu) and **Dmitri Nikshych**. *Classifying pointed braided finite tensor categories.*

One of the earliest results in the classification theory of tensor categories was given by A. Joyal and R. Street who showed that the category with objects pointed braided fusion categories and with morphisms natural isomorphisms of braided tensor functors is equivalent to the category of pre-metric groups.

I will present in this talk a weak generalization of this result. Namely, that the category with objects pointed braided finte tensor categories admitting a fiber functor and morphisms natural isomorphisms of braided equivalences is equivalent to a category of metric quadruples. This is a report on a joint work with Dmitri Nikshych. (Received September 11, 2017)

1134-18-438 **Robert B Usher*** (rusher@oregon.edu), Department of Mathematics, Fenton Hall, University of Oregon, Eugene, OR 97403. *Modular extensions of symmetric fusion categories.*

We describe the group of modular extensions of a symmetric fusion category $\mathcal{E}$ introduced by Lan, Kong, and Wen. This group consists of modular fusion categories $\mathcal{M}$ containing $\mathcal{E}$ such that $\mathcal{E}'|_{\mathcal{M}} = \mathcal{E}$.

In this talk I will describe some known results about this group, and some techniques for working with this group. (Received September 12, 2017)

1134-18-443 **Nicolle E.S. Gonzalez*** (nesandov@usc.edu), 3620 S. Vermont Ave KAP 104, Department of Mathematics, University of Southern California, Los Angeles, CA 90089. *A Diagrammatic Categorification of the Boson-Fermion Correspondence.* Preliminary report.

The boson-fermion correspondence lies at the heart of quantum mechanics and combinatorial representation theory. Mathematically speaking, it reveals how the action of the Clifford algebra on fermionic Fock space can be recovered from the action of the Weyl algebra on bosonic Fock space. Moreover, since the action of the Clifford algebra on fermionic Fock space mimics that of annihilation and creation operators in the Dirac sea of electrons and the statistic of bosons and fermions are seemingly incompatible, this connection is of great interest to quantum physicists as well. In this talk we will introduce these topics from an algebraic perspective and briefly describe how to lift this correspondence to the language of higher category theory within the framework of Khovanov's diagrammatic Heisenberg category. (Received September 12, 2017)

1134-18-445 **Vladimir V Baranovsky*** (vbaranov@math.uci.edu), 340 Rowland Hall, Department of Mathematics, Irvine, CA 92617, and **Maksym Zubkov** (zubkovmaksym@gmail.com). *Chromatic graph homology for brace algebras.*

The chromatic graph homology complex was defined earlier by Helme-Guizon and Rong. Its inputs are a graph G and a (dg) commutative algebra A.

When working over Z or a finite field, it is also desirable to be able to take A which is the cochain algebra of a topological space X. Such A is associative, but not commutative - although it has a certain weak commutativity property (i.e. commutativity up to homotopy). More precisely, such A is an algebra over a brace operad. We explain how the graph homology complex can be defined for such algebras. Another example of such A is the Hochschild cochain complex for an associative algebra B. (Received September 12, 2017)

19 ► K-theory

1134-19-58 **Aaron Mazel-Gee*** (aaron@etale.site), University of Southern California, Department of Mathematics, 3620 S. Vermont Ave., KAP 104, Los Angeles, CA 90089. *The geometry of the cyclotomic trace.*

Algebraic K-theory is a deep and far-reaching invariant, but it is notoriously difficult to compute. To date, the primary means of understanding K-theory is through its "cyclotomic trace" map $K \to TC$ to topological cyclic homology. This map is usually advertised as an analog of the Chern character, but this is something of a misnomer: TC is a further refinement of any flavor of de Rham cohomology (even "topological", i.e. built from THH), though this discrepancy disappears rationally. However, despite the enormous success of so-called "trace methods" in K-theory computations, the algebro-geometric nature of TC has remained mysterious.

In this talk, I will present a new construction of TC that affords a precise interpretation of the cyclotomic trace at the level of derived algebraic geometry, which is based on nothing but universal properties (coming from Goodwillie calculus) and the geometry of 1-manifolds (via factorization homology). This is joint work with David Ayala and Nick Rozenblyum. (Received August 06, 2017)

20 ► Group theory and generalizations

1134-20-50 **John Rhodes** and **Anne Schilling*** (anne@math.ucdavis.edu), Department of Mathematics, University of California, One Shields Avenue, Davis, CA 95661. *Grand unified theory for Tsetlin libraries.* Preliminary report.

We provide a unified framework to construct and analyze Markov chains for finite semigroups S with specified generators after two expansions are applied to S. We assume that the first expansion applied to S is stable under the second expansion. The original Tsetlin library is obtained by applying the expansions to $P(n)$. Our set-up vastly generalizes previous work involving left-regular bands by Brown and Diaconis and later R-trivial semigroups by Ayyer, Steinberg, Thiéry and the second author. We use the Karnofsky–Rhodes expansion of the right Cayley graph of S in terms of generators for the first expansion and the McCammond expansion to construct normal forms for elements in the expanded S as the second expansion. Using our previous work with Silva, we construct (infinite) semaphore codes on which we can define Markov chains. Under our assumptions, these semaphore codes can be lumped using Kleene expressions which yield the stationary distribution of the finite Markov chain of the expanded S. (Received September 05, 2017)

1134-20-104 **Robert M Guralnick*** (guralnic@usc.edu), Department of Mathematics, University of Southern California, Los Angeles, CA 90089-2537. *Quivers and Singular Value Decomposition over Finite Fields.*

We give an analog of the singular value decomposition for matrices over a finite field of square order. The proof involves the representation theory of a quiver and a result of Steinberg. (Received August 25, 2017)

1134-20-133 **Alexander Kleshchev*** (klesh@uoregon.edu) and **Robert Muth**. *Schurifying quasi-hereditary algebras.*

We present a general procedure which allows one to associated a new quasihereditary algebra S(A,n,d) to any quasihereditary (super)algebra A. When A is a field, the procedure returns the classical Schur algebra S(n,d). When A is a truncated zigzag algebra, the procedure returns the so-called Turner's double algebra, which is Morita equivalent to a generic block of a symmetric group. When A is a zigzag algebra, S(A,n,d) is conjecturally Morita equivalent to a generic block of a classical Schur algebra. (Received August 30, 2017)

1134-20-215 **Itay Kaplan** and **Pierre Simon*** (pierre.simon@berkeley.edu). *Finitely generated dense subgroups of automorphism groups.*

We give a sufficient condition for the automorphism group of an omega-categorical structure to have a 2 or 4-generated dense subgroup. This criterion seems to apply to all known examples and leads to a number of open question on omega-categorical structures. (Received September 05, 2017)

1134-20-293 **David Jordan** and **Noah White*** (noah@math.ucla.edu). *The center of the reflection equation algebra (and quantum group) for* $\mathfrak{gl}_n$.

The reflection equation algebra is a quantization of the ring of functions on $n \times n$ matrices. Reshetikhin gave a diagramatic description of a set of algebraically independant generators of the center. I will describe joint work with David Jordan giving explicit algebraic formulas for Reshetikhin's generators and establishing quantum Newton and Cayley Hamilton identities for them. An important special case is the quantum determinant, for which an explicit algebraic formula was previously only known when $n = 2$. As an immediate corollary we obtain an algebraically indepentant set of generaotrs for the center of the Drinfeld-Jimbo quantum group. Our approach unifies the descriptions of the center given by Reshetikhin, by Nazarov-Tarasov and by Gurevich-Pyatov-Sapanov. (Received September 10, 2017)

1134-20-324 **Petr Vojtechovsky*** (petr@math.du.edu), Department of Mathematics, University of Denver, 2390 S York St, Denver, CO 80208. *Involutory latin quandles of prime power order.* Preliminary report.

Quandles are algebraic structures designed to color arcs of oriented knot diagrams. In this talk we explain how to enumerate involutory latin quandles of odd prime power order. The enumeration can be carried out for rather

large quandles thanks to a correspondence between involutory latin quandles of odd order and Bruck loops of odd order, taking advantage of central extensions. (Received September 11, 2017)

1134-20-338 **Daniel R Copeland*** (drcopela@ucsd.edu). *Classification of ribbon categories with SO(N) fusion rules.* Preliminary report.

Tensor categories whose fusion ring is isomorphic to that of a classical Lie group are singly generated, ie all simple objects appear as summands in some tensor power of a distinguished simple. If the category is ribbon, then the category is essentially determined by the endomorphism algebras of these tensor powers and the tensor product rules between them. Tuba and Wenzl (2004) classified ribbon tensor categories with fusion rings corresponding to O(N) and Sp(N) by identifying these endomorphism algebras, using the fact that the braid group generates the algebras. This is not the case for SO(N)-type categories, and in this talk we discuss the path algebra approach to describe the endomorphism algebras, which allows for the classification of SO(N)-type ribbon categories. (Received September 11, 2017)

1134-20-358 **Alex S E Levin*** (asx49@wildcats.unh.edu), Department of Mathematics and Statistics, Kingsbury Hall, 33 Academic Way, Durham, NH 03824. *Subcategories of an equivariantization.*

Let G be a finite group acting on fusion category $\mathcal{A}$. We parameterize full fusion subcategories of the equivariantization $\mathcal{A}^G$ with *invariant triples*, consisting of a G-stable subcategory $\mathcal{S}$ of $\mathcal{A}$, a normal subgroup N of G, and an isomorphism of N-actions on $\mathcal{S}$ satisfying a G-invariance condition. (Received September 11, 2017)

1134-20-418 **Gus Lonergan*** (guslonergan@gmail.com) and **Spencer Leslie**. *Smith theory for parity sheaves.*

We develop a connection between parity complexes and Smith theory for varieties equipped with an action of a cyclic group of prime order p. We define a sheaf-theoretic Tate cohomology theory and study the corresponding notion of Tate-parity complex (see JMW for the classical theory). We generalize D. Treumann's "Smith theory for sheaves", and give a criterion for the sheaf-theoretic Smith functor Psm to send parity complexes on X to Tate-parity complexes on the fixed-point set X^{ϖ}. We end by applying our theory to the affine Grassmannian to give a geometric construction of the "Frobenius contraction" functor of M. Gros and M. Kaneda. (Received September 12, 2017)

1134-20-431 **Derrick Wigglesworth*** (dwiggles@math.utah.edu) and **Radhika Gupta**. *Loxodromics for the cyclic splitting complex.*

The outer automorphism group of a finite rank free group, $\mathrm{Out}(F_n)$, has strong parallels with the mapping class group of a closed surface and with $\mathrm{SL}_n(\mathbb{Z})$. In this talk, I will build on this analogy, discussing some recent results concerning the cyclic splitting complex, which can be thought of as an $\mathrm{Out}(F_n)$ analog for the curve complex. In particular, I will discuss recent work with R. Gupta in which we identify the loxodromic elements for this action. We will also discuss some results which indicate that this action may be acylindrical. (Received September 12, 2017)

1134-20-437 **Shawn T Burkett*** (shawn.burkett@colorado.edu). *Lattices of normal subgroups and supercharacter theory.*

A supercharacter theory of a finite group is an approximation of its character theory where the role of the irreducible characters is played by a certain set of characters, called supercharacters, which enjoy some similar algebraic properties. Given a supercharacter theory of G, a lattice of normal subgroups of G can be associated via the kernels of the supercharacters. Conversely, given any lattice $\mathcal{L}$ of normal subgroups of G, a supercharacter theory of G can be constructed whose associated lattice is $\mathcal{L}$ and which is as course as possible, in some sense. In this talk, we will discuss some properties of these lattices, as well as the possibility of constructing finer supercharacter theories from a lattice of normal subgroups by specifying supercharacter theories on each covering relation. (Received September 12, 2017)

22 ► Topological groups, Lie groups

1134-22-54 **George Lusztig** and **Zhiwei Yun*** (zhiwei.yun@yale.edu). *Perverse sheaves arising from cyclically graded Lie algebras and DAHA.*

Let G be a simple and simply-connected algebraic group whose Lie algebra $\mathfrak{g}$ carries a $\mathbf{Z}/m\mathbf{Z}$-grading. The grading gives a subgroup G_0 which acts on each graded piece $\mathfrak{g}_i$. Consider the derived category of G_0-equivariant sheaves

on $\mathfrak{g}_i$ that are supported on the nilpotent cone. In special cases, this category contains Fourier transforms of character sheaves and canonical bases arising from quivers.

We give a block decomposition of this category in terms of cuspidal data in the same spirit as the generalized Springer correspondence. To each block, we also attach a graded DAHA with unequal parameters and construct modules of it from objects in the block. (Received August 03, 2017)

1134-22-169 **Jonathan Brundan***, Department of Mathematics, University of Oregon, Eugene, OR 97403. *Conway skein category and* $\underline{\mathrm{Rep}}(U_q(\mathfrak{gl}_\delta))$.

I will revisit some 30-year-old work of Turaev from the perspective of Deligne categories. (Received September 03, 2017)

1134-22-364 **Kayue Daniel Wong*** (kw342@cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *On the Kraft-Procesi Model of Classical Nilpotent Varieties.*

Let G be a complex classical simple Lie group with Lie algebra $\mathfrak{g}$. The normal nilpotent varieties of $\mathfrak{g}$ were classified by Kraft and Procesi in the late 1970's. However, very little is known about the ring of regular functions of such varieties.

Based on the work of Kraft-Procesi, a quantization model of classical nilpotent varieties was given by Ranee Brylinski in 2003. We study thoroughly the representation theoretic perspective of the Brylinski model, which results in an explicit, combinatorial description on the ring of regular functions of classical nilpotent varieties in terms of the multiplicities of the irreducible, finite-dimensional representations of G.

This is a joint work with Dan Barbasch. (Received September 11, 2017)

1134-22-402 **Raphael Rouquier*** (rouquier@math.ucla.edu). *Cherednik algebras and finite groups of Lie type.*

We will present a conjectural framework unifying representations of rational Cherednik algebras and modular representations of finite groups of Lie type. This is aimed at extending Quillen-Friedlander's description of completed classifying spaces beyond the neighborhood of the trivial representation. (Received September 12, 2017)

28 ► Measure and integration

1134-28-205 **Alexander M Henderson*** (henderson@math.ucr.edu), UCR Mathematics Department, 900 University Ave, Riverside, CA 92521. *On the complex dimensions of p-adic fractal sets.* Preliminary report.

The higher dimensional theory of complex dimensions developed by Lapidus, Radunović, and Žubrinić provides a language for quantifying the oscillatory behaviour of the geometry of subsets of $\mathbb{R}^n$. In this talk, we will discuss a generalization of the theory that allows us to consider fractal sets in p-adic spaces. We will give several examples, and explore the geometric information that can be recovered from the complex dimensions of a set. (Received September 05, 2017)

30 ► Functions of a complex variable

1134-30-380 **Khang D Tran*** (khangt@csufresno.edu), Department of Mathematics, California State University, Fresno, Fresno, CA 93740. *Zeros of polynomials and their generating functions.*

We discuss an approach which shows that the zeros of various sequences of polynomials lie on fixed curves on the complex plane. Particularly, we study connections between the zeros of a sequence of polynomials and its generating function. As an example, we characterize sequences of hyperbolic polynomials satisfying four-term recurrences with constant coefficients. In another example, we analyze connections between the hyperbolicity of polynomials forming the denominator of the generating function and the hyperbolicity of the generated sequence. (Received September 11, 2017)

31 ► Potential theory

1134-31-262 **Patricia Alonso Ruiz*** (patricia.alonso-ruiz@uconn.edu). *Exact formulas for the heat kernel on diamond fractals.*

Due to their wide range of applications, heat kernels are object of interest in many different subjects and settings. On fractals they may not exist, and if they do, their existence often arises in a rather abstract way. In this talk we present work in progress concerning the heat kernel on a two-parameter family of diamond fractals. Their favorable structure will allow us to provide a pointwise formula and discuss some applications of it. (Received September 11, 2017)

32 ► Several complex variables and analytic spaces

1134-32-41 **Debraj Chakrabarti*** (chakr2d@cmich.edu), **Luke Edholm** and **Jeff McNeal**. *Bergman Spaces on Reinhardt Domains.* Preliminary report.

Let Ω be a possibly non-smooth Reinhardt domain in $\mathbb{C}^n$, and let $A^p(\Omega)$ be the Banach space of holomorphic functions on Ω whose p-th powers are integrable, $p \geq 1$. We study properties of $A^p(\Omega)$ as a linear space, for example, the question of convergence of Laurent series of functions in $A^p(\Omega)$ in the norm of $A^p(\Omega)$, and that of determining the dual of $A^p(\Omega)$. These questions have unsurprising answers when Ω is the unit disc in the plane. We show there are new phenomena in the general situation, some only partially understood. In particular we look at the special case of the Hartog's triangle, where some of the computations can be performed explicitly. This is joint work with Luke Edholm and Jeff McNeal. (Received July 10, 2017)

1134-32-72 **Phillip S Harrington*** (psharrin@uark.edu), SCEN 336, 1 University of Arkansas, Fayetteville, AR 72704. *Sufficient Conditions for Global Regularity of the Bergman Projection.*

We say that the Bergman Projection is globally regular if it preserves the space of functions that are smooth up to the boundary (sometimes this is known as Condition R). One of the most fundamental sufficient conditions for global regularity is the existence of a defining function that is plurisubharmonic on the boundary. In this talk, we will look at two generalizations of this condition: the good vector field method of Boas and Straube and a condition on the Diederich-Fornaess Index introduced by Kohn. Our goal is to show that on a large class of examples the existence of a family of good vector fields implies that the Diederich-Fornaess Index is equal to one. (Received August 16, 2017)

1134-32-106 **Mehmet Celik*** (mehmet.celik@tamuc.edu), Texas A&M University - Commerce, Department of Mathematics, Commerce, TX 75429-3011, and **Yunus E. Zeytuncu**, University of Michigan - Dearborn. *Obstructions for Compactness of Hankel Operators: Compactness Multipliers.*

We establish a connection between compactness of Hankel operators and geometry of the underlying domain through compactness multipliers for the $\overline{\partial}$-Neumann operator. In particular, we prove that any compactness multiplier induces a compact Hankel operator. We also generalize the notion of compactness multipliers to vector fields and matrices and then we use this generalization to generate compact Hankel operators. (Received August 26, 2017)

1134-32-126 **Zeljko Cuckovic*** (zcuckovi@math.utoledo.edu), University of Toledo, Department of Mathematics and Statistics, 2801 W. Bancroft Street, Toledo, OH 43606, **Sonmez Sahutoglu**, University of Toledo, Department of Mathematics and Statistics, 2801 W. Bancroft Street, Toledo, OH 43606, and **Yunus Zeytuncu**, University of Michigan-Dearborn, Department of Mathematics and Statistics, Dearborn, MI 48128. *Compactness of Toeplitz operators on domains in C^n.*

In this talk we discuss compactness of Toeplitz operators acting on weighted Bergman spaces on pseudoconvex domains. As a corollary of our main result, we obtain a characterization of compactness of Toeplitz operators on weighted Bergman spaces on strongly pseudoconvex domains. (Joint work with Sonmez Sahutoglu and Yunus Zeytuncu) (Received August 29, 2017)

1134-32-192 **Kang-Tae Kim*** (ktkim00@gmail.com). *On boundary points at which the squeezing function value converges to 1.*

Fornaess posed a question in 2015 whether the boundary point at which the squeezing function value converges to 1 has to be strictly pseudoconvex. The answer is in some cases negative, and in some other cases positive. In

this talk, I would like to present the result that the answer is affirmative if the domain is bounded in complex Euclidean space of dimension 2 and the boundary point is of finite type. [Internet version of J. Geom. Anal. 2017. DOI 10.1007/s12220-017-9910-4 by S. Joo and K.-T. Kim]. (Received September 04, 2017)

1134-32-199 **John D'Angelo** (jpda@math.uiuc.edu), 1409 W. Green St., Urbana, IL 61801, and **Ming Xiao*** (m3xiao@ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92093-0112. *Symmetries in CR complexity theory.*

We introduce concepts of Hermitian invariant groups associated to holomorphic proper maps between balls to measure their symmetry. We establish, in terms of these groups, rigidity and regularity results of proper maps. At the end of this talk, we will make connection with a super-rigidity problem studied by Mostow, Siu, Mok,etc. It is joint with D'Angelo. (Received September 04, 2017)

1134-32-201 **Andrew S Raich*** (araich@uark.edu). *The Bergman kernel on forms: General theory.*

The goal of this talk is to explore the Bergman projection on forms. In particular, we show that some of most basic facts used to construct the Bergman kernel on functions, such as the boundedness of pointwise evaluation, fail for forms. We can, however, construct the Bergman kernel and explicitly compute the Bergman kernel on $(0, n-1)$-forms. For the ball in $\mathbb{C}^2$, we also show that the size of the Bergman kernel on $(0,1)$-forms is not governed by the control metric, in stark contrast to Bergman kernel on functions. (Received September 05, 2017)

1134-32-217 **S Li*** (sli@math.uci.edu), Department of Mathematics, 340 RH, University of California at Irvine, Irvine, CA 92697-3875, and **J Luo** (luojie0520@163.com), School of Math and Information Science, Fujian Normal University, Fuzhou, Fujian 350108, Peoples Rep of China. *Forelli type theorem for harmonic map.* Preliminary report.

In this presentation, I will talk about a joint work with Jie Luo on Forelli type theorem for a mp f from the unit ball B_n in $\mathbb{C}^n$ to a Riemannian manifold. It is well that if function $f : B_n \to \mathbb{R}$ is C^∞ near $z = 0$ and $f_z(\lambda) = f(\lambda z)$ is harmonic in the unit disc $D(0,1)$ for all $z \in B_n$ then f is pluriharmonic in B_n. A question was asked by Ohsawa. Is the Forelli theorem true if one replaces the target manifold $\mathbb{R}$ by a Riemannian manifold. The talk will present our results for this problem of Ohsawa. (Received September 05, 2017)

1134-32-253 **Bingyuan Liu*** (bingyuan@ucr.edu), 900 University Ave, Surge 275A, Riverside, CA 92521. *Geometric Analysis on the Diederich-Fornæss index.*

Geometric analysis in differential geometry is a powerful tool in Riemannian geometry. It has been used to solve many problems in Riemannian geometry. In this talk, we consider problems in the Diederich—Fornæss index with a viewpoint of geometric analysis and see what we obtain. (Received September 08, 2017)

1134-32-263 **Robert E. Greene*** (greene@math.ucla.edu), Department of Mathematics, UCLA, 520 Portola Plaza, Los Angeles, CA 90095, and **Kang-Tae Kim** (kimkt@postech.ac.kr), Department of Mathematics, Pohang University of Science and Technology, Pohang, South Korea. *The Riemann Mapping Theorem Revisited.*

A complete proof will be presented based on Riemann's original approach to the Theorem. This proof differs from previous attempts to use Riemann's method, e.g., by J.L. Walsh and others, in that all topological matters are treated rigorously without appealing to any explicit or implicit results from topology as such. There will also be some discussion of historical attempts at proof, both complete and partial, and of the Theorem's role as a motivation for developments in algebraic and differential topology. (Received September 08, 2017)

1134-32-281 **David E. Barrett*** (barrett@umich.edu) and **Luke D. Edholm** (edholm@umich.edu). *The Leray transform on a family of model domains.* Preliminary report.

The domains bounded by

$$S_\beta \stackrel{\text{def}}{=} \left\{(z_1, z_2) \in \mathbb{C}^2 : \operatorname{Im} z_2 = |z_1|^2 + \beta \operatorname{Re} z_1^2\right\}$$

with $0 \le \beta < 1$ serve as useful models in the study of the affine or projective geometry of (strongly $\mathbb{C}$-convex) domains.

The Leray transform defined by

$$\mathbb{L}_\beta(f)(z) = \frac{1}{8\pi^2 i} \int_{S_\beta} \frac{f(\zeta)\, d\zeta_2 \wedge d\bar{\zeta}_1 \wedge d\zeta_1}{[(\bar{\zeta}_1 + \beta\zeta_1)(\zeta_1 - z_1) + \frac{i}{2}(\zeta_2 - z_2)]^2}$$

provides an explicit oblique projection operator from $L^2(S_\beta)$ onto the corresponding Hardy space.

The talk will provide an analysis of this operator, including a proof that the opertor norm of $\mathbb{L}_\beta$ is precisely $\frac{1}{\sqrt[4]{1-\beta^2}}$. There will also be a brief discussion of results for the Leray transform on more general domains that we believe can be proved based on the results for S_β. (Received September 09, 2017)

1134-32-289 **Harold P. Boas*** (boas@tamu.edu), Department of Mathematics, 3368 TAMU, College Station, TX 77843-3368. *Holomorphic fusion.* Preliminary report.

I will discuss methods for realizing two different holomorphic functions as slices of a single function of more variables. (Received September 10, 2017)

1134-32-317 **Yunus E Zeytuncu*** (zeytuncu@umich.edu), Dearborn, MI 48128. *Friedrichs Operator on Pseudoconvex Domains in $\mathbb{C}^n$.*

Let Ω be a smooth bounded domain in $\mathbb{C}^n$ and let $L^2(\Omega)$ denote the space of square integrable functions on Ω with respect to the Lebesgue measure. We denote the subspace of holomorphic functions in $L^2(\Omega)$ by $A^2(\Omega)$ and the Bergman projection from $L^2(\Omega)$ to $A^2(\Omega)$ by $\mathbf{B}$.

The Friedrichs operator T is a conjugate linear mapping from $A^2(\Omega)$ onto itself, defined by $f \to \mathbf{B}(\overline{f})$. It was recently observed that this operator exhibits some additional smoothing properties under certain geometric assumptions on the domain. In this talk, after a quick review of earlier results, we will prove that on any smooth bounded pseudoconvex domain Ω the Friedrichs operator T maps $A^2(\Omega)$ to $A^p(\Omega)$ for some $p > 2$. (Received September 11, 2017)

1134-32-365 **Masanori Adachi*** (adachi.masanori@shizuoka.ac.jp), Department of Mathematics, Faculty of Science, Shizuoka University, 836 Ohya Suruga-ku, Shizuoka, 422-8529, Japan. *Weighted Bergman spaces of domains with Levi-flat boundary: two case studies.*

In contrast to bounded domains in Stein manifolds, it is not clear to what extent domains with Levi-flat boundary are capable of holomorphic function with slow growth. We shall answer this question in two cases, the space of geodesic segments and the maximal Grauert tube of a compact Riemann surface, which are realized as 1-convex domains with Levi-flat boundary. We describe the weighted Bergman spaces of these domains explicitly. (Received September 11, 2017)

1134-32-453 **Claudia Miller**, Department of Mathematics, 215 Carnegie Building, Syracuse University, Syracuse, NY 13244, and **Sophia Vassiliadou***, Department of Mathematics and Statistics, St. Mary's Hall, Georgetown University, Washington, DC 20057. *On torsion and cotorsion of differentials on certain complete intersection rings.*

I will discuss some rigidity results, old and new, on torsion and cotorsion of the module of Kähler p-forms on certain complete intersections rings. Some geometric consequences of these results will also be presented. Joint work with Claudia Miller. (Received September 12, 2017)

1134-32-457 **Xin Dong*** (xindong@ucr.edu), Surge 276A, 900 University Ave, Riverside, CA 92521. *Bergman kernel and its boundary asymptotics.* Preliminary report.

We study variations of the Bergman kernel and their asymptotic behaviors at degeneration. For a holomorphic family of hyperelliptic nodal or cuspidal curves and their Jacobians, we announce our results on the Bergman kernel asymptotics near various singularities. For genus-two curves particularly, asymptotic formulas with precise coefficients involving the complex structure information are written down explicitly. (Received September 12, 2017)

34 ► Ordinary differential equations

1134-34-18 **Mostafa Ghandehari*** (ghandeha@uta.edu) and **Siamak Ardekani**. *A Double Look-Ahead Linear Car-Following Model with Multiple Time Lags.* Preliminary report.

