Abstracts

of Papers Presented to the American Mathematical Society

Volume 35, Number 3, Issue 177 Summer 2014

Abstracts for

ISSN 0192-5857 Pages 787-870

AMS

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Abstracts of Papers Presented to the American Mathematical Society (ISSN 0192-5857) is published four times a year by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294. The subscription price for Volume 35 (2014) is US$167.00 list, US$133.60 institutional member, US$100.20 individual member. Subscription renewals are subject to late fees. See `www.ams.org/customers/macs-faq.html#journal` for more information. Periodicals postage paid at Providence, RI. If ordering the paper version, add US$5 for delivery within the United States; US$11 for delilvery outside the United States. POSTMASTER: Send address change notices to Abstracts of Papers Presented to the American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA.

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PAPERS PRESENTED AT MEETINGS

THIS CALENDAR lists meetings of the Society which have been approved by the Council at which papers may be presented. Programs of Annual Meetings appear in the *Notices* and on the AMS website; programs for sectional meetings appear on the AMS Web pages in the Meetings & Conferences section, and are electronically archived in the *Notices* section on the AMS website.

MEETING #	DATE	PLACE	ABSTRACT DEADLINE	ABSTRACT ISSUE
1104	October 25–26, 2014	San Francisco, CA	EXPIRED	Vol 35, No. 4
1105	November 8–9, 2014	Greensboro, NC	EXPIRED	Vol 35, No. 4
1106	January 10–13, 2015	San Antonio, TX	EXPIRED	Vol 36, No. 1
1107	March 7–8, 2015	Washington, DC	January 20	Vol 36, No. 2
1108	March 14–15, 2015	East Lansing, MI	January 20	Vol 36, No. 2
1109	March 27–29, 2015	Huntsville, AL	February 4	Vol 36, No. 2
1110	April 18–19, 2015	Las Vegas, NV	February 24	Vol 36, No. 2
1111	June 10–13, 2015	Porto, Portugal	TBA	NONE
1112	October 3–4, 2015	Chicago, IL	August 11	Vol 36, No. 4
1113	October 17–18, 2015	Memphis, TN	August 25	Vol 36, No. 3
1114	October 24–25, 2015	Fullerton, CA	September 1	Vol 36, No. 4
1115	November 14–15, 2015	New Brunswick, NJ	September 22	Vol 36, No. 4

EAU CLAIRE, WI, September 20–21, 2014

Abstracts of the 1102nd Meeting.

01 ► History and biography

1102-01-54 **Donald A. Sokol***, 11S047 Palisades Rd., Burr Ridge, IL 60527. *Euclid, Integer Triples and the Babylonian Connection: The triangular number based spreadsheet.*

Analyses and discussion of the Babylonian table entitled Plimpton 322 suggest the Babylonians were acquainted with the algorithm, as stated in Euclid's Elements, that is used to calculate the a, b, and c of the relationship $a^2 + b^2 = c^2$. It is more likely that it was the other way around. Euclid produced the famous a = 2xy, b = x^2 - y^2, and c = $x^2 + y^2$ by attaching "-y" to the "x" in the Babylonian equation for "a". The Babylonians appear to have used this equation to create a triangular number based spreadsheet in positive integers of a, c, and b.

In so doing Euclid rotated the mapping of the Babylonian spreadsheet 45 degrees, a change that enabled him to introduce two caveats: 1) That x be greater than y and both positive, and 2) if x and y are opposite parity and relatively prime, a primitive integer triple is produced.

Driven by the need for simplicity or to avoid confusion or otherwise, this modification allowed Euclid to hide from view for over 2300 years two significant characteristics of what is now called the Pythagorean Theorem: 1) That every integer triple is founded on a triangular number, and 2) that more than one x, y combination can satisfy the same integer triple in a, b, and c and one cannot easily be certain which algorithm was used. (Received July 12, 2014)

03 ► Mathematical logic and foundations

1102-03-87 **Isaac Goldbring*** (isaac@math.uic.edu), Department of Mathematics, Science and Engineering Offices M/C 249, 851 S. Morgan St., Chicago, IL 60622. *Elementary equivalence of II_1 factors.*

II_1 factors M and N are elementarily equivalent if they have the same first-order theory. By the Keisler-Shelah theorem, this can be given a logic-free formulation, namely M and N are elementarily equivalent if and only if they have isomorphic ultrapowers. Since this notion is coarser than isomorphism, it is not surprising that it has

proven difficult to tell when two II_1 factors are elementarily equivalent or not. Currently, only three elementary equivalence classes of II_1 factors are known, although many expect there to be continuum many classes.

In this talk, I will survey what is known about elementary equivalence of II_1 factors. In particular, I will talk about recent work, joint with Thomas Sinclair, where we use Ehrenfeucht-Fraisse games to show that two II_1 factors are elementarily equivalent if and only if their unitary groups are elementarily equivalent as $\mathbb{Z}_4$ metric spaces. If time permits, I will discuss elementary equivalence of subfactors.