The double look-ahead linear car-following model involves a system of linear differential-difference equations with two time lags. Discrete Z transform is used to obtain a first order linear differential equation. Solution of differential equation and inverse Z transform gives solution for velocities of each vehicle in platoon. Stability results are discussed. (Received May 24, 2017)

1134-34-233 **Bjorn Birnir*** (birnir@math.ucsb.edu), Dept. of Math., UC Santa Barbara, Santa Barbara, CA 93106. *Across the Scales: From Molecules to Ecosystem Services, uniting IBMs (Individually based models) and DEB (Dynamic Energy Budget Theory) with Molecular Dynamics.*

How to make mathematical models that show how molecular processes, e. g. contaminants, can influence whole ecosystem and their services, is a major mathematical challenge. This requires models that reach across scales, spanning several orders of magnitude.

In this lecture we will describe one such model. An IBM models inSTREAM by Railsback et al. is combined with a DEB model of Rainbow Trout (Oncorhynchus mykiss) by Birnir et al. and a portion of a model of the Rainbow Trout Hypothalamus-Pituitary-Ovary-Liver Axis (HPOLA) by Gilles et al. , to compute the effect of natural or synthetic esterogen on fertility of males and females and oocyte (egg) growth. The inSTREAM model provides a powerful check on the DEB theory that describes the flow of energies (for growth, reserves, reproduction and eggs) in individual trouts. Properly construed the DEB theory links naturally with the HPOLA model and allows us to scale up to populations and ecosystems. This give a quantitive effect of synthetic esterogen on male fertility and egg survival rates and ultimately the probability of extinction of the whole the population in the ecosystem. (Received September 07, 2017)

35 ► Partial differential equations

1134-35-46 **Viktoria Savatorova*** (viktoria.savatorova@unlv.edu) and **Aleksei Talonov** (alextalonov@gmail.com).
Wave propagation in heterogeneous media with cracks: high- and low frequency approximations.

We study acoustic wave propagation in pre-loaded heterogeneous media with isolated, randomly oriented cracks. The concentration of cracks is distributed periodically. We suppose the existence of several length scales: the smallest microscale defining the characteristic size of cracks, the mesoscale defining the characteristic size of periodic distribution of heterogeneities, and the macroscale which can be defined as a global characteristic size. The low-frequency approximation assumes the situation where the wavelength exceeds the mesoscale's characteristic size. The high frequency approximation implies the same order of magnitude for these two characteristic lengths. For low-frequency and high-frequency cases we propose multiple scales approaches which allow us to derive expressions for displacements and velocities of waves and study how these quantities can be influenced by external stress, wave's frequency and the direction of propagation. For the high-frequency we can also derive wave dispersion. (Received July 18, 2017)

1134-35-59 **Adisak Seesanea*** (asrt8@mail.missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Finite energy solutions to inhomogeneous nonlinear elliptic equations with sub-natural growth terms.*

We obtain necessary and sufficient conditions for the existence of a positive finite energy solution to the inhomogeneous quasilinear elliptic equation

$$-\Delta_p u = \sigma u^q + \mu \quad \text{on } \mathbb{R}^n$$

in the sub-natural growth case $0 < q < p - 1$, where Δ_p $(1 < p < \infty)$ is the p-Laplacian, and σ, μ are positive Borel measures on $\mathbb{R}^n$. Uniqueness of such a solution is established as well.

Similar inhomogeneous problems in the sublinear case $0 < q < 1$ are treated for the fractional Laplace operator $(-\Delta)^\alpha$ in place of $-\Delta_p$, on $\mathbb{R}^n$ for $0 < \alpha < \frac{n}{2}$, and on an arbitrary domain $\Omega \subset \mathbb{R}^n$ with positive Green's function in the classical case $\alpha = 1$. This is joint work with Igor Verbitsky. (Received August 06, 2017)

1134-35-76 **Rizwan Rizwan*** (rixwan4630@gmail.com), Department of Mathematics University of Pesha, Peshawar, 25000, Pakistan, **Noor Badshah** (noor2knoor@gmail.com), UET, Peshawar, 25000, Pakistan, and **Akbar Zada** (akbarzada@upesh.edu.pk), UOP, Peshawar, 25000, Pakistan. *Fractional Order Total Variational Based Model For Multiplicative Noise Removal.*

In this paper we proposed a new fractional order total variation (FOTV) based model via weighted statistic for restoration of images corrupted with multiplicative noise. Explicit time marching scheme is applied to find the solution of the corresponding Euler-Lagrange partial differential equation. Experimental results demonstrate that our proposed methodology improves the visual quality of the restored images as well as increase the peak signal to noise ratio (PSNR) over other existed methods.
(Received August 18, 2017)

1134-35-125 **Xiaolong Li*** (xiaolol1@uci.edu), 340 Rowland Hall (Bldg.# 400), University of California, Irvine, Irvine, CA 92697. *Asymptotic Behavior of Nonparametric Gauss Curvature Flow.*

In this talk, I will present a result on the asymptotic behavior of some fully nonlinear parabolic partial differential equations. Such equations arise naturally in the motion of nonparametric hypersurfaces by powers of Gaussian curvature. The main result asserts that the solution asymptotically picks up the symmetry of the domain, regardless of its initial shape. (Received August 29, 2017)

1134-35-146 **Jiuyi Zhu*** (jzhu18@lsu.edu). *Quantitative uniqueness of solutions to parabolic equations.* Preliminary report.

We investigate the quantitative uniqueness of solutions to parabolic equations with lower order terms on compact smooth manifolds. Quantitative uniqueness is a quantitative form of strong unique continuation property. We characterize quantitative uniqueness by the rate of vanishing. We can obtain the vanishing order of solutions by $C^{1,1}$ norm of the potential functions, as well as the L^∞ norm of the coefficient functions. Some new quantitative Carleman estimates and three cylinder inequalities are established. (Received August 31, 2017)

1134-35-160 **David G Costa*** (david.costa@unlv.edu). *The sub-supersolution method, a Hopf-type maximum principle and local minimizers for a class of elliptic equations in $\mathbb{R}^N$.*

Our goal is to look for solutions of a class of superlinear elliptic problems in $\mathbb{R}^N$ of the form

$$(P) \qquad -\Delta u = b(x)g(u)\,,\ x \in \mathbb{R}^N\,,$$

where $g : \mathbb{R} \to \mathbb{R}$ is a continuous, subcritical nonlinearity, which is superlinear at $s = 0$. Natural hypotheses are imposed on the weight function $b(x)$ to render the above problem well-defined as a variational problem in the Hilbert space $H := \mathcal{D}^{1,2}(\mathbb{R}^N)$, which is the completion of $C_0^\infty(\mathbb{R}^N)$ under the norm $\|u\| = (\int |\nabla u|^2)^{1/2}$, and with inner product $\langle u, v\rangle = \int \nabla u \cdot \nabla v$.

In fact, the main goal and the novelty of this work is our approach by establishing a Brezis-Nirenberg type result and a Hopf-type maximum principle in the context of the space $\mathcal{D}^{1,2}(\mathbb{R}^N)$. The main ingredients are regularity results and a sub-supersolution method that we develop which are of interest in their own right. This is joint work with S. Carl (Germany) and H. Tehrani (USA). (Received September 02, 2017)

1134-35-163 **Marius Ghergu** and **Steven D. Taliaferro*** (stalia@math.tamu.edu), Mathematics Department, Texas A&M University, College Station, TX 77843-3368, and **Igor E. Verbitsky**. *Pointwise Bounds and Blow-up for Systems of Semilinear Elliptic and Parabolic Inequalities.*

We discuss the behavior near the origin of positive solutions $u(x)$ and $v(x)$ of the elliptic system

$$\begin{aligned} 0 \le -\Delta u \le v^\lambda \\ 0 \le -\Delta v \le u^\sigma \end{aligned} \qquad \text{in } B_1(0) \setminus \{0\} \subset \mathbb{R}^n,\ n \ge 3, \tag{1}$$

where λ and σ are nonnegative constants.

We also present similar results on the behavior for t small and positive of nonnegative solutions $u(x,t)$ and $v(x,t)$ of the parabolic system

$$\begin{aligned} 0 \le u_t - \Delta u \le v^\lambda \\ 0 \le v_t - \Delta v \le u^\sigma \end{aligned} \qquad \text{in } \Omega \times (0,1), \tag{2}$$

where λ and σ are nonnegative constants and Ω is an open subset of $\mathbb{R}^n$, $n \ge 1$.

The extension of our results for the elliptic system (1) to the parabolic system (2) requires new parabolic versions of Hedbergs inequality, the Hardy-Littlewood-Sobolev inequality, and nonlinear Riesz potential estimates. These new parabolic tools are proved using a modified version of the Hardy-Littlewood maximal function inequality in which Euclidean balls in $\mathbb{R}^n$ are replaced with heat balls in $\mathbb{R}^n \times \mathbb{R}$. (Received September 02, 2017)

1134-35-179 **Zijin Li** and **Qi S Zhang*** (qizhang@math.ucr.edu), Riverside, CA 92521. *Regularity of Weak Solutions of Elliptic and Parabolic Equations with Some Critical or Supercritical Potentials.*

We prove Holder continuity or differentiability of weak solutions of uniformly elliptic and parabolic equations with power like potentials which scales critically or super-critically. This is a joint work with Li Zijin. (Received September 04, 2017)

1134-35-186 **Chiu-Yen Kao*** (ckao@cmc.edu), Claremont, CA 91711. *Optimal Spatial Arrangements of Favorable and Unfavorable Regions.*

In this talk, we consider several dispersal models with periodic and Dirichlet boundary conditions and their corresponding linear eigenvalue problems. These models describe the time evolution of populations which disperse locally and/or nonlocally. We investigate how long time dynamics depend on the parameter values. Furthermore, we study the minimization of the principal eigenvalue under the constraints that the resource function is bounded from above and below, and with a fixed total integral. Biologically, this minimization problem is motivated by the question of determining the optimal spatial arrangement of favorable and unfavorable regions for the species to die out more slowly or survive more easily. We develop numerical methods based on rearrangement techniques to achieve the optimal arrangements. Numerous results are shown to demonstrate various scenarios of optimal favorable regions for different boundary conditions. (Received September 04, 2017)

1134-35-194 **Alejandro Velez-Santiago*** (alejandro.velez2@upr.edu), Department of Mathematical Sciences, University of Puerto Rico - Mayaguez, Mayaguez, PR 00681. *A quasi-linear Neumann problem of Ambrosetti-Prodi type in extension domains.*

We investigate the solvability of the Ambrosetti–Prodi problem for the p-Laplace operator with Neumann boundary conditions. Using a priori estimates, regularity theory, a sub-supersolution method, and the Leray-Shauder degree theory, we obtain a necessary condition for the non-existence of solutions (in the weak sense), the existence of at least one solution, and the existence of at least two distinct solutions. Moreover, we establish global Hölder continuity for weak solutions of the Neumann problem of Ambrosetti–Prodi type on a large class of non-smooth domains. (Received September 04, 2017)

1134-35-212 **Elaine Cozzi**, **James Kelliher*** (kelliher@math.ucr.edu) and **Gung-Min Gie**. *The aggregation equation with Newtonian potential: the vanishing viscosity limit.*

The viscous and inviscid aggregation equation with Newtonian potential models a number of different physical systems and has close analogs in 2D incompressible fluid mechanics. We consider a slight generalization of the aggregation equation in the whole space establishing well-posedness of the viscous and inviscid equations, spatial decay of the viscous solutions, and the convergence of viscous solutions to the inviscid solution as the viscosity goes to zero. (Received September 05, 2017)

1134-35-213 **Yuming Zhang*** (paulzhangyuming@gmail.com), 1418 S Bentley Ave, Apt 202, Los Angeles, CA 90025. *Vanishing viscosity approximation of a class of continuity equations.*

In this talk we consider a class of continuity equations that are conditioned to stay in general space-time domains, which is formulated as a continuum limit of interacting particle systems.

The equation is

$$\frac{\partial}{\partial t}\mu(x,t) + \nabla \cdot \left(\mu P_{x,t}(-\nabla V - \nabla W * \mu)\right)(x,t) = 0 \tag{1}$$

with nice initial data. Here V and W are respectively external and interaction potentials. The projection operator $P_{x,t}$ describes that particles on the boundary are moving along it.

We show the vanishing viscosity approximation (without the projection operator) of the system, given with the co-normal boundary condition. This result is significant since it provides a natural justification for (1). To do this we develop a modification method and we use gradient flow. (Received September 05, 2017)

1134-35-226 **Tarek M Elgindi*** (telgindi@ucsd.edu), 9500 Gilman Dr, Department of Mathematics, UC-San Diego, La Jolla, CA 92093, and **In-Jee Jeong**. *Singularity formation in incompressible fluids.*

We will present some recent results on singularity formation for solutions to the Boussinesq and 3D Euler systems. (Received September 06, 2017)

1134-35-240 **Tam Do**, **Alexander Kiselev**, **Lenya Ryzhik** and **Changhui Tan***, 6100 Main St., Houston, TX 77005. *Global regularity for Burgers equation with density dependent fractional dissipation.*

Fractional Burgers equations are a family of equations which connect inviscid and viscous Burgers equations. It is well-known that if the dissipation is strong, the solution is globally regular. On the other hand, it the dissipation is weak (called supercritical case), the solution can lose regularity in finite time. In this talk, I will introduce a model where the dissipation depends on density. The model is motivated by self-organized dynamics in math biology. Despite that the equation shares a lot of similarities to fractional Burgers equation, the solution is globally regular, even in the supercritical case. I will explain the regularization mechanism that is due to the

nonlocal nonlinear modulation of dissipation. This is a joint work with T. Do, A. Kiselev, and L. Ryzhik. (Received September 07, 2017)

1134-35-246 **Michael Liam McNulty*** (mmcnu002@ucr.edu), 720 El Cerrito Drive, Autumn #10, Riverside, CA 92507. *Development of Singularities of the Skyrme Model.*

The Skyrme model is a geometric field theory, and a quasilinear analog of the Nonlinear Sigma Model (Wave Map). In this paper we study the development of singularities for the equivariant Skyrme Model, in the strong field limit, where the restoration of scale invariance allows us to look for self-similar blow-up behavior. After introducing the Skyrme Model and reviewing what's known about formation of singularities in equivariant Wave Maps, we prove the existence of smooth self-similar solutions to the 5+1-dimensional Skyrme Model in the strong field limit, and use that to conclude that the solution to the corresponding Cauchy problem blows up in finite time, starting from a particular class of everywhere smooth initial data. (Received September 07, 2017)

1134-35-247 **Changfeng Gui*** (changfeng.gui@utsa.edu), San Antonio, TX 78249, and **Yong Liu** and **Juncheng Wei**. *Two-end solutions to the Allen-Cahn equation in the three dimensional Euclidean space.*

In this paper, we study axially symmetric solutions of Allen-Cahn equation in the three dimensional Euclidean space. Using a sophisticated continuation method, we show the existence of a complete family of axially symmetric solutions with a range of logarithmic growth rates, which may be regarded as the analogue of the family of catenoids and hence called two-end solutions. Nonexistence of two-end solution with a small growth rate is also shown, which differs from the theory of minimal surfaces. (Received September 07, 2017)

1134-35-248 **Alpár R. Mészáros*** (alpar@math.ucla.edu). *Nonlinear cross-diffusion systems: an optimal transport approach.*

In this talk we will present a degenerate cross-diffusion system which involves two densities with two different drift velocities. A general framework will be introduced based on its gradient flow structure in the Wasserstein space to derive a notion of discrete-time solutions. Its continuum limit, due to the possible mixing of the densities, only solves a weaker version of the original system. In one space dimension, where the densities are guaranteed to be segregated, a stable interface appears between the two densities, and a stronger convergence result, in particular derivation of a standard weak solution to the system, is available. We also study the incompressible limit of the system, which addresses transport under a height constraint on the total density. In one space dimension we show that the problem leads to a two-phase Hele-Shaw type flow. The talk is based on a joint work with Inwon Kim (UCLA). (Received September 08, 2017)

1134-35-257 **Di Kang*** (di.kang@cgu.edu), Claremont, CA 91711, and **Chiu-Yen Kao**, Claremont, CA 91711. *Minimization of inhomogeneous biharmonic eigenvalue problems.*

Biharmonic eigenvalue problems arise in the study of the mechanical vibration of plates. In this paper, we study the minimization of the first eigenvalue of a simplified model with clamped boundary conditions and Navier boundary conditions with respect to the coefficient functions which are of bang-bang type (the coefficient functions take only two different constant values). A rearrangement algorithm is proposed to find the optimal coefficient function based on the variational formula of the first eigenvalue. On various domains, such as square, circular and annular domains, the region where the optimal coefficient function takes the larger value may have different topologies. An asymptotic analysis is provided when two different constant values are close to each other. In addition, a symmetry breaking behavior is also observed numerically on annular domains. (Received September 08, 2017)

1134-35-260 **Jerome Vetois*** (jerome.vetois@mcgill.ca). *Blowing-up solutions for critical elliptic equations on a closed manifold.*

In this talk, we will look at the question of existence of blowing-up solutions for smooth perturbations of positive scalar curvature-type equations on a closed manifold. From a result of Druet, we know that in dimensions different from 3 and 6, a necessary condition for the existence of blowing-up solutions is that the limit equation agrees with the Yamabe equation at least at one blow-up point. I will present new existence results in situations where the limit equation is different from the Yamabe equation away from the blow-up point. I will also discuss the special role played by the dimension 6. This is a joint work with Frederic Robert. (Received September 08, 2017)

1134-35-267 **Fangbo Zhang*** (fb.zhangsjtu@gmail.com), 3265 s sepulveda blvd, apt 305, Los Angeles, CA 90034, and **Andrea Bertozzi**, **Spring Berman** and **Karthik Elamvazhuthi**. *Performance Bounds on Spatial Coverage Tasks by Stochastic Robotic Swarms.* Preliminary report.

In this paper, we model the population dynamics of the swarm as an advection-diffusion-reaction partial differential equation (PDE) with time-dependent advection and reaction terms. PDE macroscopic models can provide useful forecasting for the aggregate spatiotemporal dynamics of a stochastic swarm of robots. This paper derives rigorous error bounds on the discrepancy between a discrete model of stochastic swarming, which includes robot switching between behavioral states, and a continuum limit PDE. The main contribution of this paper is the analysis of the dependence of this error on two key parameters: the number of robots in the swarm and the robot sensing radius. We use these bounds to select the swarm size that will achieve coverage performance within a given error and the corresponding robot sensing radius that will minimize this error. We also apply the optimal control approach to compute the robots' velocity field and task-switching rates. We validate our procedure through simulations of a scenario in which a robotic swarm must achieve a specified density of pollination activity over a crop field. (Received September 09, 2017)

1134-35-269 **Martin Burger**, **Jan Haskovec**, **Jan-Frederik Pietschmann**, **Helene Ranetbauer** and **Marie-Therese Wolfram*** (m.wolfram@warwick.ac.uk), Coventry, CV47AL, United Kingdom. *Mean-field aggregation models in the life and social sciences.* Preliminary report.

In this talk we discuss different mean-field aggregation models for collective behavior in the life and social sciences. In these models individuals decrease their random motion if they perceive a high average population density in their neighborhood. This kind of behaviour was observed in insects, for example the pre-social German cockroach Blatella germanica, but also describes the dynamics of two different social groups in Schelling's model for segregation. We discuss the formerly derived mean-field models for both applications and the formation of aggregates as well as segregated states. We confirm our analytic results with numerical experiments and illustrate the dynamics with various examples. (Received September 09, 2017)

1134-35-291 **Maria C. Carvalho*** (mccarvalh@gmail.com), Department of Mathematics - FCUL, Building C6, Level 1 Campo Grande, 1749-016 Lisbon, Portugal. *Quantum Kinetic Equations from Quantum Many Particle Systems.*

The classical Kac model describes a system of N classical particles interacting through binary collisions, and in the limit N to infinity, it has a rigorous connection with the spatially homogeneous Boltzmann equations. We present recent results on a quantum analog. We study models for quantum systems of N particles undergoing random binary collisions, focusing on the rate of convergence to equilibrium and the propagation of chaos. In this case, Kac's Master equation becomes an evolution equation of Lindblad type, while the corresponding Boltzmann equation is a novel sort of non-linear evolution equation for a density matrix. The treatment departs from the classical treatment because in quantum mechanics, conditional probability is not always well defined. Nonetheless, a substantial quantum analog of the Kac program can be carried out, and it leads to an interesting and novel class of quantum kinetic equations. This is joint work with Eric Carlen and Michael Loss. (Received September 10, 2017)

1134-35-295 **Vincent Calvez**, **Jose Antonio Carrillo** and **Franca Hoffmann*** (fkoh@caltech.edu), Caltech, MC 305-16, Pasadena, CA 91125. *Equilibria of diffusing and self-attracting particles.*

We study interacting particles behaving according to a reaction-diffusion equation with non-linear diffusion and non-local attractive interaction. This class of equations has a very nice gradient flow structure that allows us to make links to homogeneous functionals and variations of well-known functional inequalities (Hardy-Littlewood-Sobolev inequality, logarithmic Sobolev inequality). Depending on the non-linearity of the diffusion, the choice of interaction potential and the dimensionality, we obtain different regimes. Our goal is to understand better the asymptotic behaviour of solutions in each of these regimes, starting with the fair-competition regime where attractive and repulsive forces are in balance. This is joint work with José A. Carrillo and Vincent Calvez. (Received September 10, 2017)

1134-35-298 **Dohyun Kwon*** (dhkwon@ucla.edu), University of California, Los Angeles, Department of Mathematics, 520 Portola Plz, Los Angeles, CA 90095, and **Inwon Kim**. *Analysis of Mean Curvature Flow with a Forcing Term.*

In this talk, we discuss about mean curvature flow with a forcing term. A forcing term appears in several physical models such as crystal growth models. This forcing term can act as a Lagrange multiplier, which corresponds to geometric constraints such as volume preserving mean curvature flow. We introduce a framework

based on both viscosity solutions and variational approaches for mean curvature flow with a forcing term. In this framework, we define a notion of solutions for this non-local equation and analyze their geometric property, preservation of star-shapedness. We show coincidence between viscosity and variational solutions followed by existence. Moreover, we show uniqueness of a solution based on convolution functions. This is joint work with Inwon Kim. (Received September 10, 2017)

1134-35-305 **Joshua Ballew** and **Konstantina Trivisa*** (trivisa@math.umd.edu), Department of Mathematics, University of Maryland, Kirwan Hall, College Park, MD 20742. *On the Euler-Smoluchowski system for fluid-particle interaction.*

Recent advances on the Euler system for fluid=particle interaction are presented. The system under consideration is governed by the continuity equation, the balance of momentum enhanced by the addition of forces that the fluid and the particle expert mutually and the Smoluchowski equation for the evolution of particles. Well-posedness of weak solutions to the Euler-Smoluchowski system for the interaction of particles and an inviscid, compressible fluid is considered. Using the method of convex integration of De Lellis and Székelyhidi, the existence of in finiitely many global-in-time weak solutions for any choice of regular initial data is shown. This result is then investigated in the case of weakly-dissipative admissible solutions obeying an energy inequality and a relative entropy inequality. (Received September 10, 2017)

1134-35-311 **Francesco Saverio Patacchini***, Wean Hall, 5000 Forbes Ave, Pittsburgh, PA 15213. *A blob method for diffusion.*

We derive a new deterministic particle method for linear and nonlinear diffusion. Inspired by classical vortex blob methods, we introduce a nonlocal regularization of our velocity field which ensures that initial Dirac masses remain Dirac masses as time evolves. We apply this to develop a numerical blob method for a range of diffusive partial differential equations of Wasserstein gradient flow type, including the heat, porous medium, Fokker–Planck, and Keller–Segel equations. Our choice of regularization is guided by this Wasserstein gradient flow structure, and the resulting regularized internal energy has a novel form combining aspects of the well-known interaction and internal energies. When restricting to nonlinear diffusion with at least quadratic exponent, we show that, under sufficient regularity assumptions, the gradient flow for the regularized energy Γ-converges to the solution of the porous medium equation. We consider a range of numerical examples that demonstrate our method's rate of convergence to exact solutions and illustrate key qualitative properties, including asymptotic behavior of the Fokker-Planck equation and critical mass of the two-dimensional Keller–Segel equation. This is joint work with J. A. Carrillo and K. Craig. (Received September 10, 2017)

1134-35-322 **Karthik Adimurthi** and **Phuc C Nguyen*** (pcnguyen@math.lsu.edu). *Quasilinear equations with gradient power source terms of natural growth and distributional data.*

We obtain necessary and sufficient conditions, with sharp constants, on the distributional data σ for the existence of a globally finite energy solution to the quasilinear equation with a gradient power source term of natural growth of the form $-\Delta_p u = |\nabla u|^p + \sigma$ in a bounded open set $\Omega \subset \mathbb{R}^n$. Here Δ_p, $p > 1$, is the standard p-Laplacian operator defined by $\Delta_p u := \operatorname{div}(|\nabla u|^{p-2}\nabla u)$. The study of $-\Delta_p u = |\nabla u|^p + \sigma$ is then applied to show the existence of globally finite energy solutions to the quasilinear equation of Schrödinger type $-\Delta_p v = \sigma\, v^{p-1}$, $v \geq 0$ in Ω, and $v = 1$ on $\partial\Omega$, via the exponential transformation $u \mapsto v = e^{\frac{u}{p-1}}$. This talk is based on joint work with Karthik Adimurthi. (Received September 11, 2017)

1134-35-331 **Kun Zhao*** (kzhao@tulane.edu). *Compressible Euler Equations with Lower Order Dissipations.*

This talk consists of several recent results concerning the global dynamics of the compressible Euler equations with lower order dissipations, such as damping and relaxation, and related models in other scientific areas, such as mathematical biology and material science. (Received September 11, 2017)

1134-35-333 **Chuong V. Tran** and **Xinwei Yu*** (xinwei2@ualberta.ca), 632 CAB, University of Alberta, Edmonton, Alberta T6G2G1, Canada. *A New Type of Regularity Criterion for the 3D Navier-Stokes Equations.*

We present a new kind of regularity criterion for the global well-posedness problem of the three dimensional Navier-Stokes equations in the whole space. The main novelty of this new criterion is that it involves the shape of the magnitude of the velocity. More specifically, we prove that if for every fixed time in $(0, T)$, the region of high velocity, appropriately defined with a parameter q, shrinks fast enough as $q \nearrow \infty$, then the solution stays regular beyond T. We further argue that reasonable flows satisfy our criterion, and singularity in Navier-Stokes is highly unlikely.

This is joint work with Prof. Chuong V. Tran of the University of St. Andrews, United Kingdom. (Received September 11, 2017)

1134-35-341 **Tam Do*** (tamdo@usc.edu). *Vorticity Gradient Growth for the Axisymmetric 3D Euler Equations Without Swirl.*

In the 2D Euler Equations, it is known that the L^∞ norm of the gradient of vorticity can grow at most double exponentially in time. This bound has been proven to be sharp by Kiselev and Sverak on the unit disc. We examine the possibility of gradient growth in the 3D axisymmetric setting for flows without swirl component. (Received September 11, 2017)

1134-35-342 **Tam Do*** (tamdo@usc.edu). *Global Regularity for the Fractional Euler Alignment System.*

We study a pressureless Euler alignment system with nonlinear density-dependent alignment term. The system originates from Cucker-Smale flocking models. The alignment term is dissipative and has the same order as the fractional Laplacian $(-\Delta)^\alpha$, $\alpha \in (0,1)$. The corresponding system with the fractional Laplacian is the fractional Burgers equation, which forms shocks in finite time. We show solutions are globally regular for all $\alpha \in (0,1)$. (Received September 11, 2017)

1134-35-355 **John K Hunter***, Department of Mathematics, University of Californai at Davis, Davis, CA 9516, and **Jingyang Shu**. *SQG Fronts.*

We derive regularized contour dynamics equations for the motion of infinite sharp fronts in the surface quasi-geostrophic (SQG) equations, and prove a short-time, weak well-posedness result for a cubic approximation of the contour dynamics equations. (Received September 11, 2017)

1134-35-356 **John Blake Temple*** (temple@math.ucdavis.edu), Department of Mathematics, University of California, Davis, Davis, CA 95616. *Causal Dissipation for the Relativistic Fluid Dynamics of Ideal Gases.*

(I discuss presenter's 2017 RSPA article, all joint work with co-author Heinrich Freistuehler). It has long been thought that there is no relativistic version of the compressible Navier-Stokes equations, (modeling dissipation by bulk and shear viscosity and heat conductivity), such that the system is causal in the sense that all wave speeds are bounded by the speed of light. Starting with the recognition that Navier-Stokes dissipation is only a leading order theory, together with the principle that fundamental equations of fluid dynamics should be symmetric hyperbolic, we prove that there is a unique sharply causal version of relativistic Navier-Stokes which is symmetric hyperbolic as a second order system when written in the natural Godunov variables that make the Euler equations symmetric hyperbolic as a first order system, such that the system is equivalent to the classical relativistic descriptions of Eckart and Landau to leading order in the coefficients of viscosity and heat conduction. Based on these properties, we propose this system as a natural candidate for the relativistic counterpart of the classical Navier-Stokes equations. (Received September 11, 2017)

1134-35-384 **Changhui Tan***, 6100 Main St., Houston, TX 77005. *Regularity and singularity formations for fractional porous medium flow.*

I will discuss some recent results on global regularity and finite time singularity formation for porous medium flow with fractional potential pressure. (Received September 12, 2017)

1134-35-388 **Igor Kukavica*** (kukavica@usc.edu), **Vlad Vicol** and **Fei Wang**. *Local existence and blowup results for the Prandtl equation.*

We will briefly survey available local and global existence results for the Prandtl boundary later equation. Then we will also present a blowup result for the Prandtl equations with van Dommelen and Shen matching data (joint with V. Vicol and F. Wang). (Received September 12, 2017)

1134-35-390 **Alexander Kiselev**, **Yao Yao** and **Andrej Zlatos*** (zlatos@ucsd.edu). *Local regularity for the modified SQG patch equation.*

We show local regularity for the patch dynamics version of the modified SQG equation, which interpolates between the two-dimensional Euler and SQG equations as a parameter α increases from 0 to $\frac{1}{2}$. The result holds for all $\alpha < \frac{1}{2}$ for the PDE on the whole plane, and for all small enough α on the half-plane. The latter case is a precursor to our proof of finite time blow-up for this model, while the question of global regularity remains open on the whole plane. (Received September 12, 2017)

1134-35-393 **Changfeng Gui** and **Amir Moradifam*** (amirm@ucr.edu). *The Sphere Covering Inequality and Its Applications.*

We show that the total area of two distinct Gaussian curvature 1 surfaces with the same conformal factor on the boundary, which are also conformal to the Euclidean unit disk, must be at least 4π. In other words, the areas of these surfaces must cover the whole unit sphere after a proper rearrangement. We refer to this lower bound of total areas as the Sphere Covering Inequality. This inequality and it's generalizations are applied to a number of open problems related to Moser-Trudinger type inequalities, mean field equations and Onsager vortices, etc, and yield optimal results. In particular we confirm the best constant of a Moser-Truidinger type inequality conjectured by A. Chang and P. Yang in 1987. (Received September 12, 2017)

1134-35-398 **Agnid Banerjee**, Bangalore, India, and **Nicola Garofalo*** (rembrandt54@gmail.com), Padova, Italy. *Space-time strong unique continuation for nonlocal parabolic equations.* Preliminary report.

In two visionary papers in 1938 and 1949 Marcel Riesz introduced the fractional powers of the Laplacian in Euclidean and Lorentzian space, developed the calculus of these nonlocal operators and studied the Dirichlet and Cauchy problems for respectively the fractional Laplacian and the wave equation. He also mentioned, but did not include in his study, the fractional heat equation. These pseudo-differential operators play an important role in many branches of the applied sciences ranging from elasticity, to geophysical fluid dynamics and to quantum mechanics. But they also appear prominently in other branches of mathematics, such as e.g. geometry and financial mathematics.

In this talk I will present a new result on the strong unique continuation property, backward in time, for zero-order perturbations of the nonlocal heat equation: $(D_t - \Delta)^s u = Vu$ for $0 < s < 1$. This is joint work with Agnid Banerjee. (Received September 12, 2017)

1134-35-399 **Mihaela Ifrim*** (ifrim@wisc.edu) and **Daniel Tataru** (tataru@math.berkeley.edu). *Long time dynamics for the Benjamin-Ono equation.*

Our goal is to take a first step toward understanding the long time dynamics of solutions for the Benjamin-Ono equation. While this problem is known to be both completely integrable and globally well-posed in L^2, much less seems to be known concerning its long time dynamics. We present that for small localized data the solutions have (nearly) dispersive dynamics almost globally in time. An additional objective is to revisit the L^2 theory for the Benjamin-Ono equation and provide a simpler, self-contained approach. This is joined work with Daniel Tataru. (Received September 12, 2017)

1134-35-407 **Wenlong Jin**, Irvine, CA 92617, and **Yifeng Yu*** (yyu1@math.uci.edu), Irvine, CA 92617. *A PDE Model of the Effective Flux (MFD) on a Signalized Ring Road.*

In this talk, we will discuss (1) how to rigorously establish the existence of effective flux (macroscopic fundamental diagram, MFD) on a ring road with one or multiple traffic lights; (2) how the MFD depends on significant parameters like cycle length, offset, etc. Our approach is based on a modified 1d conservation law (LWR model). This is a part of an ongoing joint project with Wenlong Jin. (Received September 12, 2017)

1134-35-408 **Erdogan Mehmet Ozkan*** (mozkan@yildiz.edu.tr), Yildiz Technical University, College of Arts, and Sciences, Department of Mathematics, Davutpasa Campus, Esenler, 34210 Istanbul, Turkey, **Mutlu Akar** (makar@yildiz.edu.tr), Yildiz Technical University, College of Arts, and Sciences, Department of Mathematics, Davutpasa Campus, Esenler, 34210 Istanbul, Turkey, and **Adem Cengiz Cevikel** (acevikel@yildiz.edu.tr), Yildiz Technical University, College of, Education,Department of Mathematics Education, Davutpasa Campus, Esenler, 34210 Istanbul, Turkey. *Periodic and Solitary Wave Solutions of Some Physical Models.*

In this work, we present a method for finding periodic wave solutions and solitary wave solutions of some nonlinear evolution equations in mathematical physics. The proposed technique is tested on some nonlinear evolution equations. (Received September 12, 2017)

1134-35-419 **Peter Markowich*** (peter.markowich@kaust.edu.sa). *First Principle Modeling of Biological Transportation Networks.*

We present a discrete ODE and continuum PDE modeling framework for biological transportation networks, which can be used to describe leaf venation, neuronal networks, blood vessel networks etc. (Received September 12, 2017)

1134-35-420 **Eun Heui Kim*** (eunheui.kim@csulb.edu). *Transonic problems in multidimensional conservation laws.*

We discuss the recent progress on transonic two-dimensional Riemann problems. We focus on the nonlinear wave system, which is a reduced system from the Compressible Euler system, and discuss the existence, regularity and numerical results for transonic shocks and sonic (degenerate) boundary value problems for the governing system. (Received September 12, 2017)

37 ► Dynamical systems and ergodic theory

1134-37-14 **Palle Jorgensen*** (palle-jorgensen@uiowa.edu), Dept Mathematics MLH, 2 Washington st, Univ of Iowa, Iowa City, IA 52242. *Probability theory of infinite iterated function systems.*

We shall present some topics on the spectral duality (and duality) for singular measures started with a joint paper, Jorgensen-Pedersen. Since then the subject has expanded in a variety of diverse directions. In the case of affine IFS measures mu, when an associated complex Hadamard matrix is further assumed to satisfy an additional symmetry condition; then the $L^2(mu)$ Hilbert space will have an orthogonal Fourier basis; in other words we get an associated fractal Fourier transform. In order to appreciate the nature of the spectral duality, note that spectral duality holds for the middle 1/4 Cantor measure, but not for its middle 1/3 cousin. Typically the distribution of the associated Fourier frequencies satisfies very definite lacunary properties, in the form of geometric almost-gap distributions; the size of the gaps grows exponentially, with sparsity between partitions. The probabilistic significance will be explored. Use will be made of reproducing kernel Hilbert spaces of analytic functions. (Received April 25, 2017)

1134-37-87 **J. Ding*** (jiu.ding@usm.edu), Department of Mathematics, University of Southern Mississippi, Hattiesburg, MS 39406, and **Tulsi Upadhyay**. *A maximum entropy method for stationary densities of random maps.*

For a random map consisting of a finite number of transformations with respective probabilities, we develop a maximum entropy method for the recovery of a stationary density of the corresponding Markov operator. Convergence analysis and numerical results are presented. (Received August 22, 2017)

1134-37-131 **Felix Xiao-feng Ye*** (yexf308@uw.edu), Department of Applied Mathematics, Lewis Hall 202, Box 353925, Seattle, WA 98105. *Rate of exponential forgetting in HMM and its application to statistical learning.* Preliminary report.

We consider a finite state hidden Markov model (HMM) with multidimensional observations. Under some mild assumptions, the prediction filter forgets almost surely the initial condition exponentially fast. However, it is very difficult to calculate this asymptotic rate of exponential loss of memory analytically. We restate this problem in the setting of the random dynamical system and use the Lyapunov exponents of the induced random dynamical system defined in the projective space $\mathbb{R}^{n-1}$ to approximate the convergence rate. Finally, we propose a stable numerical algorithm to calculate the rate of exponential forgetting semi-analytically. The numerical simulation result and comparison with current upper bound in literature will be shown in the presentation.

We harness this memory forgetting property to design an algorithm for efficiently estimating the gradient of log-likelihood, such that it speeds up the gradient based numerical optimization. Examples are shown in the presentation compared with traditional methods. (Received August 29, 2017)

1134-37-140 **Mariusz Urbanski*** (urbanski@unt.edu), Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203-5017, and **Volker Mayer**. *Thermodynamic formalism and integral means spectrum of asymptotic tracts for transcendental entire functions.*

We extend the theory of thermodynamic formalism to a very general class of hyperbolic entire functions of class $\mathcal{B}$. It contains the class of all entire functions for which thermodynamic formalism has been so far established. In fact, it goes much beyond. This new class contains as particular examples all Poincaré functions of topological Collet-Eckmann polynomials.

The key point is that we introduce an integral means spectrum for logarithmic tracts which takes care of the fractal behavior of the boundary of the tract near infinity. It turns out that this spectrum behaves well as soon as the tracts have some sufficiently nice geometry which, for example, is the case for quasicircle, John or Hölder tracts (the class of functions considered so far pertained to the the Lipschitz tracts). In this case we get a good control of the corresponding transfer operators, leading to full thermodynamic formalism. In addition, the graph

of the integral means spectrum has then a unique zero and allows us to prove a version of Bowen's formula for the Hausdorff dimension of the radial Julia set. (Received August 30, 2017)

1134-37-142 **Brian Ryals*** (bryals@csub.edu). *Global Stability in the 2D Ricker Competition Model.*
This talk will focus on a study of the 2D Ricker Competition Model, a four parameter system. The interest will be determining conditions on these four parameters where one has global attraction to the coexistence fixed point. We will summarize prior work on the model where a rather strict set of assumptions were used, and show that there is a large set of parameters not covered in previous studies. We will show numerically some of the troublesome issues one encounters in the more general case, in spite of the seemingly simple appearance of the equations. (Received August 31, 2017)

1134-37-143 **Pengfei Zhang*** (pengfei.zhang@ou.edu), 601 Elm Avenue, PHSC 423, Norman, OK 73019. *Homoclinic Intersections for Generic Geodesic Flows on S^2.*
We study some generic properties of the geodesic flows on the two sphere with Riemannian metrics with positive curvature. We show that generically, every hyperbolic closed geodesic admits transverse homoclinic intersections. This is a joint work with Z. Xia. (Received August 31, 2017)

1134-37-144 **Fan Yang*** (fan.yang-2@ou.edu) and **Maria Jose Pacifico**. *Hitting times distribution and extreme value laws for semi-flows.*
For flows whose return map on a cross section has sufficient mixing property, we show that the hitting time distribution of the flow to balls is exponential in limit. We also establish a link between the extreme value distributions of the flow and its hitting time distribution, generalizing a previous work by Freitas et al in the discrete time case. Finally we will talk about EVL for maps modeled by Young's tower with polynomial tail. This is a joint work with M. J. Pacifico. (Received August 31, 2017)

1134-37-183 **Chris Marx*** (cmarx@oberlin.edu), Department of Mathematics, Oberlin College, 10 N Professor Street, Oberlin, OH 44074, and **Rui Han** (rhan2@uci.edu), Insitute for Advanced Study, 1 Einstein Drive, Princeton, NJ 08540. *Large coupling asymptotics for the Lyapunov exponent of quasi-periodic Schrödinger operators.*
We consider quasi-periodic Schrödinger operators whose potential is an analytic function scaled by a real coupling parameter. Quasi-periodic Schrödinger operators are among the most prominent examples for quantum mechanical systems whose energy spectrum may exhibit fractal features.

In this talk we present a formula for the Lyapunov exponent which explicitly quantities the asymptotic dependence on the coupling parameter, thereby shedding a light on the large potential regime. Heuristically, the Lyapunov exponent can be viewed as an inverse decay rate of the solutions to the Schrödinger equation. The question of capturing the large coupling behavior of the Lyapunov exponent has a rich history which has influenced greatly the development of many aspects of the spectral theory of quasi-periodic Schrödinger operators.

The talk is based on joint work with Rui Han (IAS). (Received September 04, 2017)

1134-37-210 **Anton Gorodetski*** (asgor@math.uci.edu), Department of Mathematics, UC Irvine, Irvine, CA 92697. *Separable potentials and sums of regular Cantor sets.*
Questions on structure of sums of Cantor sets appear naturally in spectral theory. Namely, spectra of discrete Schrodinger operators on two dimensional lattice is the sum of spectra of corresponding operators on one dimensional lattice, while for a large class of operators in one dimensional case the spectrum is known to be a Cantor set. We will discuss these relations, and the series of recent results (joint with D.Damanik and B.Solomyak) on the subject. (Received September 05, 2017)

1134-37-211 **Anton Gorodetski*** (asgor@math.uci.edu), Department of Mathematics, UC Irvine, Irvine, CA 92617. *Random matrix products with parameter.*
Random products of matrices appear naturally in smooth dynamical systems, probability theory, spectral theory, mathematical physics. The crucial result is Furstenberg's Theorem on positivity of Lyapunov exponents. It claims that generically the exponential rate of growth (Lyapunov exponent) of product of random matrices is well defined and positive. We consider random products of 2x2 matrices depending on a parameter, and study existence and properties of Lyapunov exponent for a typical fixed sequence when the parameter varies. This is motivated, in particular, by discrete Schrodinger operators with random potentials. The Schrodinger cocycle is given by the random products of transfer matrices, and energy serves as a natural parameter. It is natural to fix the potential first, and then vary the energy. We show that in the non-uniformly hyperbolic regime almost surely upper Lyapunov exponent is positive (and coincides with the one prescribed by Furstenberg Theorem) for all parameters, but lower Lyapunov exponent vanishes for a topologically generic parameter. As a byproduct

of our construction, these provides a geometrical proof of the classical 1D Anderson localization for random Schrodinger operators. This is a joint project with V. Kleptsyn. (Received September 05, 2017)

1134-37-214 **Arek Goetz*** (goetz@sfsu.edu), 1600 Holloway Ave, San Franisco, CA 94132. *First example of an exchange of cones with an infinite number of periodic discs in every neighborhood of a disc.* Preliminary report.

We report on a preliminary work with Peter Ashwin from Exeter university. We study a family of measure preserving rigid exchanges of cones of the plane. The local existence of an infinite number of periodic discs for an irrational piecewise isometries has been experimentally reported and pointed out already in Ergodic Theory in 2000 by Adler, Kitchens, Tresser. More recently Quas and Goetz showed the existence of periodic families of discs for a two half plane map (Goetz's map) in an arbitrary neighborhood of infinity, yet the local behavior remained open.

In this short talk we report on an idea that likely leads to examples of three cone exchanges with local neighborhoods containing infinitely many discs. (Received September 05, 2017)

1134-37-219 **Yunping Jiang*** (yunping.jiang@qc.cuny.edu), Department of Mathematics, Queens College, 65-30 Kissena Blvd, Flushing, NY 11367. *Zero Entropy Interval Maps And MMLS-MMA Property.* Preliminary report.

We prove that the flow generated by any interval map with zero topological entropy is minimally mean-attractable (MMA) and minimally mean-L-stable (MMLS). One of the consequences is that any oscillating sequence is linearly disjoint with all flows generated by interval maps with zero topological entropy. In particular, the Möbius function is orthogonal to all flows generated by interval maps with zero topological entropy (Sarnak's conjecture for interval maps). Another consequence is a non-trivial example of a flow having the discrete spectrum. (Received September 05, 2017)

1134-37-232 **Susmita Sadhu*** (susmita.sadhu@gcsu.edu) and **Christian Kuehn**. *Noise induced mixed-mode oscillations in a stochastic predator-prey system with two time-scales.*

We study the effect of stochasticity, in the form of Gaussian white noise, in a three species predator-prey model with two distinct time-scales. The interactions between the three species is modeled by a system of slow-fast Itô stochastic differential equations. For a suitable parameter regime, the deterministic drift part of the model admits a folded node singularity and exhibits a singular Hopf bifurcation. We transform the stochastic model into its normal form near the folded node, which can be then used to understand the interplay between deterministic and stochastic small amplitude oscillations. The stochastic model admits several kinds of noise driven mixed-mode oscillations that capture the intermediate dynamics between two cycles of population outbreaks of the prey. We perform numerical simulations to study the distribution of the random number of small oscillations between two large oscillations, which can be related to the return time between the outbreaks. Depending on the noise intensity and the distance to the Hopf bifurcation, we find that the distributions of the small oscillations resemble the 1200 years record on the return times of larch budmoth outbreak events in the subalpine larch forests in the European Alps. (Received September 07, 2017)

1134-37-238 **Holger Kantz**, **Mozhdeh Massah** and **Matthew Nicol*** (nicol@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008. *Erdös-Renyi laws for dynamical systems modeled by Young Towers with exponential tails: applications to time-series analysis and large deviations.* Preliminary report.

Erdös-Rényi limit laws give the precise length scale of a time-window over which time-averages in Birkhoff sums have a non-trivial almost-sure limit. We establish Erdös-Rényi limit laws for Hölder observables on dynamical systems modeled by Young Towers with exponential tails. This extends earlier results on Erdös-Rényi limit laws from the class of non-uniformly expanding maps. We briefly discuss applications to time-series analysis and large deviations theory. (Received September 07, 2017)

1134-37-249 **Gary Froyland**, **Cecilia Gonzalez-Tokman** and **Anthony Quas*** (aquas@uvic.ca). *Stability of Lyapunov Exponents and Oseledets subspaces.*

Given a measure-preserving system, we study the effect on the Lyapunov exponents when a coercive cocycle of linear operators acting on a Hilbert space is perturbed by additive noise (for concreteness one is essentially studying the asymptotic growth rates of singular values of random products of infinite matrices, and the continuity of these growth rates as the entries are randomly perturbed). (Received September 08, 2017)

1134-37-264 **Wencai Liu*** (liuwencai1226@gmail.com), Rowland Hall 410P, Irvine, CA 92617. *Wavepacket spreading and fractal spectral dimension of quasiperiodic operators with singular spectrum.*

Lyapunov exponent is an important physical quantity to determine the spectral type of quasi-periodic operator. In the supercritical (positive Lyapunov regime), it is known that the spectral measure supports on a Lebesgue measure zero set. It is a natural question to investigate the fractal dimensions of spectral measure in the supercritical regime. In this talk, we set up the upper bound of the fractal dimensions of spectral measure, including packing dimension, and also wavepacket spreading.

Our proof contains three steps. 1. Build up the partial localization of generalized eigensolutions. 2. Set up the power law of Weyl functions $M(E+i\epsilon)\ \epsilon^{\alpha}$. 3. Use the power law of Weyl functions to study the fractal dimensions of spectral measure and wavepacket spreading.

This is a joint work with S.Jitomirskaya and S. Tcheremchantsev. (Received September 08, 2017)

1134-37-271 **Marco Antonio López*** (marco.lopez@unt.edu), Denton, TX 76201, and **Mariusz Urbański** (mariusz.urbanski@unt.edu), Denton, TX 76201. *Shrinking Targets and Non-Autonomous Systems.*

The shrinking target problem refers to the set of points in a metric space whose orbit under a dynamical system hit a ball of shrinking radius infinitely often. In our work we focus on establishing Bowen's dimension formula for such sets in the context of non-autonomous iterated function systems. In special cases such shrinking targets arise in Diophantine approximation. (Received September 09, 2017)

1134-37-272 **Nathaniel D Emerson*** (nemerson@usc.edu), University of Southern California, Department of Mathematics, 3620 S. Vermont Ave., KAP 104, Los Angeles, CA 90089-2532. *On the Topology of the Cubic Mixed Locus.*

We describe the topology of a locus of cubic polynomials in a parameter space. We consider the *cubic mixed locus*, that is cubic polynomials which have one critical point with unbounded orbit and one critical point with bounded orbit. Let $\mathcal{E}$ be the subset of the cubic mixed locus such that the connected component of the Julia set of the polynomial containing the critical point with bounded orbit is aperiodic. We show that $\mathcal{E}$ has uncountably many path components, each of which is conformally equivalent to the Riemann surface of $\sqrt[n]{z}$ with the closed unit disk removed for some n.

We study the dynamics of polynomials using the combinatorial system of a tree with dynamics. Given a polynomial in $\mathcal{E}$, we define a family of polynomials in $\mathcal{E}$ with the same tree with dynamics, that depends continuously on two real parameters . We show that each of these families is an immersed Riemann surface, and is a path components of $\mathcal{E}$. The conformal type of the Riemann surface can be determined from the tree with dynamics. (Received September 12, 2017)

1134-37-274 **Ami Radunskaya*** (aer04747@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Ave., Claremont, CA 91711. *Does noise help? Answers and more questions.*

Random fluctuations of an environment are common in ecological and economical settings. The processes describing the evolution of populations in these environments can often be described by a discrete, stochastic dynamical system, where a family of maps parametrized by a random variable forms the basis for a Markov Chain on a continuous state space. Random dynamical systems are a beautiful combination of deterministic and random processes, and they have received considerable interest since von Neumann and Ulam's seminal work in the 1940's. Key questions in the study of a stochastic dynamical system are: is there a unique, invariant measure? How does the long-term behavior compare to that of the state variable in a constant environment with the averaged parameter?

In this talk we answer these questions for a family of maps on the unit interval that model self-limiting growth. The techniques used can be extended to study other families of concave maps, and so we state several generalizations of our results as conjectures.

This is joint work with Peter Hinow, Mathematics Department, University of Wisconsin, Milwaukee. (Received September 09, 2017)

1134-37-287 **Charles C. Johnson** (ccjohnson@gmail.com), Rawles Hall, 831 East 3rd St, 47405, IN 47405, and **Robert G Niemeyer*** (robert.niemeyer@uiwtx.edu), School of Math, Science and Engineering, CPO #311, 4301 Broadway, San Antonio, TX 78209. *On the existence of fractal flat surfaces.*

The construction of the Koch snowflake fractal flat surface and the T-fractal flat surface will be given. One is then in a position to discuss the dynamics on the T-fractal flat surface, as well as properties of the elusive

singularities of the fractal flat surface. Analogies will be drawn between the Koch snowflake fractal flat surface and the T-fractal flat surface with an eye towards developing a more robust notion of a fractal flat surface. (Received September 10, 2017)

1134-37-352 **Jason Atnip*** (jason.atnip@unt.edu). *Dimensions of Non-autonomous Meromorphic Functions of Finite Order.*

In this talk we study two classes of meromorphic functions previously studied by Mayer and by Kotus and Urbański. In particular we estimate a lower bound for the Julia set and the set of escaping points for non-autonomous additive and affine perturbations of functions from these classes. For particular classes we are able to calculate these dimensions exactly. We accomplish this by constructing non-autonomous graph directed Markov systems, which sit inside of the aforementioned non-autonomous Julia sets. We also give estimates for the eventual and eventual hyperbolic dimensions of the these non-autonomous perturbations. (Received September 11, 2017)

1134-37-367 **Yan Mary He*** (he@math.uchicago.edu). *Topology of the shift locus via the big mapping class group.*

The shift locus of (monic centered) complex polynomials of degree $d > 1$ is the set of polynomials whose filled-in Julia set contains no critical points. Traversing a loop in the shift locus gives rise to a holomorphic motion of Cantor Julia sets, which can be extended to a homeomorphism of the plane minus a Cantor set up to isotopy. Then, there is a well-defined monodromy representation from the fundamental group of the shift locus to the mapping class group of the plane minus a Cantor set. In this talk, I will discuss the image and the kernel of this map as well as the presentation of the fundamental group. This is joint work with J. Bavard, D. Calegari, S. Koch and A. Walker. (Received September 11, 2017)

1134-37-387 **Michel L Lapidus** and **Sean R Watson*** (sean.wat@gmail.com). *Fractal Zeta Functions and Complex Dimensions in Ahlfors Spaces.*

We offer a brief overview of the theory of complex dimensions, developed by Lapidus and a number of collaborators, in an effort to better understand fractality in the Euclidean case and which seeks to overcome these problems. Of particular interest is the recent theory of complex dimensions in higher-dimensional Euclidean spaces, as studied by M.L.Lapidus, G. Radunovic, and D. Zubrinic. We will then show that this new theory of complex dimensions naturally generalizes to the case of Ahlfors regular spaces, along with illustrative examples from a selection of such space, as well as hints that the theory can be expanded to a more general setting. (Received September 12, 2017)

1134-37-392 **Zhenghe Zhang*** (zhenghe.zhang@ucr.edu), Department of Mathematics, Surge 202, University of California, Riverside, 900 University Avenue, Riverside, CA 92521. *Large deviation estimates in spectral analysis of some ergodic Schrödinger operators.*

Lyapunov exponent plays a key role in the spectral analysis of one dimensional ergodic Schrödinger operators, which arise naturallly in modeling the motion of quantum particles in a disordered medium. In particular, some type of uniform large deviation estimates (LDT) for the Lyapunov exponent is one of main ingredients in showing the so-called Anderson Localization phenomenon, which in physics corresponds to insulate behavior. In this talk, I will try to decribe some different mechnisms that lead to unform LDT for some different type of ergodic Schrödinger operators. (Received September 12, 2017)

1134-37-448 **William Ott*** (ott@math.uh.edu) and **Brett Geiger** (bgeiger@mail.smu.edu). *Nonstationary open dynamical systems.*

In this talk we discuss recent efforts to link two types of dynamical models: open systems and nonstationary systems. Open systems admit holes through which trajectories may escape. Nonstationary modeling allows the dynamical model itself to vary in time. (Received September 12, 2017)

42 ► Fourier analysis

1134-42-415 **Alex Iosevich*** (iosevich@gmail.com), Alex Iosevich, 145 Dunrovin Lane, Rochester, NY 14618. *Finite point configurations.*

We ask how large the Hausdorff dimension of a compact subset of Euclidean space or a Riemannian manifold needs to be to ensure that the set contains vertices of a given finite point configuration. Analytic, combinatorial and topological considerations play an important role. (Received September 12, 2017)

44 ► Integral transforms, operational calculus

1134-44-177 **Florin Catrina*** (catrinaf@stjohns.edu) and **Aurel I. Stan** (stan.7@math.osu.edu).
On the hypercontractivity of a convolution operator.

We discuss a convolution operator which appears as an integral representation of the Wick product on $L^p(\mathbb{R}, \mu)$ spaces where the probability measure μ has a Gamma distribution. The hypercontractivity of this operator is tightly connected to inequalities of Brascamp-Lieb type. (Received September 03, 2017)

45 ► Integral equations

1134-45-119 **Chenchen Mou*** (muchenchen@math.ucla.edu), 10982 Roebling Ave, Los Angeles, CA 90024. *Perron's method for nonlocal fully nonlinear equations.*

This talk is concerned with existence of viscosity solutions of non-translation invariant nonlocal fully nonlinear equations. We construct a discontinuous viscosity solution of such nonlocal equation by Perron's method. If the equation is uniformly elliptic, we prove the discontinuous viscosity solution is Hölder continuous and thus it is a viscosity solution. (Received August 28, 2017)

46 ► Functional analysis

1134-46-89 **Isaac Goldbring*** (isaac@math.uci.edu), Department of Mathematics, University of California, Irvine, Irvine, CA 92697. *On the II_1 factor $\mathcal{E}$.*

I will introduce a separable II_1 factor called $\mathcal{E}$. The talk will concern two main questions: Does $\mathcal{E}$ exist? If so, is $\mathcal{E}$ isomorphic to the separable hyperfinite II_1 factor? A positive answer to both of these questions is equivalent to a positive answer to the Connes Embedding Problem. The study of $\mathcal{E}$ has its origins in the model-theoretic notion of building models by games which I will discuss as well. (Received August 22, 2017)

1134-46-107 **Adrian Ioana*** (aioana@ucsd.edu), La Jolla, CA 92093, and **Ionut Chifan**, Iowa City, IA. *Amalgamated free product rigidity for group von Neumann algebras.* Preliminary report.

I will explain recent work with Ionut Chifan in which we provide a large family of amalgamated free product groups $\Gamma = \Gamma_1 *_\Sigma \Gamma_2$ whose amalgam structure can be completely recognized from their von Neumann algebras. Our result significantly strengthens some of the previous Bass-Serre rigidity results for von Neumann algebras. As a corollary, we obtain the first examples of amalgamated free product groups which are W*-superrigid. (Received August 26, 2017)

1134-46-141 **Edward S Sichel*** (edsichel@gmail.com), 1950 E. Sussex Way, Apt. 128, Fresno, CA 93726. *Weak Contractions and Expansions on a Compact Metric Space.*

We examine the nature of weak contractions and expansions on a compact metric space.

Inspired by the celebrated *Banach Fixed-Point Theorem*, we explore relaxing the contractiveness condition on the mapping to weak contractiveness, while strengthening the completeness condition on the space to compactness. We show, under the new conditions, that the fixed point for such a mapping still exists and is unique. We also show that expansive mappings on a compact metric space are limited to isometries. (Received August 31, 2017)

1134-46-270 **Jan Cameron*** (jacameron@vassar.edu), 124 Raymond Avenue, Poughkeepsie, NY 12604, and **Roger Smith**. *A Galois correspondence for crossed products of C*-algebras by discrete groups.*

When a discrete group G acts by outer automorphisms on a unital C*-algebra A, any subgroup H of G will generate a C*-subalgebra $A \rtimes_{\alpha,r} H$ of the reduced crossed product $A \rtimes_{\alpha,r} G$ containing A. If these are all the C*-algebras between A and $A \rtimes_{\alpha,r} G$, we say that a Galois correspondence holds for the inclusion $A \subseteq A \rtimes_{\alpha,r} G$. For a simple, unital C*-algebra A, Galois correspondences have been established when the acting group G is abelian, by work of Landstad, Olesen, and Pedersen; and when G is finite, by Izumi. In this talk we discuss recent joint work with Roger Smith, in which we generalize these results to the case of an arbitrary discrete group G. (Received September 09, 2017)

1134-46-276 **James Tener***, UC Santa Barbara, Department of Mathematics, Santa Barbara, CA 93106. *A geometric approach to constructing conformal nets.*

Conformal nets and vertex operator algebras are distinct mathematical axiomatizations of roughly the same physical idea: a two-dimensional chiral conformal field theory. In this talk I will present recent work in which local operators in conformal nets are realized as "boundary values" of vertex operators. This construction exhibits many operator algebraic features of conformal nets (e.g. subfactors, their Jones indices, and their fusion rules) in terms of the geometry of vertex operator algebras. We will discuss how this allows one to extend Wassermann's approach to showing Jones-Wassermann subfactors have finite index to a broader class of examples. (Received September 09, 2017)

1134-46-290 **Eric A Carlen*** (carlen@math.rutgers.edu), Hill Center, 110 Frelinghusen Rd, Piscataway, NJ 08854-8019. *Entropy dissipation in quantum many particle systems.*

Recent joint work with Jan Maas has shown that quantum Markov semigroups satisfying one of the natural notions detailed balance are gradient flow for the relative entropy with respect to a natural analog of the classical 2-Wasserstein transport metric, and that this approach provides an effective means for proving sharp dissipation inequalities, just as in the classical case. This is applied here in the context of some simple quantum many particle systems. (Received September 10, 2017)

1134-46-297 **Jack Spielberg*** (spielberg@asu.edu), P.O. Box 871804, Tempe, AZ 85287-1804. *C^*-algebras of left cancellative small categories.* Preliminary report.

While the C^*-algebra of a group is defined so as to duplicate the unitary representation theory of the group, it has been found that a different motivation is suitable for a semigroup. For example, the Cuntz algebra $\mathcal{O}_n$ is obtained from the free semigroup on n generators, and Cuntz and Krieger showed how this is related to the one-sided Bernoulli shift on the space of infinite words in the generators. A semigroup that is left cancellative admits a shift map analogous to the Bernoulli shift on finite words, and there is a natural process that leads to the analog of the space of "infinite words". In fact, all of this works just as well if the semigroup is replaced by a small category, as long as left cancellation still holds. In this talk I will describe this general process. (Received September 10, 2017)

1134-46-307 **Bruce K. Driver**, **Brian C. Hall** and **Todd Kemp*** (tkemp@math.ucsd.edu). *The Free Segal-Bargmann Transform, Invariant Brownian Motions, and Back Again.*

The Segal-Bargmann Transform is a unitary isomorphism between the Heisenberg and Fock representations in quantum mechanics, which generalizes to any compact type Lie group. It has a large-N limit over unitary groups $\mathrm{U}(N)$ which is related to free unitary Brownian motion, and more exotic SDEs.

In this talk, I will describe joint work with Driver and Hall, and the work of my student Ching Wei Ho, understanding these large-N limits from different perspectives. I will also describe their connection to unitarily-invariant Brownian motions, and how a characterization of those led to a new form of the Segal-Bargmann transform with a complex time parameter. (Received September 10, 2017)

1134-46-334 **Brent Nelson*** (brent@math.berkeley.edu) and **Michael Hartglass** (mhartglass@scu.edu). *Free transport for interpolated free group factors.*

A few years ago, Guionnet and Shlyakhtenko proved the existence of free monotone transport from the joint law of a free semicircular family. In particular, these results imply that the von Neumann algebra (resp. C^*-algebra) generated by a free semicircular family is isomorphic to the von Neumann algebra (resp. C^*-algebra) generated by self-adjoint operators with a joint law "close" to the semicircle law in a certain sense. Notably, the von Neumann algebra generated by a free semicircular family is a free group factor. In this talk, I will discuss how to obtain corresponding results for the interpolated free group factors using an operator-valued framework. This is joint work with Michael Hartglass. (Received September 11, 2017)

1134-46-351 **Marcel Bischoff*** (bischoff@ohio.edu). *Quantum Operations on Conformal Nets.*

Chiral conformal field theory can be axiomatized using von Neumann algebras by so-called conformal nets. A conformal net has a group of gauge automorphisms which describes its symmetries. But, due to the appearance of braid group statistics in chiral conformal field theory, automorphisms are not enough to describe all (possibly quantum) symmetries of conformal nets. I will propose the idea to generalize automorphisms to quantum operations, i.e. completely positive maps and give some structural results. (Received September 11, 2017)

1134-46-382 **Guillaume Cebron** and **Ching Wei Ho***, 9500 Gilman Dr, La Jolla, CA 92093. *The Large-N Limit of the q-Segal-Bargmann Transform.*

Sniady constructed a random matrix model which has a limiting noncommutative distribution of the q-Gaussian distribution. We prove that the Segal-Bargmann transform on the Sniady random matrix model converges to the q-Segal-Bargmann transform in L^2 sense. (Received September 11, 2017)

1134-46-389 **S. Kaliszewski***, kaliszewski@asu.edu, and **Magnus B. Landstad** and **John Quigg**. *Crossed Products and Coaction Functors.*

The new approach to the Baum-Connes Conjecture advanced by Baum, Guentner, and Willett leads naturally to the study of crossed-product operations as functors on certain categories of C^*-algebras. Buss, Echterhoff, and Willett have recently introduced and studied certain properties of crossed-product functors that are of particular significance.

In this talk I'll discuss these functors and their properties, and I'll present our analysis of crossed-product functors in terms of what we call "coaction functors". In particular, I'll show how crossed-product functors arise by composing the full crossed product functor with coaction functors, and I'll discuss how the properties of Buss-Echterhoff-Willett are inherited from analogous properties of the coaction functors. (Received September 12, 2017)

1134-46-416 **Hans Wenzl***, Dept of Mathematics, UC San Diego, La Jolla, CA. *On Charge Conjugation Modular Invariants.* Preliminary report.

It is known that every algebra object of a modular tensor category produces a modular invariant, i.e. basically a matrix Z with non-negative integer coefficients which commutes with the action of the modular group. This played a crucial role for the classification of algebras/module categories for the $SU(3)$ fusion categories. However, for $SU(N)$ with $N > 3$ there are still many unsolved questions even for the conjugation modular invariants Z with $z_{\lambda\mu} = \delta_{\bar{\lambda}\mu}$, where $\bar{\lambda}$ is the label for the dual representation of λ.

We relate this problem to results by the author about constructing subfactors related to analogs of the embedding of $SO(N) \subset SU(N)$ for the fusion category $SU(N)_k$ for even level k. This also yields formulas for the rather complicated indices of the associated subfactors, and explicit descriptions of the associated algebras. (Received September 12, 2017)

1134-46-432 **Rolando de Santiago*** (rdesantiago@math.ucla.edu), **Ionut Chifan** and **Thomas Sinclair**. *Product Rigidity for Non-Prime Group von Neumann Algebras.*

Since their inception, an important problem in the study of group von Neumann algebras is to determine which, if any, canonical properties of a group Γ remain detectable in $L(\Gamma)$, the resulting group von Neumann algebra. We begin by showing whenever Γ is a k-fold product of of non-elementary hyperbolic groups and Λ is an arbitrary group such that $L(\Gamma) \cong L(\Lambda)$, then Λ is necessarily a non-trivial k-fold product of non-amenable groups $\Lambda_1, \ldots, \Lambda_k$. In this case, the group von Neumann algebra retains the direct product structure of the underlying group.

Applying the techniques pioneered in the previous result to a broad collection of non-amenable AFP and poly-hyperbolic groups, we show the corresponding group von Neumann algebras exhibit a similar phenomenon. Namely, whenever Γ is a group in this class and $L(\Gamma)$ decomposes as a k-fold tensor product of II_1 factors, then Γ admits a decomposition as a non-trivial k-fold direct product of groups. This result further provides a complete classification of tensor product decomposition of these group von Neumann algebras. (Received September 12, 2017)

47 ► Operator theory

1134-47-8 **Marat V. Markin*** (mmarkin@csufresno.edu), Department of Mathematics, California State University, Fresno, 5245 North Backer Avenue, M/S PB108, Fresno, CA 93740-8001. *On Certain Spectral Features Inherent to Scalar Type Spectral Operators.*

Important spectral features, such as the emptiness of the residual spectrum, countability of the point spectrum, provided the space is separable, and a characterization of spectral gap at 0, known to hold for *bounded* scalar type spectral operators in a complex Banach space, are shown to naturally transfer to the *unbounded* case.

The results' encompassing normal, in particular self-adjoint, operators in a complex Hilbert space makes the foregoing characterization of interest for quantum mechanics. (Received March 21, 2017)

1134-47-198 **Konrad Aguilar*** (konrad.aguilar@asu.edu) and **Frederic Latremoliere**. *Compact quantum metrics from conditional expectations.*

We discuss two interesting cases of when conditional expectations produce compact quantum metrics in the sense of M. A. Rieffel. The first case will come from unital AF algebras equipped with faithful tracial states. These quantum metrics will provide continuous families of natural classes of AF algebras in the Gromov-Hausdorff propinquity topology of F. Latremoliere. The second case will be associated to full matrix algebras, in which these quantum metrics will be used to show that any compact metric space is a limit of matrix algebras in the Gromov-Hausdorff propinquity topology. Motivated by our work with conditional expectations on AF algebras, we also present quantum metrics on any unital AF algebra from quotient norms. (This is, in part, joint work with F. Latremoliere). (Received September 04, 2017)

1134-47-242 **Waleed K. Al-Rawashdeh*** (walrawashdeh@mtech.edu), Montana Tech, 1300 West Park Street, Butte, MT 59701. *Weighted Differentiation Composition Operators from Nevanlinna Classes to Weighted-type Spaces.*

Let ϕ be an analytic self-map of open unit disk $\mathbb{D}$. Let $\mathcal{H}(\mathbb{D})$ be the space of all analytic functions on $\mathbb{D}$. For a nonnegative integer n, the weighted differentiation composition operator on $\mathcal{H}(\mathbb{D})$ is defined as $D^n_{\phi,u}f(z) = u(z)f^{(n)}(\phi(z))$, for $f \in \mathcal{H}(\mathbb{D})$ and $z \in \mathbb{D}$. In this paper, we characterize the boundedness and compactness of the weighted differentiation composition operator $D^n_{\phi,u}$ from the weighted Nevanlinna classes $\mathcal{N}^p_\alpha$ to the weighted-type space H^∞_μ and the little weighted-type space $H^\infty_{\mu,0}$. (Received September 07, 2017)

1134-47-266 **Stephan Ramon Garcia*** (stephan.garcia@pomona.edu), Department of Mathematics, 610 N College Ave, Claremont, CA 91711. *Toeplitz operators and lattices.*

How do Toeplitz operators and frames relate to properties of lattices? We discuss recent results about the interplay between operator theory and lattice theory. This is joint work with A. Böttcher, S. Eisenbarth, L. Fukshansky, H. Maharaj, and D. Needell. (Received September 09, 2017)

1134-47-280 **Andrea Arauza Rivera*** (arauza@math.ucr.edu), 900 University Ave., Riverside, CA 92521. *Spectral triples and fractal geometry.*

There is a long tradition in mathematics of using algebraic tools to study the geometry of a space. The duality between the category of compact Hausdorff spaces and the category of commutative unital C*-algebras means that one can study a topological space X by studying the algebra of continuous functions on X. Dropping the commutativity requirement leads to the study of noncommutative C*-algebras and hence noncommutative spaces. The field of noncommutative fractal geometry uses operator algebraic tools to study geometry and analysis on fractal sets. We will see how one can use the spectral triples of noncommutative geometry to formulate notions of dimension, metric, and measure on fractal spaces. (Received September 09, 2017)

1134-47-315 **Lauren C. Ruth*** (ruth@math.ucr.edu). *Two new settings for examples of von Neumann dimension.*

Let $G = PSL(2, \mathbb{R})$, let Γ be a lattice in G, and let $\mathcal{H}$ be an irreducible unitary representation of G with square-integrable matrix coefficients. A theorem in Goodman–de la Harpe–Jones (1989) states that the von Neumann dimension of $\mathcal{H}$ as a $W^*(\Gamma)$-module is equal to the formal dimension of the discrete series representation $\mathcal{H}$ times the covolume of Γ, calculated with respect to the same Haar measure. We will present two results inspired by this theorem. First, we show there is a representation of $W^*(\Gamma)$ on a subspace of cuspidal automorphic functions in $L^2(\Lambda\backslash G)$, where Λ is any other lattice in G, and $W^*(\Gamma)$ acts on the right; and this representation is unitarily equivalent to one of the representations in [GHJ]. Next, we explain how their proof carries over to a wider class of groups, and we calculate von Neumann dimensions when G is $PGL(2, F)$, for F a local non-archimedean field of characteristic 0; Γ is a torsion-free lattice in $PGL(2, F)$, which, by a theorem of Ihara, is a free group; and $\mathcal{H}$ is the Steinberg representation, or a depth-zero supercuspidal representation, each yielding a different dimension. (Received September 11, 2017)

1134-47-330 **Daniel Drimbe**, **Daniel J. Hoff*** (hoff@math.ucla.edu) and **Adrian Ioana**. *Between Popa's Intertwining and Measure Equivalence.*

A result of Furman says that two countable groups are measure equivalent if and only if they admit stably orbit equivalent free ergodic probability measure preserving actions. As this in turn can be characterized in terms of the associated group measure space von Neumann algebras, the framework of Sorin Popa's deformation/rigidity theory becomes available. This talk will focus on the implications of Popa's intertwining in this setting. In particular, we will give an operator algebraic tool for determining when measure equivalence between $\Gamma_1 \times \Gamma_2$ and $\Lambda_1 \times \Lambda_2$ can be upgraded to measure equivalence between the factors, as is the case in a well known result

of Monod and Shalom. This talk is on joint work with Daniel Drimbe and Adrian Ioana. (Received September 11, 2017)

1134-47-353 **Rui Han*** (rhan@ias.edu) and **Svetlana Jitomirskaya** (szhitomi@math.uci.edu).
Discrete Bethe-Sommerfeld conjecture.

We will talk about the proof of a discrete version of the Bethe-Sommerfeld conjecture. Namely, we show that the spectra of multi-dimensional discrete periodic Schrödinger operators on $\mathbb{Z}^d$ lattice with sufficiently small potentials contain at most two intervals. Moreover, the spectrum is a single interval, provided one of the periods is odd, and can have a gap whenever all periods are even. (Received September 11, 2017)

1134-47-354 **Fan Yang*** (yangf@ias.edu) and **Svetlana Jitomirskaya** (szhitomi@math.uci.edu).
Spectral transition line in phase for the almost Mathieu operator.

In this presentation, we talk about the spectral transition line in phase of the almost Mathieu operator in the positive Lyapunov exponent regime. We show that both pure point spectrum and purely singular continuous spectrum occur for dense subsets of phases on this transition line. (Received September 11, 2017)

1134-47-371 **Ian L Charlesworth*** (ilc@math.ucsd.edu), Department of Mathematics, University of California, San Diego, 9500 Gilman Drive # 0112, La Jolla, CA 92093-0112, and **Paul Skoufranis**. *Bi-free probability, vaccine, and entropy.* Preliminary report.

Bi-free probability was introduced by Voiculescu in 2013 as a generalization of free probability to study the joint distributions of families "left" and "right" random variables simultaneously. In this talk I will discuss a vaccine, a characterization of bi-free independence analogous to the vanishing of mixed moments characterization of free independence. From there, I will speak on some recent attempts to extend non-microstates free entropy to the bi-free setting, difficulties encountered along the way, and peculiarities arising in this more general setting which are not present in the free case. (Received September 11, 2017)

1134-47-413 **Hassan Yousefi*** (hyousefi@fullerton.edu), Fullerton, CA. *On Completely Rank Nonincreasing Multilinear Maps.* Preliminary report.

D. Larson and D. Hadwin introduced the notion of completely rank-nonincreasing (CRNI) linear maps in an attempt to characterize the linear maps on a subspace of operators on a Hilbert space that are point-strong limits of similarities or point-strong limits of skew-compressions. In this talk we extend the notion of CRNI linear maps to include the multilinear maps. We show that a bilinear map on a finite dimensional vector space on any field is CRNI if and only if it is a skew-compression bilinear map. We also characterize CRNI continuous bilinear maps defined on the set of compact operators. (Received September 12, 2017)

1134-47-424 **Daniel Drimbe*** (ddrimbe@ucsd.edu), 8324 Regents Road, Unit #1F, San Diego, CA 92122, and **Daniel Hoff** and **Adrian Ioana**. *Prime II_1 factors arising from irreducible lattices in products of rank one simple Lie groups.*

In this talk I will present joint work with Daniel Hoff and Adrian Ioana in which we obtain that II_1 factors associated to icc irreducible lattices in products of simple Lie groups of rank one are prime, i.e. they cannot be decomposed as a tensor product of II_1 factors. This gives the first examples of prime II_1 factors arising from lattices in higher rank semisimple Lie groups. (Received September 12, 2017)

49 ► Calculus of variations and optimal control; optimization

1134-49-53 **Ugur G. Abdulla**, **Vladislav Bukshtynov** and **Saleheh Seif*** (sseif2014@my.fit.edu), 150 W University Blvd, Melbourne, FL 32901. *Breast Cancer Detection through Electrical Impedance Tomography and Optimal Control Theory: Theoretical and Computational Analysis.*

We analyze the inverse problem of breast cancer detection through Electrical Impedance Tomography. EIT is a non-invasive medical imaging method to recover electrical conductivity of the body from electrical measurements on its surface. Mathematical formulation of the problem is referred to as Calderon's inverse problem on the identification of the conductivity coefficient of the second order elliptic PDE from additional boundary measurements. We pursue variational formulation and consider the optimal control problem on the minimization of the L_2-norm declination of the flux on certain subset of the boundary for the uniformly elliptic PDE

$$(a_{ij}(x)u_{x_j})_{x_i} + b_i(x)u_{x_i} + a(x)u = f(x)$$

with unknown matrix a_{ij}, and subject to the mixed Neumann-Robin type boundary conditions. We prove Frechet differentiability in the Banach space of bounded measurable matrix functions, and derive first order optimality condition. We pursue numerical analysis in a simplified two-dimensional case by implementing projective gradient method in Banach spaces, re-parametrization and space reduction based on principal component analysis, Tikhonov regularization and sensitivity analysis with respect to relative size and locations of cancerous tumors. (Received July 27, 2017)

1134-49-164 **Stan Alama**, **Lia Bronsard**, **Rustum Choksi** and **Ihsan Topaloglu***, iatopaloglu@vcu.edu. *Droplet breakup in the liquid drop model with background potential.*

We consider a variant of Gamow's liquid drop model, with a general repulsive Riesz kernel and a long-range attractive background potential with weight Z. The addition of the background potential acts as a regularization for the classical liquid drop model in that it restores the existence of minimizers for arbitrary mass. In this project, we consider the regime of small Z and characterize the structure of minimizers in the limit $Z \to 0$ by means of a sharp asymptotic expansion of the energy. This asymptotic limit leads to a discrete attractive-repulsive nonlocal functional. In the process of studying this limit we also characterize all minimizing sequences for the Gamow's model in terms of "generalized minimizers". (Received September 02, 2017)

1134-49-189 **Katy Craig*** (kcraig@math.ucsb.edu), **Inwon Kim** and **Yao Yao**. *From slow diffusion to a hard height constraint: characterizing congested aggregation.*

For a range of physical and biological processes–from dynamics of granular media to biological swarming–the evolution of a large number of interacting agents is modeled according to the competing effects of pairwise attraction and (possibly degenerate) diffusion. In the slow diffusion limit, the degenerate diffusion formally becomes a hard height constraint on the density of the population, as arises in models of pedestrian crown motion.

Motivated by these applications, we bring together new results on the Wasserstein gradient flow of nonconvex energies with the theory of free boundaries to study a model of Coulomb interaction with a hard height constraint. Our analysis demonstrates the utility of Wasserstein gradient flow as a tool to construct and approximate solutions, alongside the strength of viscosity solution theory in examining their precise dynamics. By combining these two perspectives, we are able to prove quantitative estimates on convergence to equilibrium, which relates to recent work on asymptotic behavior of the Keller-Segel equation. This is joint work with Inwon Kim and Yao Yao. (Received September 04, 2017)

1134-49-204 **Andres Zuniga*** (ajzuniga@indiana.edu), 831 E 3rd St, Bloomington, IN. *Continuity of minimizers to weighted least gradient problems.*

We revisit the question of existence and regularity of minimizers to weighted least gradient problems

$$\inf\{\int_\Omega \mathbf{a}(x)|Du| : u \in BV(\Omega), u|_{\partial\Omega} = g\},$$

where $g \in C(\partial\Omega)$, and the weight $\mathbf{a}$ is strictly positive with $\mathbf{a} \in C^3(\bar{\Omega})$. Under some geometric conditions on $\Omega \subset \mathbb{R}^n$, we construct continuous solutions of this problem for any $n \geq 2$, by extending the technique in [3]. The level sets of the constructed minimizer are minimal surfaces in the conformal metric $\mathbf{a}^{2/(n-1)} I_n$. This result complements the approach in [1] since it provides a continuous solution even in high dimensions where the level sets might develop singularities. The proof relies on an application of a strict maximum principle for area-minimizing sets established in [2].

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1134-49-273 **Yongxin Chen** (yongchen@iastate.edu), Department of Electrical and Computer Eng, Iowa State University, Ames, IA 50011, **Tryphon T. Georgiou*** (tryphon@uci.edu), Department of Mechanical and Aerospace Eng, 3230 Engineering Gateway, Irvine, CA 92697, and **Allen Tannenbaum** (allen.tannenbaum@stonybrook.edu), Dept of Computer Science and Applied Math, Stony Brook University, Stony Brook, NY 11794. *Matrix-valued and vector-valued density flows.*

We will discuss certain new directions in the nexus of ideas that originate in Optimal Mass Transport (OMT) and the Schroedinger Bridge Problem (SBP). More specifically, we will discuss generalizations to the setting of matrix-valued and vector-valued distributions. Matrix-valued OMT in particular allows us to define a Wasserstein geometry on the space of density matrices of quantum mechanics and, as it turns out, the Lindblad equation of open quantum systems (quantum diffusion) turns out to be exactly the gradient flow of the von Neumann quantum entropy in this sense. (Received September 09, 2017)

1134-49-425 **Weiwei Hu*** (weiwei.hu@okstate.edu), 416 Math Science Building, Stillwater, OK 74078. *Boundary Control of Optimal Mixing in Stokes and Navier-Stokes Flows.* Preliminary report.

We discuss the problem of optimal mixing of an inhomogeneous distribution of a scalar field via an active control of the flow velocity, governed by Stokes or Navier-Stokes equations, in a two dimensional open bounded and connected domain. The problem is motivated by mixing the fluids within a cavity or vessel by moving the walls or stirring at the boundaries. It is natural to consider the velocity field that is induced by a control input tangentially acting on the boundary of the domain through the Navier slip boundary conditions. Our main objective is to design an optimal Navier slip boundary control that optimizes mixing at a given final time. This essentially leads to a finite time optimal control problem of a bilinear system. A rigorous proof of the existence of an optimal controller and the first-order necessary conditions for optimality are presented. (Received September 12, 2017)

1134-49-463 **Maxim Zyskin*** (maxim.zyskin@nottingham.ac.uk), School of Mathematics, University of Nottingham, Nottingham, Nottingham NG7 2RD, United Kingdom. *Equilibrium configurations of defective crystals.*

I will discuss the set-up and results on variational problems which provide equlibrium configurations of defective crystals. Young measure valued solutions are allowed, and in certain cases it is possible to compute energies and stresses. (Received September 13, 2017)

51 ► Geometry

1134-51-97 **Jun Kigami*** (kigami@i.kyoto-u.ac.jp). *Ahlfors regular conformal dimension and critical value of p-energies of a compact metric space.*

Given a metric space, we are going to identify Ahlfors regular conformal dimension with the critical value of p-energies associated with the canonical partition of the metric space. Such an identification has been shown by M. Carassco Piaggio for the case of the critical index for discrete modulus. Moreover, we are going to show a relation between the Ahlfors regular conformal dimension and the spectral dimension. (Received August 24, 2017)

1134-51-200 **Zhongmin Jin*** (jin@math.ucsb.edu), UCSB Math Department, Santa Barbara, CA 93106. *Finite homeomorphism type with integral curvature bound.*

In the 1991 paper of Anderson and Cheeger, they proved the finite diffeomorphism types of the collection of compact Riemannian manifolds with uniform two-sided Ricci curvature bound, diameter upper bound, volume lower bound and integral curvature upper bound. The main tool is the so called $C^{1,\alpha}$ harmonic coordinates and main ingredients are ϵ-regularity theorem and neck theorem with the smallness of Ricci curvature two-sided bound and small integral curvature on balls or annular domain. In this talk, we will introduce the finiteness theorem without the Ricci curvature upper bound by using Reifenberg parametrization, where $C^{1,\alpha}$ harmonic radius type argument fails. (Received September 04, 2017)

1134-51-275 **Andrea Arauza Rivera*** (arauza@math.ucr.edu), 900 University Ave., Surge 258, Riverside, CA 92521. *Spectral triples and resistance forms on fractal sets.*

The field of noncommutative fractal geometry seeks to use operator algebraic tools to study the geometry and analysis of fractal sets. One can formulate notions of dimension, distance, and measure on a fractal set by using what is known as a spectral triple. In some cases, spectral triples can also be used to describe resistance forms

on fractals. We discuss the work of Cipriani, Guido, Isola, and Sauvageot, which shows how one can use spectral triples to recover the standard energy form on the Sierpinski gasket. We also discuss possible extensions to spaces like the stretched Sierpinski gasket. (Received September 09, 2017)

52 ► Convex and discrete geometry

1134-52-101 **Pei-Ken Hung*** (pkhung@math.columbia.edu). *Area bounds for minimal surfaces that pass through a prescribed point in a ball.*

Let Σ^k be a k-dimensional minimal submanifold in the n-dimensional unit ball B^n. If the distance from Σ to the origin is d, it is conjectured by Alexander, Hoffman an Osserman that the sharp area lower bound of Σ^k is $|B^k|(1-d^2)^{k/2}$. We find a special vector field W and apply the first variational formula to prove the conjecture. This is a joint work with Simon Brendle. (Received August 24, 2017)

53 ► Differential geometry

1134-53-40 **Luis Guijarro** and **Frederick Wilhelm*** (fred@math.ucr.edu). *Jacobi Field Comparison.*

The classical Rauch Comparison Theorem comparison only works for Jacobi fields whose initial value or initial derivative is 0. This is a major drawback. In most cases, the inequality is strict. When it is strict at some time t_1, examples suggest that it typically is stricter at times $t > t_1$. Unfortunately, other examples show that this is not always the case.

Recently Guijarro and I remedied this situation by proving a comparison lemma. It shows that when the Rauch inequality is strict for some field at some time t_1, the expected "even stricter" estimate holds at future times for a field that is possibly different from the original one. The proof exploits a powerful, but technical tool—Wilking's Transverse Jacobi equation.

Our comparison lemma has several applications including an optimal estimate for the norm of any submanifold's second fundamental form, a version of the Soul Theorem for Intermediate Ricci curvature, and a rigidity theorem for positively curved manifolds. (Received July 09, 2017)

1134-53-42 **Lee Kennard*** (kennard@ou.edu) and **Burkhard Wilking**. *Positive curvature and torus symmetry.*

It is an open problem whether every simply connected, closed manifold admitting non-negative sectional curvature also admits positive sectional curvature. One conjectured obstruction is due to Hopf: In even dimensions, positive sectional curvature implies positive Euler characteristic. I will discuss joint work with Burkhard Wilking on this problem in the presence of torus symmetry. (Received July 10, 2017)

1134-53-45 **Daniel Perry*** (daniel.perry3@montana.edu), Bozeman, MT 59715. *On Homotopy Groups of 3-Dimensional Contact Manifolds.* Preliminary report.

Restrictions of motion in a smooth manifold may be captured by a distribution, a subbunde of the tangent bundle. Considerations of distributions, along with the Lie Bracket, allow for interpretation and definition of certain structures, foliations and contact manifolds, along with an appropriate sense of mapping, contact maps. These contact maps are used to define homotopy groups on contact manifolds. An indication as to what these groups are will be provided. (Received July 15, 2017)

1134-53-49 **Thomas Murphy*** (tmurphy@fullerton.edu), Dept. of Mathematics, 800 N State College Blvd., Fullerton, CA 92831. *Complex Riemannian foliations of Kahler manifolds.*

For many natural problems arising in Riemannian geometry, the Kahler setting is restrictive enough to allow concrete classification results. In this vein I will outline joint work with Paul-Andi Nagy classifying complex Riemannian foliations of any open subset of a Hermitian symmetric space of compact type. This has applications to the study of quaternionic-Kahler metrics with restricted sectional curvatures. General results restricting such foliations on any Kahler manifold are also derived. (Received July 24, 2017)

1134-53-62 **Llohann D. Speranç a*** (lsperanca@gmail.com). *Totally geodesic Riemannian foliations on Compact Lie groups.*

We present a classification of Riemannian foliations on compact Lie groups with bi-invariant metrics, whose leaves are totally geodesic.

A foliation with these properties is obtained by considering right (or left) cosets of a subgroup. That is, given a compact Lie group G with bi-invariant metric and a subgroup $H < G$, one considers $\mathcal{F} = \{gH \mid g \in G\}$ (or $\mathcal{F} = \{Hg \mid g \in G\}$). It turns out that all Riemannian foliations with totally geodesic leaves are (up to isometry) of this form.

The proof is somehow indirect, showing that the group of (local) holonomy transformations acts (locally) freely and transitively on leaves.

The proof is broken in two parts: in the first part a new root system, related to the foliation itself, is introduced. The relation of the new and the classical root systems is used to gather information about the A-tensor along a leaf; in the second part, the isotropy representation of the group of local holonomy transformations is studied through the geometry of a new principal bundle which replaces the holonomy bundle in the context of foliations.

The proof passes through an Ambrose–Singer type of characterization for dual leaves (under curvature restrictions) and uses a recent classification of Clifford–Killing spaces. (Received August 08, 2017)

1134-53-64 **Thomas Murphy** and **Frederick Wilhelm*** (fred@math.ucr.edu). *Random Manifolds have no Totally Geodesic Submanifolds.*

For $n \geq 4$ we show that generic closed Riemannian n–manifolds have no nontrivial totally geodesic submanifolds, answering a question of Spivak. An immediate consequence is a severe restriction on the isometry group of a generic Riemannian metric. Both results are widely believed to be true, but we are not aware of any proofs in the literature. (Received August 09, 2017)

1134-53-69 **Peng Lu*** (penglu@uoregon.edu), Dept of Math, University of Oregon, 1222 13th Avenue, Eugene, OR 97403. *New proofs of Perelman's theorem on shrinking Breathers in Ricci flow.*

We give two new proofs of Perelman's theorem that shrinking breathers of Ricci flow on closed manifolds are gradient Ricci solitons, using the fact that the singularity models of type I solutions are shrinking gradient Ricci solitons and the fact that non-collapsed type I ancient solutions have rescaled limits being shrinking gradient Ricci solitons. (Received August 15, 2017)

1134-53-77 **Chenxu He*** (chenxuhe@math.ucr.edu), Department of Mathematics, 202 Surge, University of California at Riverside, Riverside, CA 92521, and **Priyanka Rajan**. *Fake projective spaces with cohomogeneity one actions, and their curvatures.*

A fake real projective space is a manifold that is homotopy equivalent, but not diffeomorphic, to the standard real projective space. In 1964, Hirsch-Milnor discovered fake 5- and 6-projective spaces as the first such examples. They are $\mathbb{Z}_2$ quotients of certain embedded standard 5- and 6-spheres inside Milnor's exotic 7-spheres. In this talk, we show that some embedded standard 13-spheres in Shimada's exotic 15-spheres have $\mathbb{Z}_2$ quotient spaces, P^{13}s, that are fake projective spaces. These P^{13}s are octonionic analogues of the Hirsch-Milnor fake 5-dimensional projective spaces, P^5s. I will also discuss their symmetry groups and curvature properties of invariant metrics. It is a joint work with Priyanka Rajan at U. Notre Dame. (Received August 18, 2017)

1134-53-86 **Xin Zhou***, Department of Mathematics, UC Santa Barbara, Santa Barbara, CA 93106. *Min-max theory for constant mean curvature (CMC) hypersurfaces.*

In this talk, I will present constructions of closed CMC hypersurfaces using min-max method. In particular, given any closed Riemannian manifold, I will show the existence of closed CMC hypersurfaces of any prescribed mean curvature. This is a joint work with Jonathan Zhu. (Received August 22, 2017)

1134-53-91 **Xiangwen Zhang*** (xiangwen@math.uci.edu). *Alexandrov's uniqueness theorem for convex surfaces.*

A classical uniqueness problem of Alexandrov says that a closed strictly convex twice differentiable surface in $\mathbb{R}^3$ is uniquely determined to within a parallel translation when one gives a *proper* function of the principle curvatures. We will talk about a PDE proof for this theorem, by using the maximal principle. Moreover, a stability result related to the uniqueness problem will be mentioned. This is a joint work with P. Guan and Z. Wang. (Received August 23, 2017)

1134-53-92 **Shiguang Ma*** (sma81@ucsc.edu), 202, Castillion Terrace, Santa Cruz, CA 95060, **Jie Qing** (qing@ucsc.edu), Santa Cruz, CA 95060, and **Vincent Bonini** (vbonini@calpoly.edu), San Luis Obispo, CA 93407. *Hypersurfaces with Nonegative Ricci Curvature in hyperbolic space.*

The embedded and immersed hyper surfaces with various nonnegative curvature conditions in Euclidean space and hyperbolic space are interesting and classical objections in differential geometry. We classify the embedded

hyper surfaces with nonnegative Ricci curvature in hyperbolic space. This problem is related to p-Laplacian equations. (Received August 23, 2017)

1134-53-99 **Marco Aldi*** (maldi2@vcu.edu). *A spinorial approach to generalized CRF-structures.*
The goal of this talk is to illustrate how a the pure spinor formalism used in generalized complex geometry can be extended and applied to generalized CRF-structures that are not necessarily generalized complex structures. (Received August 24, 2017)

1134-53-105 **Wei Hong*** (hong_w@whu.edu.cn), Wuhan, Hubei , Peoples Rep of China. *Poisson cohomology of holomorphic toric Poisson manifolds.*
A holomorphic toric Poisson manifold is a smooth toric variety, equipped with a holomorphic Poisson structure, which is invariant under the torus action. In this talk, we described the Poisson cohomology groups of holomorphic toric Poisson manifolds under some conditions. As a special case, we give the structures of Poisson cohomology groups of CP^n. (Received August 26, 2017)

1134-53-111 **Ryushi Goto*** (goto@math.sci.osaka-u.ac.jp), Toyonaka, osaka 560-0043, Osaka, Japan. *Scalar curvature is moment map in generalized Kähler geometry.*
Behind the Kähler geometry, a framework of symplectic geometry appears and plays an important role. Fujiki and Donaldson showed that the scalar curvature of Kähler manifolds arises as the moment map. In this talk we shall pursue an analogue of the moment map framework in generalized Kähler geometry. We shall introduce the notion of the curvature of generalized connection and define the scalar curvature to be the mean curvature of the canonical generalized connection of the canonical line bundle over a compact generalized Kähler manifold. Then a framework of symplectic geometry over generalized Kähler manifolds naturally appears and we show that the scalar curvature is the moment map in generalized Kähler geometry. Then we prove that the smooth part of the moduli space of generalized Kähler structures with constant generalized scalar curvature is a finite dimensional Kähler manifold. Explicit descriptions of the generalized Ricci form and the generalized scalar curvature are given on a generalized Kähler manifold of type (0,0). Poisson structures constructed from a Kähler action of a commutative Lie group on a Kähler-Einstein manifold provide intriguing deformations of generalized Kähler-Einstein structures. (Received August 27, 2017)

1134-53-112 **Zhuo Chen*** (zchen@math.tsinghua.edu.cn), Department of Math, Tsinghua University, Beijing, Beijing 100084, Peoples Rep of China. *On the ∂- and $\bar{\partial}$-Operators of a Generalized Complex Structure.*
We prove that the ∂- and $\bar{\partial}$-operators introduced by Gualtieri for a generalized complex structure coincide with the d_*- and ∂_*-operators introduced by Alekseev-Xu for Evens-Lu-Weinstein modules of a Lie bialgebroid. (Received August 27, 2017)

1134-53-145 **Yongjia Zhang*** (yoz020@ucsd.edu), Department of Mathematics, University of California, San Diego, San Diego, CA 92093. *On the equivalence between bounded entropy and noncollapsing for ancient solutions to the Ricci flow.*
In Perelman's celebrated paper *the entropy formula for the Ricci flow and its geometric applications* he asserted that for an ancient solution to the Ricci flow with nonnegative curvature operator, bounded entropy is equivalent to κ-noncollpasing on all scales. We prove this assertion with an additional assumption on one time slice of bounded geometry, that is, that the curvature is bounded from above and the volume of unit balls is bounded from below. (Received August 31, 2017)

1134-53-147 **Chenxu He*** (chenxuhe@math.ucr.edu) and **Guofang Wei**. *Fundamental gap of convex domains in the sphere.*
For a bounded convex domain on a Riemannian manifold, the fundamental gap is the difference of the first two non-trivial Dirichlet eigenvalues. In their celebrated work, B. Andrews and J. Clutterbuck proved the fundamental gap conjecture for convex domains in the Euclidean space, showing that the gap is at least as large as the one for a one-dimensional model. They also conjectured that similar results hold for spaces with constant sectional curvature. Very recently, on the unit sphere, Seto-Wang-Wei proved that the fundamental gap is greater than the gap of the one dimensional sphere model, in particular, $\geq 3\pi^2/D^2$ ($n \geq 3$), provided the diameter of the domain $D \leq \pi/2$. In a joint work with Guofang Wei at UCSB, we extend Seto-Wang-Wei's lower bound estimate to all convex domains in the hemisphere. (Received August 31, 2017)

1134-53-152 **Curtis Pro*** (cpro@csustan.edu) and **Fred Wilhelm** (fred@math.ucr.edu).
Diffeomorphism stability and codimension 4.

The class of n-dimensional Riemannian manifolds with a lower sectional curvature bound, upper diameter bound, and lower volume bound is precompact in the Gromov-Hausdorff topology. Perelman's Stability Theorem implies that for any converging sequence $\{M_i\}$ of manifolds in this class, all but finitely many of the M_i's are homeomorphic. A natural question to ask is if the result still holds if "homeomorphic" is replaced with "diffeomorphic". A positive answer to this question in general would close many open questions in Riemannian Geometry with a lower sectional curvature bound. I'll discuss joint work with Fred Wilhelm where we answer this question affirmatively in the special case when all of the singularities of the limit space occur along smoothly and isometrically embedded Riemannian manifolds of codimension at most 4. (Received September 01, 2017)

1134-53-159 **Bohui Chen**, **Bai-Ling Wang** and **Rui Wang*** (ruiw10@math.uci.edu), University of California, Irvine, 410N Rowland Hall, Irvine, CA 92697. *The compactification for the quantum Kirwan morphism moduli spaces.* Preliminary report.

Assume (X, ω) is a compact symplectic manifold admitting a Hamiltonian connected compact Lie group action, and M is the symplectic reduction at the regular value 0 of moment map. We construct a moduli space with evaluation maps to the inertia orbifold of M to quantize the Kirwan morphism from $H^*_G(X)$ to $H^*(M)$. In this talk, the compactness of this moduli space will be discussed in details. (Received September 02, 2017)

1134-53-171 **Janet Talvacchia*** (jtalvac1@swarthmore.edu), Department of Mathematics, Swarthmore College, 500 College Ave, Swarthmore, PA 19081. *Sasakian Structures in Generalized and Extended Generalized Geometry.* Preliminary report.

This talk will discuss notions of Sasakian structures for generalized and extended generalized geometry that have appeared in both the mathematics and physics literature. I'll present an approach to generalized Sasakian structures on a 5-dimensional manifold M^5 as a reduction from an $O(5,5)$ structure to an $SU(2) \times SU(2)$ structure with conditions on the generalized contact metric structure data on M^5. I'll then look at how this approach matches up with definitions of Sasakian structures in dimension 5 in the extended generalized geometry setting put forward by physicists interested in quantum gravity. (Received September 03, 2017)

1134-53-180 **Shoo Seto*** (shoseto@ucsb.edu). *Fundamental gap estimate on convex domains of spheres (elliptic approach).*

The fundamental gap conjecture, indepedently conjectured by van den Berg, Ashbaugh and Benguria, Yau, in the 80's states that the gap between the first two Dirichlet eigenvalue on a convex domain $\Omega \subset \mathbb{R}^n$ has a sharp lower bound of $\frac{3\pi^2}{d^2}$ where d is the diameter of Ω. This conjecture was proved by Andrews-Clutterbuck. In joint work with G. Wei and L. Wang, we prove the conjecture for convex domains of spheres of dimension $n \geq 3$ and diameter $\leq \frac{\pi}{2}$. C. He and G. Wei later remove the diameter restriction and in joint work with X. Dai and G. Wei, we prove the conjecture for dimension $n \geq 2$. (Received September 04, 2017)

1134-53-187 **Jeff Streets*** (jstreets@uci.edu). *Overview of pluriclosed flow.*

The pluriclosed flow, introduced in joint work with G. Tian, is a geometric flow generalizing Ricci flow designed to understand problems in complex, non-Kahler geometry. In this talk I will give background and a brief overview of the main results and conjectures for this flow. (Received September 04, 2017)

1134-53-190 **Jeff Streets*** (jstreets@uci.edu). *The Calabi-Yau equation in generalized Kahler geometry.*

Generalized Kahler geometry is a very natural extension of Kahler geometry with applications to mathematical physics. In this setting there is also a natural Calabi-Yau equation generalizing the classical Kahler version. I will introduce this equation and discuss the new PDE challenges this equation presents, some of which have been overcome. (Received September 04, 2017)

1134-53-209 **Lihan Wang*** (lihan.wang@uconn.edu). *Symplectic Boundary Conditions and Cohomologies.* Preliminary report.

In this talk, we study the symplectic manifolds with boundary from an analytic point of view. New types of conditions are introduced on differential forms, which are called symplectic boundary conditions. These conditions help us to build elliptic systems for special Laplacians. As a result, new type relative cohomologies can be well defined, which corresponds to the cohomology introduced by Tseng and Yau. We will discuss interesting properties of these relative cohomologies. (Received September 05, 2017)

1134-53-224 **Zhiqin Lu*** (zlu@uci.edu). *Hearing the shape of a trapezoid by its Neumann eigenvalues.* We shall prove that the shape of a trapezoid is determined by its Neumann eigenvalues. The Dirichlet eigenvalue case will also be discussed. This is the joint work with Hamid Hezari and Julie Rowlett. (Received September 06, 2017)

1134-53-235 **Qiang Guang*** (guang@ucsb.edu), South Hall, Room 6723, University of California, Santa Barbara, CA 93106, and **Martin Man-chun Li** and **Xin Zhou**. *Curvature estimates for stable free boundary minimal hypersurfaces.*

Free boundary minimal hypersurfaces are critical points of the area functional in compact manifolds with boundary. In this talk, we will present uniform curvature estimates for stable free boundary minimal hypersurfaces, which can be viewed as a generalization of Schoen-Simon-Yau's interior curvature estimates up to the boundary. In particular, for embedded stable free boundary minimal surfaces in 3-manifolds, we present a stronger curvature estimate without a priori area bound. The proof uses the theory of minimal laminations developed by Colding and Minicozzi. (Received September 07, 2017)

1134-53-241 **Duong H. Phong**, **Sebastien Picard*** (picard@math.columbia.edu) and **Xiangwen Zhang**. *The Anomaly flow and the Hull-Strominger system.*

The Anomaly flow is a geometric flow which implements the Green-Schwarz anomaly cancellation mechanism originating from superstring theory, while preserving the conformally balanced condition of Hermitian metrics. Its stationary points satisfy the Hull-Strominger system of partial differential equations. The Anomaly flow allows metrics with torsion, and it is quadratic in the Riemann curvature tensor. I will discuss general features of this geometric flow, and describe its behavior on certain examples. This is joint work with D.H. Phong and X.-W. Zhang. (Received September 07, 2017)

1134-53-251 **Adam Moreno*** (amoreno3@nd.edu). *Point Leaf Maximal Singular Riemannian Foliations in Positive Curvature.* Preliminary report.

Positively curved Riemannian manifolds with "large" symmetry have received special attention since the early 90's. *Cohomogeneity one* actions, for example, have simple orbit spaces which carry information about the topology of the given manifold. Groups acting *fixed point homogeneously* share an important property with cohomogeneity one manifolds and were classified by Grove and Searle in 1997. Here, we interpret this property in the context of singular Riemannian foliations, where the group action is absent. We find that manifolds that can be equipped with these so-called *point leaf maximal* SRF's have a nice structure which resembles (cohomologically) that of the compact rank one symmetric spaces. (Received September 08, 2017)

1134-53-265 **Ved V Datar*** (vvdatar@berkeley.edu), 970 Evans Hall #3840, Berkeley, CA 94720-3840. *Constant scalar curvature metrics on blow-ups of Kahler surfaces.*

It is known that the blow-up of a constant scalar curvature Kahler (cscK) manifold of (complex) dimension strictly greater than 2 also admits a cscK metric if it is K-stable. I will present some open questions and partial results in dimension two. (Received September 08, 2017)

1134-53-285 **Thomas Murphy*** (tmurphy@fullerton.edu), Dept. Mathematics CSU Fullerton, 800 N. State College Blvd., Fullerton, CA 92831. *Bounding the invariant spectrum of toric Kaehler manifolds.*

We generalise a theorem of Engman and Abreu–Freitas which bounds the first invariant eigenvalue of a non-negatively curved T^1-invariant metric on S^2 to toric Kaehler metrics with non-negative scalar curvature. Bounds for all higher eigenvalues are determined: these can be combinatorially determined from the Delzant Polytope. Similar results in the extremal case are also derived. This is joint work with Stuart Hall. (Received September 10, 2017)

1134-53-319 **Anna Fino**, University di Torino, **Gueo Grantcharov***, Florida International University, and **Luigi Vezzoni**, University di Torino. *Balanced and astheno-Kaehler metrics on fibrations.*

We study balanced, SKT and astheno-Kaehler metrics and the interplay between them on specific examples. After noticing that some twistor spaces which have balanced metrics do not admit astheno-Kaehler ones, we provide a construction of astheno-Kaehler structures on toric bundles over Kaehler manifolds leading to new examples. In particular, we find non-Kaehler examples which admit a balanced and an astheno-Kähler metric, thus answering to a question of Szekelyhidi-Tosatti-Weinkove. We also show that the Lie groups SU(3) an G_2 admit SKT and astheno-Kaehler metrics, which are different. Furthermore, we investigate the existence of balanced metrics on compact complex homogeneous spaces with an invariant volume form, showing in particular

that if a compact complex homogeneous space M with invariant volume admits a balanced metric, then its first Chern class does not vanish. Finally we characterize Wang C-spaces admitting SKT metrics. (Received September 11, 2017)

1134-53-340 **Li-Sheng Tseng*** (lstseng@math.uci.edu). *Symplectic analysis of differential forms.*
On symplectic manifolds, there are natural differential operators, dependent on the symplectic structure, that act on forms. We will describe how analyses of these operators can lead to geometric invariants on such spaces. (Received September 11, 2017)

1134-53-347 **Maree Jaramillo**, **Raquel Perales** and **Priyanka Rajan*** (rajan@math.ucr.edu), Santa Clara, CA, and **Catherine Searle** and **Anna Siffert**. *Alexandrov Spaces with Integral Current Structure.*
Alexandrov Spaces are locally compact complete length spaces, which form a generalization of Riemannian manifolds with curvature bounded from below. Integral current spaces can be intuitively thought of as abstract metric spaces for which some kind of Stokes theorem can hold.

We endow each closed, orientable Alexandrov space (X, d) with an integral current T of weight equal to 1, $\partial T = 0$ and $set(T) = X$, in other words, we prove that (X, d, T) is an integral current space with no boundary. (Received September 11, 2017)

1134-53-376 **Patrick Allmann**, **Longzhi Lin*** (lzlin@ucsc.edu) and **Jingyong Zhu**. *Modified mean curvature flow of entire locally Lipschitz radial graphs in hyperbolic space.*
The modi ed mean curvature flow (MMCF) was introduced a few years ago in my joint work with L. Xiao, where we showed the long time existence and convergence of the flow of star-shaped hypersurfaces in hyperbolic space with prescribed asymptotic boundary at infinity, assuming the so-called uniform ball condition on the boundary. In this talk, I will talk about recent joint work with P. Allmann and J. Zhu on the long-time existence of the MMCF starting from entire locally Lipschitz continuous radial graphs in hyperbolic space. This can be thought of as complement of our previous results without assuming the uniform ball condition on the boundary at infinity. (Received September 11, 2017)

1134-53-379 **Peter Smillie*** (smillie@math.harvard.edu), 6 7th St, Cambridge, MA 02141. *Weingarten foliations of three dimensional Lorentzian spaceforms.* Preliminary report.
Given a parametrized curve $(a(t), b(t), c(t))$ in $\mathbb{R}^3$, we consider foliations of a three-dimensional Lorentzian spaceform M by spacelike surfaces Σ_t whose principle curvatures satisfy the Weingarten equation $a(t)\kappa_1\kappa_2 + b(t)(\kappa_1 + \kappa_2) + c(t) = 0$. Foliations of M by constant mean curvature surfaces (that is, $a = 0$) are a well-studied model for the long-time behavior of constant mean curvature time functions in general relativity; foliations by constant Gaussian curvature surfaces (that is, $b = 0$) have found applications in Teicmuller theory through the landslide flow of Bonsante, Mondello and Schlenker. Generalizing to Weingarten foliations unites techniques that have been applied to the these two different cases and also gives the flexibility to construct geometrically natural foliations of some new domains. (Received September 11, 2017)

1134-53-414 **David Wiygul*** (dwiygul@uci.edu). *Some recent gluing constructions of minimal surfaces in the 3-sphere and Euclidean space.*
I will describe new joint work with Nicos Kapouleas constructing some interesting minimal surfaces in the 3-dimensional round sphere and Euclidean space by gluing techniques. (Received September 12, 2017)

1134-53-421 **Marco Radeschi*** (marco.radeschi@gmail.com), 426 E Pokagon St, South Bend, IN 46617. *On the Petersen-Wilhelm conjecture.*
The Petersen-Wilhelm Conjecture asserts that, given a Riemannian submersion between manifolds with positive curvature, the dimension of the base is grater than the dimension of the fiber. Previous results show that this conjecture fails if the curvature of the bigger space is assumed to be almost positive, i.e., non-negative and positive almost everywhere. In particular, proving the conjecture true would be very subtle. In this talk, on the other hand, we present a proof that every submersion (not necessarily Riemannian) from a manifold homotopy equivalent to one of the known positively curved examples, must satisfy the conclusion of the Petersen-Wilhelm Conjecture. In particular, any counterexample to the conjecture would provide a manifold with positive curvature and different topology from the known ones, a well-known hard task. This is based on a joint work with David Gonzales-Alvaro. (Received September 12, 2017)

1134-53-429 **Yihan Li*** (yhli@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, Santa Barbara, CA 93106. *Asymptotic Spectral Flow with Heat Equation Method.*

The notion of spectral flow for a one parameter family of Dirac operator D_s for $s \in [0,1]$ is introduced by Atiyah-Patodi-Singer in their study of index theory on manifolds with boundary and is intimately related to the η invariant which is also introduced by Atiyah-Patodi-Singer. Motivated by work by Taubes on asymptotic spectral flow and idea of local index theorem. We extend the interval to $[0,r]$ and use the heat kernel approach to give an estimate of the dependence of the spectral flow on the parameter r as it approaches to infinity. This involve the estimate for both heat kernel of the operator D_s and η invariant $\eta(D_s)$ of their dependence on the parameter. (Received September 12, 2017)

1134-53-434 **Jeff Viaclovsky*** (jviaclov@uci.edu), Dept. of Math., UC Irvine, Irvine, CA 92697. *Scalar-flat Kahler ALE metrics.*

I will discuss some new examples of scalar-flat Kahler ALE (asymptotically locally Euclidean) metrics on complex surfaces. This is joint work with Jiyuan Han. (Received September 12, 2017)

1134-53-462 **Chris Connell** and **Xianzhe Dai***, South Hall 6511, UCSB, Santa Barbara, CA 93106, and **Jesus Nunez-Zimbron**, **Requel Perales**, **Pablo Suarez-Serrato** and **Guofang Wei**. *Volume entropy rigidity for RCD spaces.* Preliminary report.

Volume entropy is a fundamental geometric invariant defined as the exponential growth rate of volumes of balls in the universal cover. It is a very subtle invariant which has attracted extensive study. We will be concerned with the generalization to RCD spaces of the volume entropy rigidity result of Ledrappier and Wang which says that for a compact Riemannian manifold whose Ricci curvature is bounded from below by -(n-1), then the volume entropy is bounded from above by (n-1) and the equality holds iff the manifold is hyperbolic. (Received September 13, 2017)

54 ► General topology

1134-54-368 **Wade Bloomquist*** (bloomquist@math.ucsb.edu) and **Zhenghan Wang**. *Skein Theory and Asymptotic Faithfulness.*

Quantum representations of mapping class groups arise from (2+1) dimensional TQFTs, and thus modular tensor categories using a construction of Turaev. Given a Lie algebra and a level, there exists a modular tensor category and thus a mapping class group representation. Using techniques based on the spiders of Kuperberg for rank 2 Lie algebras we explore properties of these representations as the level tends towards infinity. (Received September 11, 2017)

55 ► Algebraic topology

1134-55-15 **Zhen Huan*** (huanzhen84@yahoo.com). *Quasi-elliptic cohomology.*

Quasi-elliptic cohomology is closely related to Tate K-theory. It can be interpreted by orbifold loop spaces and expressed in terms of equivariant K-theories. We formulate the complete power operation of this theory. Applying that we proved the finite subgroups of Tate curve can be classified by the Tate K-theory of symmetric groups modulo a certain transfer ideal. Moreover, we construct a G-orthogonal spectra weakly representing quasi-elliptic cohomology. Unfortunately, our construction does not arise from a global spectra; thus, we consider a new formulation of global stable homotopy theory that contains quasi-elliptic cohomology. (Received May 03, 2017)

1134-55-16 **Clover May*** (clover@uoregon.edu). *A structure theorem for RO(G)-graded cohomology.* Preliminary report.

Computations of singular cohomology groups are very familiar. An equivariant analogue is $RO(G)$-graded Bredon cohomology with coefficients in a constant Mackey functor. Computations in this setting are often more challenging and are not well understood. In this talk I will present a structure theorem for $RO(C_2)$-graded cohomology with $\underline{\mathbb{Z}/2}$ coefficients that substantially simplifies computations. The structure theorem says the cohomology of any finite C_2-CW complex decomposes as a direct sum of two basic pieces: shifted copies of the cohomology of a point and shifted copies of the cohomologies of spheres with the antipodal action. I will sketch

the proof, which depends on a Toda bracket calculation, and give some examples. (Received September 12, 2017)

1134-55-29 **Alexander Suciu** (a.suciu@neu.edu), Department of Mathematics, Northeastern University, BOSTON, MA 02115, and **He Wang*** (hew@unr.edu), Department of Mathematics & Statistics, University of Nevada, Reno, Reno, NV 89557. *Formality properties: generalizations and applications.*

Formality property arises from the rational homotopy theory developed by Quillen and Sullivan in 70's. Roughly speaking, the rational homotopy type of a formal simply-connected space is determined by its cohomology algebra. For each $k \geq 1$, the k-formality is a partial formality property filtered by the degree of the CDGA model. A closely related property of a finitely generated group is 1-formality, which allows one to reconstruct the rational pro-unipotent completion of the group solely from the cup products of degree 1 cohomology classes. We separate 1-formality into two complementary properties: graded-formality and filtered-formality, by studying various Lie algebras over a field of characteristic 0 attached to such group, including the associated graded Lie algebra, the holonomy Lie algebra and the Malcev Lie algebra. We explain how these notions behave with respect to split injections, coproducts, direct products, as well as field extensions. (Received June 24, 2017)

1134-55-56 **Pedro Boavida de Brito**, **Geoffroy Horel** and **Marcy Robertson*** (marcy.robertson@unimelb.edu.au). *An action of the Grothendieck-Teichmüller group on the operad of stable curves of genus zero.*

In this talk, we show that the group of homotopy automorphisms of the profinite completion of the (cyclic) framed little 2-discs operad is isomorphic to the (profinite) Grothendieck-Teichmüller group. We deduce that the Grothendieck-Teichmüller group acts nontrivially on an operadic model of the genus zero Teichmuller tower. (Received August 05, 2017)

1134-55-57 **Safia Chettih*** (safia@reed.edu) and **Daniel Lütgehetmann** (daniel.luetgehetmann@fu-berlin.de). *Configurations with sinks and on graphs.*

Given a graph Γ, there exist discretized models for its n-point configuration space that are cubical complexes. The model constructed by A. Abrams in his 2000 PhD thesis is the most well-known, but in 2001 Świątkowski constructed a lesser-known model whose dimension stabilizes as the number of points increases. We have constructed a Świątkowski-style discretized model for configurations with sinks, where multiple points are allowed to occupy certain vertices of the graph. In my talk, I will discuss these various constructions and their implications for the topology of ordered configuration spaces of graphs. (Received August 05, 2017)

1134-55-63 **Nick Gurski**, **Niles Johnson** and **Angélica M Osorno***, aosorno@reed.edu. *Picard 2-categories and stable 2-types.*

It is a classic result that groupoids model unstable homotopy 1-types, and that lead to Grothendieck's homotopy hypothesis: n-groupoids model unstable n-types. In this talk I will talk about the stable version of the hypothesis: that is, Picard n-groupoids (i.e., symmetric monoidal n-categories with invertible cells in all dimensions) model stable homotopy n-types. I will talk about the proof for the case $n = 2$, and I will explain how some of the homotopy invariants can be read directly from the categorical side. (Received August 09, 2017)

1134-55-96 **Apurva Nakade*** (anakade1@jhu.edu), 505 W Univ Pkwy, Apt B3, Baltimore, MD 21210. *Manifold calculus and the h-principle.*

Manifold calculus is a form of functor calculus that tries to analyze contravariant functors from some category of manifolds to spaces by providing *Taylor approximations* for them. In current literature there are very few functors for which the Taylor approximations are known. In this talk we'll use h-principle to construct several examples of *analytic functors* in the sense of manifold calculus. We'll prove that the analytic approximation of the Lagrangian embeddings functor is the totally real embeddings functor. As a byproduct we'll also provide a geometric model for the *embeddings modulo immersions* functor. (Received August 23, 2017)

1134-55-102 **Sebastian Goette**, **Martin Kerin** and **Krishnan Shankar*** (krishnan.shankar@gmail.com). *2-connected, 7-manifolds with non-negative curvature and non-standard linking form.* Preliminary report.

From the work of Grove and Ziller we know that every $\mathbf{S}^3$-bundle over $\mathbf{S}^4$ admits a complete Riemannian metric of non-negative sectional curvature. Given a 2-connected, 7-manifold with the same cohomology as such a bundle, it is known (from the work of Kitchloo and the presenter) that it is either homotopy equivalent (and hence PL-homeomorphic) to such a bundle if and only if the quadratic linking form on the cohomology group H^4 is equivalent to a standard form. Using the new construction of codimension one biquotient foliations by

the authors, we show that there are infinitely many examples with non-negative curvature and non-standard linking form. Thus, there are infinitely many new examples of cohomology $\mathbf{S}^3$-bundles over $\mathbf{S}^4$ that are not even homotopy equivalent to any such bundle. (Received August 24, 2017)

1134-55-124 **Inbar Klang*** (inbark@stanford.edu). *Factorization homology and topological Hochschild cohomology of Thom spectra.*

By a theorem of Lewis, the Thom spectrum of an n-fold loop map to BO is an E_n-ring spectrum. I will discuss a project studying the factorization homology and the E_n topological Hochschild cohomology of such Thom spectra, and talk about some applications, such as computations, and a duality between topological Hochschild homology and cohomology of certain Thom spectra. (Received August 28, 2017)

1134-55-129 **James C Cameron*** (jccamer@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350. *The Duflot filtration in equivariant cohomology and applications to the local cohomology modules of group cohomology rings.*

Duflot defined a filtration on the Borel equivariant cohomology ring of a smooth manifold with an elementary abelian p-group action, and among other applications used this filtration to show that for G a compact Lie group, all associated primes of H^*BG come from restricting to elementary abelian p-groups. This filtration was also used by Symonds to show that group cohomology rings have Castelnuovo-Mumford regularity zero.

We present a formalization of the algebraic structure enjoyed by rings having an analog of the Duflot filtration, and give a refinement of the Duflot filtration to a filtration by a poset related to fixed point data. We show how to from this framework derive basic results in the commutative algebra of group cohomology rings, and give new computations of some of the local cohomology modules for the group cohomology ring of the p-Sylow of S_{p^n}. (Received August 29, 2017)

1134-55-138 **Eric Hogle*** (ehogle@uoregon.edu), Fenton Hall, University of Oregon, Eugene, OR 97401. *The $RO(C_2)$-graded Bredon cohomology of equivariant Grassmannians.*

The Grassmannian manifold of k-planes in $\mathbb{R}^n$ has a group action if $\mathbb{R}^n$ is taken to be a real representation of the group. When the group is C_2, the Schubert cell construction of the Grassmannian generalizes to an equivariant representation-cell structure. However, this generalization is not unique; an identificiation of representation with $\mathbb{R}^n$ must be chosen.

I am interested in computing the $RO(C_2)$-graded Bredon cohomology of these spaces. Although a theorem of Kronholm dictates that this must be free, determining the degrees of the generators is nontrivial. The ambiguity introduced by the choice mentioned above turns out to be an asset for this task. Using a computation by Dan Dugger of the cohomology of an infinite equivariant Grassmannian, and some theorems about equivariant flag manifolds, I will present a way to succeed in finding the cohomologies of several infinite families of finite-dimensional equivariant Grassmannians. (Received August 30, 2017)

1134-55-245 **Ben Williams*** (benedict.williams@gmail.com). *The A^1 calculation of the 4th homotopy group of the 6,3-sphere and a conjecture of Suslin.*

The algebraic K-theory, due to Quillen, of a field is related to a theory defined by Milnor called Milnor K-theory and denoted K^M. In the 1980s, Andrei Suslin constructed a map $K_n(F) \to K_n^M(F)$, and conjectured that the image was the subgroup $(n-1)!K_n^M(F)$. He also proved the conjecture for $n \leq 3$. For $n = 5$, we reinterpret the construction as a construction in the A^1 homotopy groups of spheres and BGL, and by calculating these groups, show that the conjecture is true in this case as well. This represents part of a joint project with Aravind Asok, Jean Fasel and Kirsten Wickelgren. (Received September 07, 2017)

57 ► Manifolds and cell complexes

1134-57-52 **Vladimir Chernov**, **David Freund*** (dfreund@math.dartmouth.edu) and **Rustam Sadykov**. *Minimizing intersection points of flat virtual links.* Preliminary report.

A virtual n-string is a collection of n closed curves on an oriented surface M and counting the minimal number of intersection points in the homotopy class of this collection is a classical problem. We address the analogous problem for flat virtual links, i.e., equivalence classes of virtual n-strings related by homotopy and by stabilization/destabilization of the supporting surface. In particular, we use generalizations of the Cahn cobracket and the Andersen–Mattes–Reshetikhin bracket to obtain the minimal number of intersection points for a flat virtual link and show that it is realized on a minimal genus representative. (Received July 27, 2017)

1134-57-70 **Frederick Cohen**, **Rafal Komendarczyk**, **Robin Koytcheff*** (robin.koytcheff@louisiana.edu) and **Clayton Shonkwiler**. *Homotopy string links, configuration spaces, and the kappa invariant.*

A link is an embedding of disjoint circles in space. A link homotopy is a path of links where distinct components may not pass through each other, but where a component may pass through itself. In the 1990s, Koschorke conjectured that link homotopy classes of n-component links are distinguished by the kappa invariant. This invariant is essentially the map that a link induces on configuration spaces of n points. It can be viewed as a generalization of the pairwise linking number, suitably interpreted in terms of homotopy classes of maps. We recently proved an analogue of this conjecture for long links (a.k.a. string links). An important ingredient in the proof is a multiplication on maps of configuration spaces, akin to concatenation of loops in a space. (Received August 16, 2017)

1134-57-83 **Nicolas Petit*** (petitnicola@gmail.com), Oxford, GA 30054. *Finite-type invariants for virtual tangles.* Preliminary report.

Vassiliev invariants (also known as finite-type invariants) are combinatorial knot invariants, obtained by extending a knot invariant to knots with double points by taking a weighted sum of the possible resolutions of the double points. We will present two Vassiliev invariants for virtual tangles, which are generalizations of the polynomial and smoothing invariants previously studied by the author. We will also discuss the possibility of a universal Vassiliev invariant for virtual tangles, and the obstacles we encountered. (Received August 22, 2017)

1134-57-85 **Allison Henrich*** (henricha@seattleu.edu). *An Intransitive Relation on Knots.*

In this talk, we will introduce and explore the following relation on knots. A knot D is said to be a descendant of another knot P if there is a minimal crossing diagram of P on which some subset of crossings can be changed to produce a diagram of D. In this case, P is said to be a parent of D. The descendant-parent relation has many interesting properties—for instance, intransitivity—and it enjoys useful connections with other previously studied relations on knots. We explore several such properties and connections, and we provide a variety of computational results.

This is joint work with Jason Cantarella, Elsa Magness, Oliver O'Keefe, Kayla Perez, Eric Rawdon, and Briana Zimmer. (Received August 22, 2017)

1134-57-90 **Louis H Kauffman*** (kauffman@uic.edu), 5530 South Shore Drive, Apt 7C, Chicago, IL 60637-1946. *Virtual Knots, Knotoids and Bonded Knotoids.* Preliminary report.

This talk is joint work with Neslihan Gugumcu and in parts with Sofia Lambropoulou, Dimos Goundaroulis and Julien Dorier. We study knotoids (knot diagrams with free ends taken up to Reidemeister moves away from the ends) using techniques and ideas from virtual knot theory. We extend knotoids to bonded knotoids, forming models for folded proteins and polymer chains. We obtain invariants of bonded knotoids by inserting tangles into the bonds and calculating invariants of the resulting knotoids. These results use bracket invariants, arrow polynomial invariants and loop versions of these when the knotoids are planar. Actual proteins and polymers can be studied in this way by projecting to a plane and studying the resulting bonded knotoid. Many projections for a given chain in space give information about its configuration in three dimensional space. (Received August 23, 2017)

1134-57-121 **Hans U Boden**, **Micah Chrisman*** (mchrisma@monmouth.edu) and **Robin Gaudreau**. *Slice Genera of Virtual and Almost Classical Knots.*

Up to symmetry, there are 92800 virtual knots having six or fewer crossings. Of these 76 are almost classical, i.e. they have a homologically trivial representative in some thickened surface. We give some practical techniques that can be used to determine the slice status and slice genus bounds for these virtual knots. Useful lower bounds for virtual knots are obtained through generalizing Turaev's graded genus invariant to virtual knots. For almost classical knots, we introduce slice obstructions arising from a Seifert pairing, such as ω-signatures and Alexander-Conway polynomials. These slice obstructions can be extended to all virtual knots using parity projection and Turaev's coverings of knots. The result of applying these tools to the virtual knots having at most six crossings is given. (Received August 28, 2017)

1134-57-150 **Robert G Todd*** (rtodd@mtmercy.edu) and **Micah Chrisman**. *The Alexander polynomial of some virtual knots via the multi-variable Alexander polynomial of links.*

Almost classical virtual knots are those that are homologically trivial in the thickened Carter surface. Boden et al. show these virtual knots have an Alexander polynomial whose definition is analogous to that for classical knots. Using the theory of virtual covers we show that for some almost classical virtual knots their Alexander

polynomial can be found as an evaluation of the classical multi-variable Alexander polynomial of a corresponding two component link. We also comment on an interpretation of the index of a crossing in a virtual knot. A further conjecture will be discussed. (Received September 01, 2017)

1134-57-176 **Carmen Caprau***, Department of Mathematics, California State University-Fresno, 5245 N. Backer Avenue M/S PB 108, Fresno, CA 93740, and **Abigayle Dirdak**, **Rita Post** and **Erica Sawyer**. *Markov-type theorems for virtual trivalent braids.* Preliminary report.

Markov's theorem is essential in knot theory for understanding the relationship between classical braids and knots. In this talk, we provide two Markov-type theorems for virtual trivalent braids. (Received September 03, 2017)

1134-57-195 **Ryan Blair***, ryan.blair@csulb.edu, and **Marion Campisi**, **Scott Taylor** and **Maggy Tomova**. *Distortion and the bridge distance of knots.*

We extend techniques due to Pardon to show that there is a lower bound on the distortion of a knot in $\mathbb{R}^3$ proportional to the minimum of the bridge distance and the bridge number of the knot. We also exhibit an infinite family of knots for which the minimum of the bridge distance and the bridge number is unbounded and Pardon's lower bound is constant. (Received September 04, 2017)

1134-57-229 **W. Edwin Clark** and **Masahico Saito*** (saito@usf.edu). *Quandle knot invariants from $SU(2)$.* Preliminary report.

The quandle 2-cocycle invariant was originally defined in state-sum form using colorings by finite quandles and 2-cocycles as weights at crossings. Eisermann gave an interpretation of this invariant as the image of the longitude for the knot group representation corresponding to the coloring. This interpretation is used towards generalizing the invariant to topological quandles. As an example, colorings of long knots by $SU(2)$ and spherical quandles of rotations are studied using unit quaternions. The invariant value for $(2, n)$-torus knots are determined, and a few other examples are presented. (Received September 06, 2017)

1134-57-321 **Michael Abel*** (maabel@math.duke.edu) and **Michael Willis**. *Colored Khovanov-Rozansky homology of infinite braids.* Preliminary report.

We show that the limiting unicolored $\mathfrak{sl}(N)$ Khovanov-Rozansky chain complex of any infinite positive braid categorifies a highest-weight projector. This result extends an earlier result of Cautis categorifying highest-weight projectors using the limiting complex of infinite torus braids. Additionally, we show that the results hold in the case of colored HOMFLY-PT Khovanov-Rozansky homology as well. An application of this result is given in finding a partial isomorphism between the HOMFLY-PT homology of any braid positive link and the stable HOMFLY-PT homology of the infinite torus knot as computed by Hogancamp. (Received September 11, 2017)

1134-57-323 **J. Scott Carter*** (carter@southalabama.edu), Department of Mathematics and Statistics, Mobile, AL 36688. *Moves for knotted 2-foams, Abstract Tensors, and Prismatic Homology.*

A 2-dimensional foam is constructed as a space that is locally modeled on the 2-dimensional associator which has one vertex, four edges, and six faces. These are dual, respectively, to the 3-cell, faces, and edges of a tetrahedron. Local pictures of knottings of 2-foams can be constructed by examining how foams overlay in products of simplices: tetrahedron, two different prisms, and a cube. The next higher order relation between these are movie-move type relations that involve families of trees that have a half-twist at the trunk. We examine the eight movie moves and their higher dimensional analogues to propose a family of polytopes that include the permutahedron, and a system of abstract tensor relations that encompass a (3,2)-move and the Zamolochikov tetrahedral relation (quadruple point move). A solution is proposed that involves cocycle conditions.

Categorical concepts will be discussed in connection with foams as will homotopical interpretations of cocycle invariants. (Received September 11, 2017)

1134-57-400 **Alexander Zupan*** (zupan@unl.edu). *Representing knotted surfaces in dimension four.* Preliminary report.

In 2015, Jeffrey Meier and I introduced tri-plane diagrams for knotted surfaces in 4-dimensional space, a novel way to represent such objects as 2-dimensional data. A more classical way of accomplishing this task is called a broken surface diagram, which is an immersed surface in 3-dimensional space with "crossing" data at double and triple points. I'll discuss a new method by which to convert a tri-plane diagram to a broken surface diagram, with relevant examples. (Received September 12, 2017)

1134-57-426 **Stephen Bigelow*** (bigelow@math.ucsb.edu), Department of Mathematics, South Hall room 6607, University of California, Santa Barbara, CA 93106. *How a quantum computer might work.*

I will describe Kitaev's hypothetical topological quantum computer, specifically one that uses "Fibonacci anyons". I will give an impressionistic picture of how the hardware would work, followed by a slightly more accurate description of how to write software. Computer programs are braids, or more generally, tangled graphs. This is joint work with Claire Levaillant. (Received September 12, 2017)

1134-57-430 **Marion Campisi** and **Matt Rathbun*** (mrathbun@fullerton.edu). *Hyperbolic manifolds containing high topological index surfaces.*

If a graph is in bridge position in a 3-manifold so that the graph complement is irreducible and boundary irreducible, we generalize a result of Bachman and Schleimer to prove that the complexity of a surface properly embedded in the complement of the graph bounds the graph distance of the bridge surface. We use this result to construct, for any natural number n, a hyperbolic manifold containing a surface of topological index n. (Received September 12, 2017)

1134-57-433 **Radmila Sazdanovic*** (rsazdanovic@math.ncsu.edu), Department of Mathematics NC State, P.O. Box 8205, Raleigh, NC 17606, and **Daniel Scofield**. *Patterns in Khovanov link and chromatic graph homology.* Preliminary report.

Khovanov homology of a link and chromatic graph homology are known to be isomorphic in a range of homological gradings that depend on the girth of a graph. In this talk, we discuss patterns shared by these two homology theories. In particular, we improve the bounds for the homological span of chromatic homology by Helme-Guizon, Przytycki and Rong. An explicit formula for the rank of the third chromatic homology group on the main diagonal is given and used to compute the corresponding Khovanov homology group and the fourth coefficient of the Jones polynomial for links with certain diagrams. (Received September 12, 2017)

1134-57-456 **L. Fadali*** (lfadali@oxy.edu). *TQFT, n-categories, and surfaces.*

Classical examples of topological quantum field theory can be computed as skein modules of 1-dimensional objects in a 3-manifold. I will discuss various options for definining a TQFT as a skein module of 2-dimensional objects, including how my work on Bar-Natan skein modules fits into the landscape of TQFT. (Received September 12, 2017)

58 ► Global analysis, analysis on manifolds

1134-58-66 **Matthew J Gursky**, **Casey L Kelleher*** (clkelleh@uci.edu) and **Jeffrey D Streets**. *A conformally invariant gap theorem in Yang-Mills theory.*

We show a sharp conformally invariant gap theorem for Yang-Mills connections in dimension 4 by exploiting an associated Yamabe-type problem. (Received August 13, 2017)

1134-58-173 **Christine Escher** and **Catherine Searle*** (searle@math.wichita.edu), Dept. of Mathematics, Statistics, and Physics, Wichita State University, 1845 Fairmount Avenue, Wichita, KS 67260. *Non-negatively curved 6-manifolds with almost maximal symmetry rank.*

We classify closed, simply-connected, non-negatively curved 6-manifolds of almost maximal symmetry rank up to equivariant diffeomorphism. (Received September 03, 2017)

1134-58-223 **Michel L. Lapidus*** (lapidus@math.ucr.edu), University of California, Department of Mathematics, Riverside, CA 92521-0135, **Goran Radunovic**, University of Zagreb, Department of Applied Mathematics, Zagreb, Croatia, and **Darko Zubrinic**, University of Zagreb, Department of Applied Mathematics, Zagreb, Croatia. *Fractal Zeta Functions and Complex Fractal Dimensions: A Brief Introduction and Overview.*

In this talk, we plan to give a short introduction and overview of the theory of complex fractal dimensions via fractal zeta functions, with emphasis on the higher-dimensional theory. For pedagogical reasons and by necessity of concision, we will stress a few results and examples illustrating them.

The main reference for this presentation (beside a series of nine accompanying research papers by the same group of authors) is the recent book by Michel L. Lapidus, Goran Radunovic and Darko Zubrinic, entitled "Fractal Zeta Functions and Fractal Drums: Higher-Dinensional Theory of Complex Dimensions" (Springer Monographs in Mathematics, Springer, New York, June 2017, 685 pages). (Received September 06, 2017)

60 ► Probability theory and stochastic processes

1134-60-7 **Eka Oche Ogbaji***, Department of Mathematics and Statistics, Federal University Wukari, Wukari, 96000001, Nigeria, and **E. S. Onah** and **A. R. Kimbir**. *Simplified Stochastic Runge-Kutta (SSR-K) scheme for a Stock Market Model.* Preliminary report.

A system of stochastic differential equations in the form of a geometric Brownian motion was formulated. This was to model a compartmental stock market situation. We simplified stochastic Runge-Kutta scheme to solve four - dimensional stochastic differential equation and show N- dimension simplified stochastic Rung-Kutta (SSR-K) scheme . In this research work, the simplification follows the principle of Runge-Kutta scheme for ordinary differential equation. We showed the theoretical analysis of convergence, stability, consistence and order of the scheme by using the existence and uniqueness theorem. We conclude that the formulated model can be use to show the real application of stock market in four compartment.We conclude that ndimensional stochastic differential equation can be solve by using n-dimensional simplified stochastic Runge-Kutta scheme. (Received February 04, 2017)

1134-60-11 **Ralph L Wojtowicz*** (rwojtowi@shepherd.edu), 301 North King Street, Shepherdstown, WV 25443. *Categorical Logic as a Foundation for Reasoning Under Uncertainty.*

A zoo of uncertainty models has emerged in past decades to address perceived deficiencies in the capacity of probability theory to represent vagueness, ignorance, and related concepts. A small sample of these newer models includes fuzzy set theory, Dempster-Shafer theory, the theory of hints, rough sets, vague sets, higher-order probabilities, likelihood logic, and imprecise probabilities. Such models are employed in real engineering systems. Moreover, examples arise in which different models are implemented in a single system or in systems that must work together. Category theory provides a natural framework for relating distinct uncertainty models and for supporting interoperability. Although category theory has been applied to probability since the 1960s, and has been used to formulate fuzzy set theories, little work has been done with many other uncertainty models. In this talk we discuss (1) a categorical formulation of Dempster-Shafer belief functions (2) mappings between categories of belief functions and probabilities, and (3) a general category-theoretic program for relating uncertainty models. This work grew out of research conducted under Small Business Innovative Research contracts in recent years. (Received April 06, 2017)

1134-60-19 **Mrinal K Roychowdhury***, University of Texas Rio Grande Valley, 1201 West University Drive, Edinburg, TX 78539. *An overview of optimal quantization.*

The basic goal of quantization for probability distribution is to reduce the number of values, which is typically uncountable, describing a probability distribution to some finite set and thus approximation of a continuous probability distribution by a discrete distribution. Mixed distributions are an exciting new area for optimal quantization. Recently, in the paper "An overview of the quantization for mixed distributions", available in arXiv, I have determined the optimal sets of n-means, the nth quantization error, and the quantization dimensions of different mixed distributions. Besides, I have discussed whether the quantization coefficients for the mixed distributions exist. The results in this paper will give a motivation and insight into more general problems in quantization of mixed distributions. This talk will mostly contain mixed distributions of different fractal measures. (Received May 27, 2017)

1134-60-44 **Andrey Sarantsev*** (sarantsev@pstat.ucsb.edu), South Hall 5607A, University of California, Santa Barbara, CA 93106, and **Tomoyuki Ichiba** (ichiba@pstat.ucsb.edu), South Hall 5607A, University of California, Santa Barbara, CA 93106. *Explicit Rates of Exponential Convergence for Diffusions.* Preliminary report.

We find explicit estimates for rates of exponential convergence for solutions of stochastic differential equations on the real line, on the half-line with reflection, and for related processes. (Received July 15, 2017)

1134-60-61 **Craig A. Tracy*** (tracy@math.ucdavis.edu), Department of Mathematics, One Shields Ave., University of California, Davis, CA 95616, and **Harold Widom** (widom@ucsc.edu), Department of Mathematics, University of California, Santa Cruz, CA 95064. *Blocks in the Asymmetric Simple Exclusion Process.*

In earlier work the authors obtained formulas for the probability in the asymmetric simple exclusion process that the mth particle from the left is at site x at time t. They were expressed in general as sums of multiple integrals and, for the case of step initial condition, as an integral involving a Fredholm determinant. In the present work these results are generalized to the case where the mth particle is the left-most one in a contiguous block of

L particles. The earlier work depended in a crucial way on two combinatorial identities, and the present work begins with a generalization of these identities to general L. (Received August 07, 2017)

1134-60-148 **Roman Vershynin*** (rvershyn@uci.edu), Department of Mathematics, University of California, Irvine, Irvine, CA 92617. *What makes the random matrix blow up?*

From early results in random matrix theory we know that the spectral norm of a random matrix is nicely bounded under mild conditions: iid entries have mean zero, unit variance and bounded fourth moment. But there are situations where the fourth moment condition is too restrictive. This happens, for example, for sparse random matrices (e.g. adjacency matrices of random graphs) and for random sub matrices of a fixed matrix (motivated by data analysis, e.g. covariance estimation). In such cases, the spectral norm of a random matrix blows up: there are outlying singular values. As we will discuss, such blow-up is always caused by a small problematic sub-matrix. We will show how to "repair" the spectral norm by changing this sub-matrix slightly. We will see implications for the community detection problem in sparse networks. This work is based on a paper joint with Can Le and Liza Levina and a paper joint with Elizaveta Rebrova. (Received August 31, 2017)

1134-60-151 **Sean O'Rourke*** (sean.d.orourke@colorado.edu), Department of Mathematics, University of Colorado Boulder, Campus Box 395, Boulder, CO 80309-0395, and **Behrouz Touri**, **Van Vu** and **Ke Wang**. *Eigenvectors of random matrices and graphs.*

Eigenvectors of large matrices (and graphs) play an essential role in combinatorics and theoretical computer science. The goal of this talk is to present several properties of the eigenvectors when the matrix (or graph) is random. In particular, I will focus on properties of the eigenvectors that allow us to analyze controllability attributes of random linear systems and prove a conjecture of Godsil. (Received September 01, 2017)

1134-60-155 **Yuichiro Kakihara*** (ykakihar@csusb.edu), Department of Mathematics, California State University, 5500 University Parkway, San Bernardino, CA 92407-2393. *Gramian Schauder basic measures and gramian uniformly bounded linearly stationary processes.* Preliminary report.

Hilbert space valued second order stochastic processes $\{x(t)\}$ on a locally compact abelian group are considered. When $\{x(t)\}$ is gramian uniformly bounded linearly stationary, some equivalence conditions are known. We add a few such conditions in terms of its representing measure and the family of stochastic processes it generates, where we introduce gramian Schauder basic measures as an analogy to Schauder basic measures. (Received September 01, 2017)

1134-60-165 **Joe Chen** and **Jonah Kudler-Flam*** (jkudlerflam@uchicago.edu). *Limit shape universality in cellular automata models on the Sierpinski gasket.*

It has been conjectured that on any state space, the growing clusters associated with the four cellular automata models, internal diffusion-limited aggregation (IDLA), rotor-router aggregation, divisible sandpiles, and abelian sandpiles, have the same limit shape. This "limit shape universality" conjecture is far from proven. For instance, even on $\mathbb{Z}^d$, while the limit shapes of the IDLA, rotor-router, and divisible sandpiles are Euclidean balls, the case of the abelian sandpile remains open.

I will explain that on the infinite Sierpinski gasket (SG), when particles are launched from the corner vertex o of SG, all four models fill balls, thus presenting the first realization of "limit shape universality" beyond $\mathbb{Z}$. I will also address interesting features in the fluctuations about the limit shapes. We do not know the extent to which such phenomenon holds on other graphs, but some of our proof methods may hint at possible mechanisms underlying the universality. (Received September 02, 2017)

1134-60-196 **Gerandy Brito***, 686 Cherry Street, Atlanta, GA 30332, and **Ioana Dumitriu** and **Kameron Harris**. *Alon's conjecture in random bipartite biregular graphs.*

We show a tight upper bound on the second largest eigenvalue of a random bipartite biregular graph, proving Alon's conjecture for this family of graphs. Our method works when the degrees grow slowly with the number of vertices of the graph. (Received September 04, 2017)

1134-60-203 **Jinho Baik** and **Zhipeng Liu*** (zhipeng@ku.edu). *Multi-point distribution of periodic TASEP.*

The height fluctuations of the models in the KPZ class are expected to converge to a universal process. The spatial process at equal time is known to converge to the Airy process or its variations. However, the temporal process, or more generally the two-dimensional space-time field, is less well understood. We consider this question for the periodic TASEP (totally asymmetric simple exclusion process). For a particular initial condition, we evaluate the multi-time and multi-location distribution explicitly in terms of a multiple integral involving a Fredholm

determinant. We then evaluate the large time limit in the so-called relaxation time scale. This is a joint work with Jinho Baik. (Received September 05, 2017)

1134-60-230 **Karl E Liechty*** (kliechty@depaul.edu). *Nonintersecting Brownian motions on the unit circle.*

Nonintersecting Brownian bridges on the unit circle form a determinantal point process whose kernel is expressed in terms of a system of discrete orthogonal polynomials which may be studied using Riemann–Hilbert techniques. If the Brownian motions have a drift, then the weight of the orthogonal polynomials becomes complex. I will discuss the tacnode and k-tacnode processes as scaling limits of nonintersecting Brownian motions on the unit circle and will discuss some of the features and difficulties of Riemann–Hilbert analysis of discrete orthogonal polynomials with varying complex weights.

This is joint work with Dong Wang and Robert Buckingham. (Received September 06, 2017)

1134-60-231 **Zhou Fan*** (zhoufan@stanford.edu). *Eigenvalues of multivariate variance components estimates.*

Variance components (a.k.a. random/mixed effects) models are commonly used to measure genetic variance-covariance matrices of quantitative phenotypic traits in a population. The eigenvalue spectra of such matrices describe the evolutionary response to selection, but may be difficult to estimate from limited samples when the number of traits is large. In this talk, I will discuss the eigenvalues of classical MANOVA estimators of these matrices, including a characterization of the bulk empirical eigenvalue distribution, Tracy-Widom fluctuations at the spectral edges under a "sphericity" null hypothesis, the behavior of outlier eigenvalues under spiked alternatives, and a statistical procedure for estimating true population spike eigenvalues from the sample. These results are established using tools of random matrix theory and free probability. Mathematical novelties include an asymptotic (conditional) freeness result for rectangular orthogonally-invariant matrices, a proof of GOE Tracy-Widom limits at interior edges of the spectrum in a multi-cut ensemble, and the study of a spiked model with non-orthogonal population spike eigenvectors.

This is joint work with Iain Johnstone, Mark Blows, and Yi Sun. (Received September 06, 2017)

1134-60-258 **Sean O'Rourke** and **Philip Matchett Wood*** (pmwood@math.wisc.edu), UW-Madison Department of Mathematics, Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706. *Spectra of nearly Hermitian random matrices.*

In this talk, we discuss what happens happens to the spectrum of a random Hermitian matrix when perturbed by a low-rank matrix, including the location of outlier eigenvalues and quantifying changes in the bulk distribution. We will discuss perturbations of Wigner random matrices and perturbations of sample covariance matrices, describing a new outlier result for the latter. A key tool in the proofs of these results is the Isotropic Semicircle Law due to Knowles and Yin and the more general Isotropic Local Laws due to Bloemendal, Erdos, Knowles, H-T Yau, and Yin. Joint work with Sean O'Rourke. (Received September 08, 2017)

1134-60-261 **Anirban Basak** and **Nicholas Cook***, nickcook@math.ucla.edu, and **Ofer Zeitouni**. *Circular laws for random regular digraphs.*

We show that the circular law holds for the asymptotic bulk distribution of eigenvalues for the adjacency matrices of two models of large random regular directed graphs: the uniform model and the permutation model. While the result is the same for the two models, the proofs are quite different. For the uniform model we make use of Lindeberg swapping and combinatorial arguments to compare with a Gaussian matrix, while for the permutation model we use the the symmetric group structure to derive and analyze a system of Schwinger-Dyson equations. In both proofs a key technical step is to obtain quantitative control on the pseudospectrum. Based on joint work with Anirban Basak and Ofer Zeitouni. (Received September 08, 2017)

1134-60-292 **Indrajit Jana** and **Alexander Soshnikov*** (soshniko@math.ucdavis.edu), UC Davis, One Shields Avenue, Department of M, Davis, CA 95616. *Distribution of singular values of random band matrices. Marchenko-Pastur law and more.*

We consider the limiting spectral distribution of matrices of the form $\frac{1}{2b_n+1}(R+X)(R+X)^*$, where X is an $n \times n$ band matrix of bandwidth b_n and R is a non random band matrix of bandwidth b_n.

We show that the Stieltjes transform of ESD of such matrices converges to the Stieltjes transform of a non-random measure. And the limiting Stieltjes transform satisfies an integral equation. For $R = 0$, the integral equation yields the Stieltjes transform of the Marchenko-Pastur law. (Received September 10, 2017)

1134-60-304 **Raj Rao Nadakuditi*** (rajnrao@umich.edu), Ann Arbor, MI 48103. *Random Matrix Theory enabled Applications in Machine Learning and Optics.*

Random matrix theory (RMT) continues to enable new applications and new ways of looking at old applications. We describe some of the most exciting new advances enabled by random matrix theory in machine learning where RMT has enabled the development of new algorithms for 'unmixing' mixed matrices and in optics where RMT has been used to justify the existence of, and the study of, algorithms for 'sculpting' light to see through materials that were previously considered 'opaque', such as egg shells, milk and fog. We bring into sharper focus the role of 'incoherent' matrices in both of these advances. (Received September 10, 2017)

1134-60-308 **Rose Elliott Smith**, **Haiyu Huang**, **Yinan Ling**, **Xiaohe Luo**, **Eric Lybrand**, **Jue Wang** and **Todd Kemp*** (tkemp@math.ucsd.edu). *Random Matrices with Structured Correlations.*

I will discuss very recent work with CURE (Collaborative Undergraduate Research Experience) students, studying random matrices with structured correlations: namely, where diagonals (or constant width "bands") have prescribed correlations. These generalize Toeplitz, Hankel, and Circulant matrices studied over the last decade.

We show that all such random matrix ensembles exhibit universality and concentration similar to Wigner ensembles. We also study several specific new models generalizing random Toeplitz matrices, and prove that their limit empirical spectral distributions all have unbounded support. (Received September 10, 2017)

1134-60-337 **Anirban Basak** (anirbanb.math@gmail.com), **Elliot Paquette*** (paquette.30@osu.edu) and **Ofer Zeitouni** (ofer.zeitouni@weizmann.ac.il). *Random perturbations of non-normal matrices.*

Suppose one wants to calculate the eigenvalues of a large, non-normal matrix. For example, consider the matrix which is 0 in most places except above the diagonal, where it is 1. The eigenvalues of this matrix are all 0. Similarly, if one conjugates this matrix, in exact arithmetic one would get all eigenvalues equal to 0. However, when one makes floating point errors, the eigenvalues of this matrix are dramatically different. One can model these errors as performing a small, random perturbation to the matrix. And, far from being random, the eigenvalues of this perturbed matrix nearly exactly equidistributed on the unit circle. This talk will give a probabilistic explanation of why this happens and discuss the general question: how does one predict the eigenvalues of a large, non-normal, randomly perturbed matrix? (Received September 11, 2017)

1134-60-349 **R. Basu** and **S. Ganguly*** (sganguly@berkeley.edu). *Lattice Gauge Theory and String Duality.*

Matrix integrals provide models for many physical systems. The Gaussian models are the most well studied. However certain unitarily invariant matrix ensembles such as Lattice Gauge theories have been studied in the physics literature as discrete approximations to quantum Yang-Mills theory for a long time. Primary statistics of interest in these models are expectations of the so called "Wilson loop variables". In his recent seminal work Chatterjee (2015) rigorously established a gauge-string duality for the $SO(N)$ group, by solving, what is known as the "Makeenko-Migdal" equation in the physics literature. This allows one to write the Wilson loop expectations in Lattice Gauge theories in a certain limit, in any dimension, as a sum of certain weights over string trajectories. A study of the string theory seems crucial to further our understanding of the model. I will discuss a first step towards that, by describing geometrically the string theory in the planar case using correspondence to combinatorial objects such as decorated trees and non-crossing partitions. Some applications in high dimensions and several open questions will also be discussed.

Based on joint work with Riddhipratim Basu. (Received September 11, 2017)

1134-60-410 **Ryan D. Coatney*** (rcoatney@math.arizona.edu) and **Marek Rychlik** (rychlik@email.arizona.edu). *On the Convergence of Various Clustering Algorithms.*

Clustering algorithms are an important part of modern data analysis. The K-means and EM clustering algorithm both use an iterative process to find hidden variables in a mixture distribution. In connection with these algorithms, we look at a random family of nonlinear mappings obtained via the joint distribution of a sample of size N from a mixture of K distributions. We look at the dynamics of this family and give a proof of convergence. We also use Birkhoff's method of applying the Hilbert metric to get bounds on convergence. We compare the answers obtained to those found by maximizing using Lagrange multipliers. (Received September 12, 2017)

1134-60-446 **Nikhil Srivastava*** (nikhil@math.berkeley.edu), 970 Evans Hall, Berkeley, CA 94609, and **Ankit Garg**. *Matrix Concentration for Expander Walks.* Preliminary report.

We prove a Chernoff-type for sums of matrix-valued random variables with Markov dependence, showing that one obtains concentration almost as good as in the independent case when the chain has a spectral gap. Our proof

is based on a recent multi-matrix extension of the Golden-Thompson inequality due to Sutter et al. discovered in the context of quantum information theory. (Received September 12, 2017)

1134-60-459 **Ted Theodosopoulos*** (ttheodosopoulos@nuevaschool.org), 131 E 28th Ave., San Mateo, CA 94403. *From econophysics to econobiology: a categorical approach to stochastic network models.* Preliminary report.

The past fifteen years have witnessed a proliferation of stochastic interaction models played on networks. These 'network games' have formed the basis of the burgeoning field of agent-based economics. They began as simple Interacting Particle Systems played on fixed, regular lattices, and progressively they evolved into Markov processes driven by frustrated interaction Hamiltonians (e.g. the Ising model and the Minority Game). The current proposal seeks to contribute to the overlap of these two research directions, by investigating agent-based dynamics on evolving graphs, driven by interaction Hamiltonians that couple with the network formation process. We present an abstract algebraic framework that represents such dynamics as path measures on colorings of a simplicial complex. The resulting unified scheme allows us to construct appropriate thermodynamic limits and explore the onset of non-ergodicity. We apply this abstract framework to market microstructure and neuronal architecture models. This illustrates the gradual transition from physics-motivated universality patterns in economics as perturbation around an equilibrium, to fully fledged market disequilibrium effects, inspired by persistent and robust biological state transitions. (Received September 13, 2017)

65 ► Numerical analysis

1134-65-71 **Abram Kay Rodgers*** (aks.rodgers@gmail.com), 335 Walk Circle, Santa Cruz, CA 95060. *High Speed Numerical Analysis of Experimentally Obtained Data via Low Power Computing Devices.* Preliminary report.

Today in Numerical Analysis, it is extremely common to rely on high-level programming environments (such as Octave, MATLAB, and R) in order to make the process of analyzing large data sets easier. However, this introduces a bottlenecking effect which raises the time required to compute. In exchange, we allow ourselves to have easier to read and use code. In this presentation, we challenge the norm of "easy coding needs to be slow computing." We present a derivation of a commonly used curve fitting method known as "Linear Least Square Regression." We then provide an implementation of this regression algorithm in the C programming language. As proof of concept, we provide a visual of this algorithm using an old low power micro-controller called the "Nintendo GameBoy Advance," (a.k.a. "GBA," a computer over 50 times slower (in clock speed) than a Raspberry Pi 2, which in turn is much slower than a common laptop). All code is open source and hosted with video examples at: https://github.com/akrodger/brams-math-methods/tree/regression-gba-demo (Received August 16, 2017)

1134-65-167 **Jian-guo Liu**, **Min Tang** and **Li Wang*** (lwang46@buffalo.edu), 244 Mathematics Building, Buffalo, NY 14260, and **Zhennan Zhou**. *An accurate front capturing scheme for tumor growth models with a free boundary limit.*

We consider a class of tumor growth models under the combined effects of density-dependent pressure and cell multiplication. When the cell population is congested and expanding, and the free boundary model can be derived as an asymptotic limit. In this talk, I will introduce a numerical scheme based on a novel prediction-correction reformulation that can accurately approximate the front propagation when the nonlinearity is extremely strong. We show the connection of our scheme with the free boundary limit via a relaxation framework, which manifests the efficiency of our scheme in capturing the correct front speed. Though proper spacial discretization, our scheme enjoys an improves stability, preserves positivity, and is easy to implement. Plenty of examples in both one and two dimensions will be provided in the end. (Received September 02, 2017)

1134-65-188 **José Antonio Carrillo**, **Katy Craig*** (kcraig@math.ucsb.edu) and **Francesco Patacchini**. *A Blob Method for Diffusion.*

For a range of physical and biological processes, from biological swarming to dynamics of granular media, the evolution of a large number of interacting agents can be described in terms of the competing effects of drift, diffusion, and nonlocal interaction. The resulting partial differential equations are gradient flows with respect to the Wasserstein metric. This gradient flow structure provides a natural framework for numerical particle methods. However, developing deterministic particle methods for problems involving diffusion poses unique challenges, particularly when nonlocal interaction terms are also present. In this talk, I will present new work on

a blob method for diffusion and degenerate diffusion, inspired by blob methods from classical fluid mechanics. This is joint work with Francesco Patacchini and José Antonio Carrillo. (Received September 04, 2017)

1134-65-335 **Thomas Trogdon***, University of California, Irvine, Irvine, CA , and **Percy Deift**, Courant Institute, New York University, New York, NY. *Universality in numerical computations.*

This talk will concern recent progress on the statistical analysis of numerical algorithms with random initial data. In particular, with appropriate randomness, the fluctuations of the iteration count (halting time) of numerous numerical algorithms have been demonstrated to be universal, i.e., independent of the distribution on the initial data. This phenomenon has given new insights into random matrix theory. Furthermore, recent estimates from random matrix theory allow for fluctuation limit theorems for simple algorithms and halting time estimates for others. (Received September 11, 2017)

1134-65-375 **David R Mahakian*** (david.mahakian@student.csulb.edu), **Chung-min Lee** and **Alessandro Corbetta**. *Application of Kalman Filter to Pedestrian Dynamics.* Preliminary report.

We study pedestrian dynamics using Kalman filtering methods. Kalman filters apply the Bayesian approach to a time series and incorporate the uncertainty in both the measurement and the mathematical model to create a better state estimate of a system, and are commonly used to reduce error in state estimates for applications ranging from radar systems to GPS.

We first worked on the linear system of stochastic differential equations to model undisturbed pedestrian dynamics, which is motivated by the work from Corbetta et al. The model uses Langevin equations to describe the Brownian motion-like perturbations in pedestrian trajectories. We utilize the data collected over one year from the Eindhoven University of Technology MetaForum building. Our goal is to combine a Kalman filter and the Kuhn-Munkres algorithm to not only predict the locations of the pedestrians but also reconstruct their walking path trajectories. While our measurement data are recorded with relatively high frequency and low noise, we will also investigate the effect of reduced data quality by adding more noise to and downsampling our data set. Finally, we will extend our study to a pedestrian model similar to the social force model described by Helbing et al. that includes pedestrian avoidance behavior. (Received September 11, 2017)

68 ► Computer science

1134-68-336 **Peter Y. Gates*** (peter@catinf.com), Categorical Informatics, 250 Main St #426035, Cambridge, PA 02142, and **Ryan Wisnesky**. *Data modeling and integration using the open source tool Algebraic Query Language (AQL).*

In this talk we present a new approach to databases based on category theory. A database schema is represented as a category C, and a database instance on C is represented as a functor C -¿ Set. Mappings between schemas correspond to functors F : C -¿ D, and each mapping induces three data migration functors: Delta_F : D-¿Set -¿ C-¿Set and its two adjoints Pi_F, Sigma_F : C-¿Set -¿ D-¿Set. In this way we obtain a basis of data manipulation operations suitable for querying data (providing an alternative to relational algebra), and for migrating/integrating data (providing an alternative to an algorithm from database theory known as "the chase"). This project originated at MIT in 2010, and has culminated in an open-source data integration tool called AQL, available at categoricaldata.net/aql.html, as well as a start-up company, Categorical Informatics, which is building out the tool with the support of the National Institute of Standards and Technology (NIST). In this talk we sketch the broad outlines of this research program, as well as demonstrate the AQL tool. (Received September 11, 2017)

1134-68-406 **Mutlu Akar*** (makar@yildiz.edu.tr), Yildiz Technical University, College of Arts, and Sciences, Department of Mathematics, Davutpasa Campus, Esenler, 34210 Istanbul, Turkey, and **Nikolay Metodiev Sirakov** (nikolay.sirakov@tamuc.edu), Texas A&M University-Commerce, Dept. of Mathematics, Dept. of Computer Science, P.O. Box 3011, Commerce, TX 75429. *Basics of Skin Lesion Classification in Clifford Algebra.*

Bayre-Corrochano, et al (2010) introduced the Clifford Support Vector Machines (CSVM) as a generalization of the real- and complex-valued Support Vector Machines (SVM) using the Clifford geometric algebra. We will use skin lesion data, where every skin lesion image is presented as a 11D vector. Out of the 11 features 5 have been determined as significant by Sirakov, et al (2015). In this study we represent the 5D (11D) vectors in a Clifford

Algebra basis, which is orthonormal. Our goal is to apply on the such presented vectors a SVM to classify skin lesion images to benign and malignant. (Received September 12, 2017)

70 ► Mechanics of particles and systems

1134-70-452 **JEE WON ANDREA CHONG*** (info@choicerg.com), Choice Research Group, Cresskill, NJ 07626, and **RICHARD KYUNG** (nycrick@gmail.com), Choice Research Group, Cresskill, NJ 07626. *Mechanical and Computational Analysis of Engine Torque and Dynamic Properties.*

Recently, the demand for the development of dynamic properties of internal combustion engine is continuously rising in order to find a new and efficient engine model. This research presents mathematical and computational analysis for a motion of a non-offset piston connected to a crank through a connecting rod in internal combustion engine. This paper shows how the engine torque and other dynamic properties are found, and also shows the outcomes as different graphs. The force resulting from the pressure in the cylinder was calculated using factors such as the area of the piston, the indicated cylinder pressure, and the atmospheric pressure. Also the inertial forces of moving parts are considered in the calculation the total force, because it was necessary to know the effect of moving mass as well. Torque was found after checking the force acting in the axial direction of the cylinder, and the force acting on the connecting rod axis was found in terms of connecting the rod angle. To obtain the torque of an engine, a coding was written using the Matlab software. (Received September 12, 2017)

74 ► Mechanics of deformable solids

1134-74-286 **Eleni Panagiotou*** (panagiotou@math.ucsb.edu), South Hall, UCSB, Santa Barbara, CA 93106, and **Kenneth C. Millett** and **Paul J. Atzberger**. *Topological analysis and simulation of the roles of polymer entanglements in the viscoelastic responses of complex fluids.*

We investigate how the entanglement of polymeric chains relates to bulk viscoelastic responses in polymeric materials. We show how the structure of the material can be analyzed using results from topology to develop new tools for entanglements. We develop three dimensional computational models to relate entanglement topology, polymer fiber mechanics, to bulk viscoelastic responses of the material. We study in particular woven polymer configurations of very different topologies varying from untangled to strongly entangled conformations. We also investigate the role of polymer density. Our approaches provide new mathematical tools for characterizing the origins of the rheological responses of polymeric materials. (Received September 10, 2017)

76 ► Fluid mechanics

1134-76-237 **Adam Larios*** (alarios@unl.edu), 203 Avery Hall/PO BOX 880130, University of Nebraska, Lincoln, NE 68588, and **Mark Petersen**, **Edriss S Titi** and **Beth Wingate**. *A new approach to the computational study of the blow-up of the 3D Euler equations.*

We report the results of a computational investigation of two recently proved blow-up criteria for the 3D incompressible Euler equations. These criteria are based on an inviscid regularization of the Euler equations known as the 3D EulerVoigt equations. The latter are known to be globally well-posed. Moreover, simulations of the 3D Euler-Voigt equations also require less resolution than simulations of the 3D Euler equations for fixed values of the regularization parameter. Therefore, the new blow-up criteria allow one to gain information about possible singularity formation in the 3D Euler equations indirectly; namely, by simulating the better-behaved 3D Euler-Voigt equations. To test the robustness of the inviscid-regularization approach, we also investigate analogous criteria for blow-up of the 1D Burgers equation, where blow-up is well-known to occur. (Received September 07, 2017)

1134-76-436 **Elaine Cozzi*** (cozzie@math.oregonstate.edu), Oregon State University, Department of Mathematics, Corvallis, OR 97331. *The aggregation equation with Newtonian potential.*

The aggregation equation with Newtonian potential models several different physical problems, including chemotaxis (when diffusion is present) and type-II superconductivity (without diffusion). In this talk, we apply techniques from two-dimensional fluid mechanics to investigate well-posedness theory and the inviscid limit for a

generalization of this equation. This is joint work with Gung-Min Gie and James P. Kelliher. (Received September 12, 2017)

78 ► Optics, electromagnetic theory

1134-78-450 **Yannan Shen*** (yannan.shen@csun.edu). *Nonlinear wave in electrical lattice.*
We consider the model of nonlinear left-handed electrical lattice that mimic left-handed materials. Utilizing a multiple scales expansion, we transforms the model into a nonlinear Schrodinger equation. We exam possible nonlinear waves that can be supported by the lattice and hence in a left-handed material. (Received September 12, 2017)

81 ► Quantum theory

1134-81-48 **Michael G Dombroski*** (dombroskistm11@verizon.net). *From Harari, Shupe, and Seiberg; to Kalusa & Einstein, using Transpose(\) with Cispose(/) to obtain Fermion and Boson matrices.* Preliminary report.
Dr. Don Lincoln wrote an article in SA Nov12. In it he referred to "a theory of sublime simplicity". He was talking about a straight-forward model of "preons" proposed independently in 1979 by Haim Harari Michael A. Shupe, and Nathan Seiberg. In this paper we extend the work of HSS by using two sets of nine real 3x3 Universal Base Matrices (UBS and ubs). The "average" of the elements of one set is (0), the other (+1/3). This is analogous to the electric charges of HSS. The Transpose(\) with the new Cispose(/), generate real, Fermion and Boson Matrices. This gives a new, complete, and extremely high degree of symmetry, to physics. A 9x9 matrix is generated, whose 81 elements are themselves 3x3 matrices. They are exclusively one of 4 types. These "types" of 3x3 integer matrices are called "shapes", depending on the location of the zero elements. They are tentatively named: E, S, W, G, analogous to 4 forces. One result is an unexpected symmetry of disorder/order. For successive powers, the disorder numbers change, but order numbers are constant. We hypothesize a classical, non-statistical, observable, analog of the Big Bang initial conditions. This lets us "see" to the origin of the universe through the fog of seeming "disorder". (Received August 01, 2017)

1134-81-137 **V. S. Varadarajan*** (vsv@math.ucla.edu). *Quantum Foundations: an evolutionary view.*
In any active area of science, the structure of its foundations is not static but evolves with new discoveries and new techniques. For instance, the views of a contemporary mathematician on the foundations of analysis or algebraic geometry would be markedly different from the views of mathematicians a century earlier. The same is true for the foundations of quantum theory. In this talk I intend to sketch the evolution of the foundations of quantum theory from its early days at the beginning of the twentieth century to the present, touching on some of the following themes:

- The Bohr-Einstein dialogues
- Quantum mechanics = deformation of classical mechanics
- The von Neumann formalism/theory of measurement
- (Pauli) Symmetric and Grassmann algebras
- (Weyl-Wigner) Covariance = projective representations
- Feynman path-integrals
- The Aharanov-Bohm discovery and gauge theories
- Micro-structure of spacetime

(Received August 30, 2017)

1134-81-225 **Michel L. Lapidus*** (lapidus@math.ucr.edu), University of California, Department of Mathematics, Riverside, CA 92521-0135. *The Feynman Integral and Feynman's Operational Calculus, Revisited: Open Problems and a Short Overview (in Memory of Gerald W. Johnson).*
Our goal in this talk is to present and discuss aspects of two closely related but different subjects; namely, the Feynman path integral and Feynman's operational calculus for noncommuting operators. Emphasis will be placed on a few operator-theoretic and probabilistic approaches as well as on several (often very difficult) open problems.

The main references for this presentation, from the perspective chosen in this talk, are the following two books:

Gerald W. Johnson and Michel L. Lapidus, The Feynman Integral and Feynman's Operational Calculus, Oxford Mathematical Monographs, Oxford University Press, Oxford and New York, 2000 (paperback edition, 2002); approx. 800 pages.

Gerald W. Johnson, Michel L. Lapidus and Lance Nielsen, Feynman's Operational Calculus and Beyond: Noncommutativity and Time-Ordering, Oxford Mathematical Monographs, Oxford University Press, 2015 (approx. 400 pages).

This talk is dedicated to the memory of the presenter's long-time friend and collaborator, Gerald (Jerry) W. Johnson. (Received September 06, 2017)

1134-81-277 **James Tener***, UC Santa Barbara, Department of Mathematics, Santa Barbara, CA 93106. *Construction of Segal CFTs.*

The category of representations of a two-dimensional (rational, chiral) conformal field theory is a modular tensor category (MTC). One question motivating ongoing research is that of how much more information such a CFT contains beyond its representation category. In this talk, I will explain Graeme Segal's definition of a conformal field theory, and how this can be regarded as a MTC with extra structure. I will also discuss joint work in progress with André Henriques to construct unitary Segal CFTs from conformal nets. (Received September 09, 2017)

1134-81-372 **Alexander Teplyaev*** (teplyaev@member.ams.org), Department of Mathematics, University of Connecticut, Storrs, CT 06269-1009. *Spectral analysis on non-smooth spaces.* Preliminary report.

The talk will outline recent achievements and challenges in spectral and stochastic analysis on non-smooth spaces that are very singular, but can be approximated by graphs or manifolds. In particular, the talk will present two of most interesting examples that are currently under investigation. One example deals with the spectral analysis of the Laplacian on the famous basilica Julia set, the Julia set of the polynomial $z^2 - 1$. This is a joint work with Luke Rogers and several students at UConn. The other example deals with spectral analysis for the canonical diffusion on the pattern spaces of an aperiodic Delone set. This is a joint work with Patricia Alonso-Ruiz, Michael Hinz and Rodrigo Trevino. (Received September 11, 2017)

1134-81-373 **N Reshetikhin***, 917 Evans Hall. UC Berkeley, Berkeley, CA 94720. *Invariants of knots with flat connections in the complement.*

Using representation theory of quantum groups with large center one can construct invariants of pairs (a link, a flat connection in the complement). After a short overview of the construction factorization formulae for corresponding R-matrices will be given and some conjectures about the semiclassical behaviour of the invariants. The presentation is partially based on joint work with C. Blanchet, N. Geers and B. Patureau-Mirand. (Received September 11, 2017)

1134-81-427 **Robert Clare*** (robert.clare@ucr.edu), Dept of Physics & Astronomy, UC Riverside, Riversdie, CA 92521. *Experiment Confronts Theory.* Preliminary report.

I will discuss how high energy experiments make their measurements and how these measurements are then compared to theoretical calculations, which are typically based on the standard model (SM) of particle physics, or extensions to the SM. (Received September 12, 2017)

1134-81-428 **Per J Kraus*** (pkraus@ucla.edu), Department of Physics and Astronomy, UCLA, Los Angeles, CA 90095. *Status of quantum theory in string theory and quantum gravity.*

I will discuss some implications of current thinking about string theory and quantum gravity on the foundations of quantum mechanics. (Received September 12, 2017)

1134-81-460 **Can Ozan Oğuz*** (coguz@usc.edu), University of Southern California, Department of Mathematics, KAP 405, Los Angeles, CA 90089, and **Michael Reeks**. *Twisted Heisenberg Category and W-algebra $W_{1+\infty}$.*

Heisenberg algebra $\mathfrak{h}$ appears in quantum mechanics and also its relations are satisfied by the induction and restriction functors on the representations of the symmetric groups S_n for all n. Using this fact, in 2010, Khovanov described a diagrammatic category $\mathcal{H}$ which is a conjectural categorification of the Heisenberg algebra. In 2015, Cautis-Lauda-Licata-Sussan calculated the trace decategorification of $\mathcal{H}$ and showed that it is isomorphic to a quotient of the W-algebra $W_{1+\infty}$ from Conformal Field Theory.

Again in 2015, Cautis and Sussan gave description of a similar diagrammatic category $\mathcal{H}_{tw}$, this time with a super grading, whose split Grothendieck group is the twisted Heisenberg algebra $\mathfrak{h}_{tw}$. In the twisted case,the role of the symmetric group S_n is played by the Sergeev algebra(a.k.a Hecke-Clifford algebra). We recently computed the trace decategorification of $\mathcal{H}_{tw}$ and showed it is isomorphic to a quotient of a subalgebra of $W_{1+\infty}$, denoted W^- which contains $\mathfrak{h}_{tw}$ in its degree zero part. This process gives a more direct connection between $\mathfrak{h}_{tw}$ and W^-. (Received September 13, 2017)

82 ► Statistical mechanics, structure of matter

1134-82-25 **Davar Khoshnevisan*** (davar@math.utah.edu), Department of Mathematics, The University of Utah, Salt Lake City, UT 84105, and **Kunwoo Kim** and **Carl Mueller**. *A macroscopic multifractal analysis of parabolic stochastic PDEs.*

It is generally argued that the solution to a stochastic PDE with multiplicative noise—such as $\dot{u} = \frac{1}{2}u'' + u\xi$, where ξ denotes space-time white noise—routinely produces exceptionally-large peaks that are "macroscopically multifractal." See, for example, Gibbon and Doering (2005), Gibbon and Titi (2005), and Zimmermann et al (2000). A few years ago, we proved that the spatial peaks of the solution to the mentioned stochastic PDE indeed form a random multifractal in the macroscopic sense of Barlow and Taylor (1989; 1992). The main result of the present paper is a proof of a rigorous formulation of the assertion that the spatio-temporal peaks of the solution form infinitely-many different multifractals on infinitely-many different scales, which we sometimes refer to as "stretch factors." A simpler, though still complex, such structure is shown to also exist for the constant-coefficient version of the said stochastic PDE. (Received June 22, 2017)

83 ► Relativity and gravitational theory

1134-83-197 **Jordan M Keller*** (jordan_keller@fas.harvard.edu). *Linear Stability of Higher Dimensional Schwarzschild Black Holes.*

The Schwarzschild-Tangherlini black holes are higher-dimensional generalizations of the Schwarzschild spacetimes, comprising a static, spherically symmetric family of black hole solutions to higher-dimensional vacuum gravity. The physical relevance of such solutions is intimately related to their stability under gravitational perturbations. This talk will address results on the linear stability of the Schwarzschild-Tangherlini black holes, part of ongoing joint work with Pei-Ken Hung and Mu-Tao Wang. (Received September 04, 2017)

1134-83-350 **Jonathan Luk*** (jluk@stanford.edu) and **Mihalis Dafermos**. *Interior of dynamical vacuum black holes.*

We present results on the C^0 stability of the interior of subextremal, strictly rotating Kerr black holes and discuss what it means in the context of Penrose's celebrated strong cosmic censorship conjecture in general relativity. (Received September 11, 2017)

91 ► Game theory, economics, social and behavioral sciences

1134-91-98 **Wuchen Li***, 520 Portola Plaza Math Sciences Building 6363, CA. *Optimal transport on graphs with applications.*

Optimal transport theory provides powerful tools in both mathematics and applications. In this talk, we consider similar matters on finite graphs. Various recent developments related to Fokker-Planck equations, Shannon-Boltzmann entropy, Fisher information, as well as Wasserstein metric on graphs will be presented. Some applications are presented, including evolutionary games and "geometry" of finite graphs. (Received August 24, 2017)

92 ► Biology and other natural sciences

1134-92-139 **Bo Li*** (bli@math.ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92093. *Multi-Scale Modeling and Simulation of the Growth of Bacterial Colony with Cell-Cell Mechanical Interactions.*

The growth of bacterial colony exhibits striking patterns that are determined by the interactions among individual, growing and dividing bacterial cells, and that between cells and the surrounding nutrient and waste. Understanding the principles that underlie such growth has far-reaching consequences in biological and health sciences. In this work, we construct a multi-scale model of the growth of E. coli cells on agar surface. Our model consists of detailed, microscopic descriptions of the cell growth, cell division with fluctuations, and cell movement due to the cell-cell and cell-environment mechanical interactions, and macroscopic diffusion equations for the nutrient and waste. We use the velocity Verlet algorithm to simulate the motion of individual cells and iterative algorithm to update the nutrient. Our large-scale simulations reproduce experimentally observed growth scaling laws, strip patterns, and many other features of an E. coli colony. This work is the first step toward detailed multi-scale computational modeling of three-dimensional bacterial growth with mechanical and chemical interactions. This is joint work with Mya Warren, Hui Sun, Yue Yan, and Terry Hwa. (Received August 30, 2017)

1134-92-254 **Weitao Chen*** (weitaoc@ucr.edu), **Qing Nie**, **Arthur Lander** and **Anne Calof**. *Robustness strategies in growth and morphogenesis during tissue development.*

Patterns of tissues are usually specified by the spatial information recognized by cells with a precise control of shapes and sizes. Current studies focus on pattern formation or growth independently, but new experimental data points to the importance of the interplay between patterning and growth. However, the mechanisms underlying the crosstalk between growth and morphogenesis remain unknown. In this talk, I will present our recent works on robustness strategies in growth control and developmental patterning with an emphasis on the role of coordination between growth and patterning in morphogenesis. We used stochastic PDE models consisting of moving boundaries of tissues that contain stem cells and their progenitors. Biological systems we studied include wing imaginal discs of drosophila and taste bud patterning of mouse tongue. (Received September 08, 2017)

1134-92-284 **Melisa Hendrata*** (mhendra@calstatela.edu), Department of Mathematics, California State University, Los Angeles, Los Angeles, CA 90032. *Multiscale Model for Mesenchymal Stem Cell-induced Apoptosis in Cancer Therapy.*

Mesenchymal stem cells (MSCs) are stromal cells that have been extensively used in regenerative medicine. In recent years, the potential of MSC in cancer therapy has started to be explored due to its ability to induce cell death (apoptosis) in tumor cells directly, or by suppressing angiogenesis. This talk will present a hybrid multiscale model for tumor growth that can be used to investigate the efficacy of MSC in suppressing tumor growth during avascular stage. Comparison between simulation and experimental results will also be presented. (Received September 10, 2017)

1134-92-288 **Song Xu**, **Sanggu Kim**, **Irvin S. Y. Chen** and **Tom Chou*** (tomchou@ucla.edu), Dept. of Biomathematics, Life Sciences Bldg 5209, UCLA, Los Angeles, CA 90095-1766. *Lineage tracking in hematopoiesis: the role of self-renewal and generational aging in clonal fluctuations, extinction, and resurrection.*

In recent experiments, individually tagged hematopoietic stem cells (HSCs) were autologously transplanted into rhesus macaques and peripheral blood cells sampled over fourteen years. Peripheral blood samples were sequenced quantified. Analysis of clone sizes using a rescaled neutral growth model indicated rapid equilibration of clone size distributions after transplantation. Besides a heterogeneous clone size distribution, the data revealed large temporal variations of individual clone populations that included occasional extinctions and resurrections. Through mathematical modeling and statistical analysis using of the number of extinctions, we find that clonal size heterogeneity and temporal fluctuations can be explained by random HSC self-renewal events coupled with generation-limited progenitor cell expansion. Within this mechanistic picture, we use the data to infer estimates for the total HSC differentiation rate and a consistent maximum number of progenitor cell divisions. (Received September 10, 2017)

1134-92-318 **Paul K Newton*** (newton@usc.edu), Department of Aerospace & Mechanical Eng., University of Southern California, Los Angeles, CA 90089-1191. *Chemotherapeutic scheduling based on tumor growth rates: The case for low dose metronomic high entropy therapies.*

Classic tumor regression models (Skipper's and Norton-Simon laws) are based on instantaneous regression rates of the unperturbed tumor. We introduce a stochastic Moran process model of tumor cell kinetics, coupled with a prisoner's dilemma evolutionary game-theoretic cell-cell interaction model to design chemotherapeutic strategies tailored to different tumor growth characteristics. With this model, we contrast the regression results from metronomic (low-dose) schedules to more standard maximum tolerated dose schedules and make the case for the former in certain situations we can identify. The model supports the concept of designing different chemotherapeutic schedules for tumors with different growth rates and develops quantitative tools to optimize these schedules for maintaining low volume tumors. (Received September 11, 2017)

1134-92-444 **Alethea Barbaro*** (abb71@case.edu), CWRU Dept. of Math, Applied Math & Statistics, 10900 Euclid Ave, Cleveland, OH 44106, and **Abdulaziz Alsenafi**. *A Segregation Model Motivated by Graffiti Markings.*

We propose a two-gang lattice model for gang territorial dynamics. Each gang member puts down graffiti markings as it moves on the lattice, and the gang members preferentially avoid areas marked by the other gang. From numerical simulations, we observe a phase transition as the parameters vary. We then take a formal limit to derive a coupled system of four continuum equations; we find that we can use the system to pinpoint where the phase transition occurs. (Received September 12, 2017)

93 ► Systems theory; control

1134-93-103 **Jason Erbele*** (erbele@math.ucr.edu). *Controllability and observability: diagrams and duality.*

Diagrams of systems appear in many different fields of study, and for good reason: they can dramatically simplify communication of and calculations with those systems. In many cases, large diagrams can be viewed as coming from piecing together smaller diagrams in ways that preserve important data, and complicated diagrams can be rewritten to produce simpler diagrams that represent the same behavior. Category theory provides a framework to reason with diagrams as mathematical objects that can be composed and transformed by rewrite rules. In particular, for linear, time independent control systems, the dual notions of controllability and observability can be expressed in terms of a the dual notions of epimorphism and monomorphism, as applied to certain composite diagrams. (Received August 25, 2017)

94 ► Information and communication, circuits

1134-94-36 **Joseph Moeller*** (moeller@math.ucr.edu), **John Baez**, **Blake Pollard** and **John Foley**. *Operads for modeling networks.*

A network is a complex of interacting systems which can often be represented as a graph equipped with extra structure. Networks can be combined in many ways, including by overlaying one on top of the other or sitting one next to another. We introduce network models - which are formally a simple kind of lax symmetric monoidal functor - to encode these ways of combining networks. By applying a general construction to network models, we obtain operads for the design of complex networked systems. (Received July 01, 2017)

97 ► Mathematics education

1134-97-75 **Cezar Lupu*** (cel47@pitt.edu), 2330 Eldridge Street, Pittsburgh, PA 15213. *How to discover and train talented undergraduate students for the Putnam competition.* Preliminary report.

In this talk, I shall discuss my experience as a coach for the Putnam competition at the University of Pittsburgh over the past 4 years. The Putnam competition is the premier competition North America which takes place in the first Saturday of December and reunites the best undergraduate students from top universities. I shall describe my interaction with the very talented students at the University of Pittsburgh through the Putnam seminar. The seminar was organized and maintained together with George Sparling and with the help of some

other faculty and graduate students. Last but not least, I shall talk about Pitt's best performance in recent years. (Received August 18, 2017)

1134-97-175 **Edward W. Zeng*** (weichengzeng@gmail.com). *Interesting Problems for AMC Preparation.* Preliminary report.

This presentation will include a discussion of selected problems from previous AMC contests as well as from Problem-Solving Strategies by Arthur Engel. These problems helped me personally prepare for the AMC. (Received September 03, 2017)

1134-97-193 **Guadalupe Lozano*** (guada@math.arizona.edu), 617 N. Santa Rita Ave., Department of Mathematics, The University of Arizona, Tucson, AZ 85719, and **Jose Maria Menendez**. *Supporting pre-calculus teaching and learning through mentorship and problem-solving: a collaboration focused on better outcomes for 2-year HSI students and 4-year transfers.* Preliminary report.

Evidence Based Pedagogies (EBPs), specifically peer-collaborative problem-solving courses, have been particularly successful in improving performance of engineering STEM majors at our university. Spurred by this success, we explore the impact of such pedagogies in supporting the mathematics performance and persistence of the growing population of transfer students from 2-year Hispanic Serving Institutions (HSIs). Working in collaboration with community college faculty, we focus mostly on pre-calculus level students before and after transfer. In this talk I will describe successful elements of this project from various perspectives, including addressing the transition from 2-year to 4-year colleges, supporting undergraduates' success in pre-calculus/calculus, and growing internal capacity to teach mathematics using EBPs, at various levels. (Received September 04, 2017)

1134-97-207 **Scott Annin*** (sannin@fullerton.edu), 800 N. State College Blvd, Department of Mathematics, California State University, Fullerton, Fullerton, CA 92831. *Teaching Our Students to be Better Problem Solvers: A Challenge and Charge to Mathematics Educators.*

Many mathematics subjects enjoy a foundation grounded in formulas and procedures that are familiar and routine. In such cases, natural pathways into the content are present. Calculus, Linear Algebra and many other subjects fall into this camp. Problem solving, however, is a different animal. Problem solving is a mathematical skill that pervades the aforementioned subjects and more, and yet, it can be a slippery enterprise. How do we teach it? In the 1940s, George Polya proposed a 4-step process in his timeless classic "How To Solve It". Many other manuscripts on the subject have followed. Still, teaching problem solving has remained one of my greatest challenges as a mathematics educator. And yet, teaching students to be capable problem solvers should be one of our greatest aspirations as educators. I have spent much time thinking about this as an author of a book to prepare high school students for the American Invitational Math Exam, and as director of a program preparing undergraduates for graduate school through a direct emphasis on problem solving, paired with more traditional research experiences. I will discuss my challenges, triumphs, and lessons from trying to teach problem solving to students, and in doing so, we will try to solve many problems along the way! (Received September 05, 2017)

1134-97-220 **Matt Rathbun*** (mrathbun@fullerton.edu). *Affine line between genius and madness.*

We demonstrate how affine transformations can be employed to simplify many geometry problems from mathematical competitions, including the Putnam Exam. Further, understanding how and when such an approach may be helpful provides insights for students into the nature of geometric relationships, and generic arrangements. (Received September 05, 2017)

1134-97-243 **Evelyn Rose Easdale*** (eeasdale@uci.edu). *Preparing for the AMC 8 at the Fullerton Math Circle.*

The Fullerton Math Circle dedicates many sessions every fall semester to preparation for the American Mathematics Competition and American Invitational Mathematics Examination. In this talk, I will discuss the strategy we used to prepare our advanced elementary and junior high students for the competitive AMC 8 exam. We will highlight a variety of teaching techniques used in our weekly sessions, student reactions, and the results achieved by our students. (Received September 07, 2017)

1134-97-255 **Eric Hsu*** (erichsu@sfsu.edu), 1600 Holloway Ave, SCI 211, San Francisco, CA 94132. *Equity, Placement and Practice: Student Success in California State College Gateway Courses.*

We examine research literature on the (in)effectiveness of placement strategies and curriculum for algebra and precalculus college courses. We also share the promising results from an NSF-supported approach to developmental algebra in the context of the California State University system, combining conceptual learning, team problem-solving, and an unusual online homework system. (Received September 08, 2017)

1134-97-259 **Tatiana Shubin*** (tatiana.shubin@sjsu.edu). *Competitions: are they good, bad, or ugly?*

Why support competitions in the era of cooperation? One of the possible answers is that many mathematical competitions promote right things such as deep thinking, creativeness, and yes, cooperation. We will discuss several competition types with the emphasis on the math wrangle and its positive influence on budding mathematicians in different settings from specialized prep schools to rural communities. (Received September 08, 2017)

1134-97-278 **Stacy M. Musgrave*** (smmusgrave@cpp.edu). *Understanding and Improving Instructors' Mathematical Meanings for Teaching.*

At many universities, courses leading up to and including calculus are taught by graduate teaching assistants (GTAs). These typically novice instructors face the challenge of teaching ideas foundational to calculus, yet data suggests GTAs often hold impoverished meanings for those ideas themselves. In this presentation, I share data revealing the varied meanings held by GTAs regarding average rate of change, angle measure and the sine function, before and after being involved in an intervention designed to support them in developing richer meanings for these and other ideas found in algebra and pre-calculus courses. I then describe how a targeted intervention supported these instructors in developing richer and more connected meanings for the content, as well as increased their fluency in discussing foundational ideas for precalculus and calculus. (Received September 09, 2017)

1134-97-300 **Claudia F. Gutierrez*** (cgutierrez@vcccd.edu). *Enriching Primary Students into Gifted Mathematicians.*

In this talk we will be sharing information on the 7/8 grade Fullerton Math Circle workshop along with the history and achievements of the program at CSU Fullerton. We include a conversation on training students in logical discipline. We will also engage in a dialog on opportunities and ideas on how we can support gifted students in pre-service courses. (Received September 10, 2017)

1134-97-312 **Marilyn P. Carlson*** (marilyn.carlson@asu.edu). *Improving Student Success and Student Learning in Precalculus Level Courses: One Promising Approach.*

The Pathways Project resulted from ongoing research into the mathematical meanings and instructional supports that result in greater student learning and success in precalculus level courses. This foundation knowledge informed the development, alignment, and ongoing refinement of our instructional goals, assessments, curriculum, and faculty professional development. This session will share results of what our project's research has revealed about effective ways to help instructors achieve greater student learning, confidence, retention, and success. I will focus on the content of quantitative reasoning to illustrate our approach, and use data to argue for the benefits of supporting beginning algebra through calculus level students engage in conceptualizing and representing quantitative relationships. I will illustrate how this way of thinking leads to students' developing both basic mathematical literacy, and foundational ways of thinking and understandings needed for continued STEM learning. I'll conclude with a few comments about the complexity of shifting an instructional culture toward conceptually oriented teaching, and the potential role of online curriculum in building students' quantitative reasoning abilities. (Received September 10, 2017)

1134-97-314 **Mihaela B Vajiac*** (mbvajaic@chapman.edu), Von Neumann Hall 102, Chapman University, One University Drive, Orange, CA 92866. *Geometry: Synthesis Tool for Mathematics Contests.*

In my many years of experience and participation in several programs designed for teaching contest problem-solving skills to gifted students, I have come to the conclusion that geometry is acting as a synthetic tool for mathematics contests and olympiads.

Multi-faceted problems, using geometry, algebra, and combinatorics are lynch-pins to a successful completion of such a program. In this talk I will present coherent ways of teaching these types of problems with examples. (Received September 11, 2017)

1134-97-359 **Michael A Tallman*** (michael.tallman@okstate.edu), 3523 Bristol Road Ave, Stillwater, OK 74074. *Strategies for Improving Students' Perseverance in Mathematics Gateway Courses.*

Students' lack of perseverance is a primary factor contributing to low success rates in mathematics gateway courses. Perseverance in mathematics is a multifaceted construct involving students' interests and proclivities, their will and skill. Often perseverance is portrayed as a kind of trait that a student possesses—a kind of generalized intellectual toughness—rather than a behavior that emerges from a variety of subjective constructions and appraisals students make in the context of particular situations. In this presentation, I integrate a number of related lines of inquiry in the field of mathematics motivation to propose a model for the development of perseverance in mathematics. Specifically, I redefine perseverance as a self-regulatory strategy involving a dynamic interplay between mathematical tasks, mathematics as an intellectual pursuit, and the goals, interests, and resources students bring to the learning environment. The model of perseverance I describe includes four central aspects: interests and identity, establishing goals, utilizing resources, and anticipating consequences. For each of these aspects, I offer specific suggestions for how instructors can improve students' perseverance in mathematics gateway courses. (Received September 11, 2017)

1134-97-381 **Sepideh Stewart*** (sepidehstewart@ou.edu). *Moving between three Worlds of Mathematical Thinking in Linear Algebra.*

Linear algebra consists of many languages and representations. Instructors often move between these languages and modes fluently and expect students to follow along. In reality, many students do not have the cognitive framework to perform the move that is available to the experts. In this talk, employing Tall's three-world model, I present a set of linear algebra tasks that are designed to encourage students to move between the embodied, symbolic and formal worlds of mathematical thinking. We anticipate that creating opportunities to move between the worlds, will encourage students to think in multiple modes and to broaden their mathematical knowledge. (Received September 11, 2017)

1134-97-385 **Olga Radko*** (radko@math.ucla.edu), 12016 Rose ave, Los Angeles, CA 90066. *AMC preparation in the framework of a Math Circle.*

I will discuss the benefits of incorporating AMC preparation into Math Circle meetings and consider various approaches to preparing students for AMC competitions in the framework of a Math Circle. From helping each student to set his/her own goals to analyzing the results of a contest, it is a never ending cycle of using AMC to improve your own Math Circle program. (Received September 12, 2017)

1134-97-422 **Charley T. R. Conley*** (cconley@math.ucr.edu). *Crash Coursing Students into Competitors.* Preliminary report.

Very often, even top students in math will not be prepared for the differences between competition math and classroom math. From the perspective of a long time competitor and tutor, a few methods for quickly and actively bridging these gaps will be discussed. Examples will be drawn from geometry, infinite series, and beginning topology. (Received September 12, 2017)

1134-97-435 **Danielle D. Champney*** (dchampne@calpoly.edu), 1 Grand Avenue - Cal Poly, Faculty Offices East - Math Department, Building 25, San Luis Obispo, CA 93407. *Transforming our Classrooms into Calculus Communities, and the Role of Productive Failure.*

Our students come to us from a variety of backgrounds, and go on to a variety of STEM degrees, but are first asked to join together for several quarters to build a diverse community of calculus learners and problem solvers. How do these emergent calculus communities come to support each other in their learning, and how do they use and value their time together in and outside of class? In many cases, students' prior experiences often lead them to prize perfectionism, answer-seeking, and efficiency rather than the winding problem solving journey that we recognize as the authentic calculus learning experience. During this talk, we will discuss how to build student attitudes that frame "failure" productively, how to harness students' struggle with difficult calculus concepts as an avenue along which they grow to help one another, and how to foster classroom communities that value this struggle and failure as critical components of success, and not roadblocks to success. In viewing our job as building a *calculus community* that prioritizes inquiry and struggle, rather than a simple *calculus class*, we can help our students to leverage calculus as a key piece of their lifelong commitment to STEM. (Received September 12, 2017)

1134-97-440 **Shandy Hauk*** (shauk@wested.org). *Supporting Gateway Success with the College Mathematics Instructor Development Source (CoMInDS).*

The purpose of the National Science Foundation-funded College Mathematics Instructors Development Source (CoMInDS) is to provide readily accessible resources for teaching-related professional learning for college mathematics instructors. The project is creating an infrastructure, housed and supported by the Mathematical Association of America (MAA), to enhance the mathematics community's ability to provide high quality supports for improving college teaching, particularly in service and gateway courses commonly taught by novice college mathematics instructors (e.g., Teaching Assistants (TAs), recent doctoral and master's graduates). CoMInDS project components are designed to address the needs of three core groups whose efforts have significant influence on the quality of undergraduate mathematics instruction: *Providers* – faculty who provide seminars or course coordination to TAs and other instructors. *Scholars* – faculty and graduate students whose research or other scholarly activity centers on the teaching of undergraduate mathematics. *TAs* – graduate students whose responsibilities include teaching mathematics courses. The session will include attendee participation in example activities for instructor professional learning. (Received September 12, 2017)

1134-97-449 **Clifford Augustus Heinecke*** (thatonetrainee@yahoo.com), 1744 poli st, Ventura, CA 93001. *Systematic Method for 'FOIL' Reduction By Powers of Ten.*

Systematic Method for 'FOIL' Reduction By Powers of Ten C.A. Heinecke Received date: accepted date:

Abstract. To promote individuals in using mental math, I examined the use of "Foil" method to develop a systematic solution to solve circumstantial arithmetic in an effortless way. In particular, patterns in which the last two digits end in a sum of ten, allowing one to complete the solution by using powers of ten and avoiding the use of tools.

Assume 0 < a, b, c, d < 10 Assume b + d = 10 and a > c and b > d (10a+b) * (10c+d) = 100ac+10[(a-c)d+10c] + bd Proof. (10a + b)(10c+d) = 100ac + (10ad + 10cb) + bd. (10ad + 10cb) = 10(a-c)d + 10cd + 10 cb =10(a-c)d + 10c(b+d) =10(a-c)d + (10c) * 10 =10[(a-c)d + 10c] (Received September 12, 2017)

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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