No prior knowledge of logic will be assumed. (Received July 22, 2014)

05 ► Combinatorics

1102-05-1 **Matthew Kahle*** (mkahle@math.osu.edu), Dept. of Mathematics, Ohio State University, 231 W. 18th Ave., Columbus, OH 43210. *Recent progress in random topology.*

The study of random topological spaces: manifolds, simplicial complexes, knots, and groups, has received a lot of attention in recent years. This talk will mostly focus on random simplicial complexes, and especially on a certain kind of topological phase transition, where the probability that that a certain homology group is trivial passes from 0 to 1 within a narrow window. The archetypal result in this area is the Erdős–Rényi theorem, which characterizes the threshold edge probability where the random graph becomes connected.

One recent breakthrough has been in the application of Garland's method, which allows one to prove homology-vanishing theorems by showing that certain Laplacians have large spectral gaps. This reduces problems in random topology to understanding eigenvalues of certain random matrices, and the method has been surprisingly successful.

This is joint work with Christopher Hoffman and Elliot Paquette. (Received July 17, 2014)

1102-05-5 **Dara Moazzami*** (dmoazzami@ut.ac.ir), Prof. Mathematics, University of Tehran, College of Engineering, Department of Engineeg Science, Thehran, Iran. *On the Tenacity Parameter and Complexity of Recognizing Tenacious Graphs.*

The tenacity of a graph G, $T(G)$, is defined by $T(G) = min\{\frac{|S|+\tau(G-S)}{\omega(G-S)}\}$, where the minimum is taken over all vertex cutsets S of G. We define $\tau(G-S)$ to be the number of the vertices in the largest component of the graph $G-S$, and $\omega(G-S)$ be the number of components of $G-S$. A connected graph G is called T-tenacious if $\mid S \mid +\tau(G-S) \geq T\omega(G-S)$ holds for any subset S of vertices of G with $\omega(G-S) > 1$. In this paper we consider the relationship between the minimum degree $\delta(G)$ of a graph and the complexity of recognizing if a graph is T-tenacious. Let $T \geq 1$ be a rational number. We first show that if $\delta(G) \geq \frac{Tn}{T+1}$, then G is T-tenacious. On the other hand, for any fixed $\epsilon > 0$, we show that it is NP-hard to determine if G is T-tenacious, even for the class of graphs with $\delta(G) \geq (\frac{T}{T+1} - \epsilon)n$.
(Received November 29, 2013)

1102-05-18 **Patricia Hersh*** (plhersh@ncsu.edu) and **Karola Meszaros**. *SB-labelings and posets with each interval homotopy equivalent to a ball or sphere.*

This talk will introduce a new class of poset edge-labelings called SB-labelings. I will briefly indicate why lattices with SB-labelings have the property that each open interval is homotopy equivalent to a ball or a sphere of some dimension. Then I will describe SB-labelings for several familiar lattices and suggest other examples that could perhaps also admit SB-labelings. This is joint work with Karola Meszaros. (Received June 14, 2014)

1102-05-19 **Jozsef Balogh**, **Hong Liu**, **Maryam Sharifzadeh** and **Andrew Treglown*** (a.c.treglown@bham.ac.uk). *The number of maximal sum-free subsets of integers.*

A set S of integers is sum-free if $x+y \notin S$ for every $x, y \in S$. Green and independently Sapozhenko proved that there are $O(2^{n/2})$ sum-free sets in $\{1, \ldots, n\}$, thereby resolving a conjecture of Cameron and Erdős.

Cameron and Erdős also raised the question of how many *maximal* sum-free sets there are in $\{1, \ldots, n\}$, giving a lower bound of $2^{\lfloor n/4 \rfloor}$. In this talk we show that there are in fact at most $2^{(1/4+o(1))n}$ maximal sum-free sets in $\{1, \ldots, n\}$.

Our proof makes use of 'container' and 'removal' lemmas of Green as well as a result of Deshouillers, Freiman, Sós and Temkin on the structure of sum-free sets. (Received June 15, 2014)

1102-05-42 **Mitch Phillipson*** (phillipson@math.tamu.edu), College Station, TX 77845, and **Catherine H. Yan**. *2-chains in layer polyominoes.*

In a permutation matrix occurrences of northeast (ne) and southeast (se) 2-chains correspond to inversions and co-inversions, respectfully. If permutations are instead represented by fillings of two Ferrers diagrams then the

sum of these chains in each diagram correspond to crossing (*cros*) and nestings (*nest*) in the permutation. In 2005 Sylvie Corteel proved the distribution of the joint statistic $(cros, nest)$ is symmetric and equidistributed with occurrences of $2-31$ and $31-2$ in permutations. In this talk we'll discuss these results and introduce layer polyominoes, which are row convex and intersection–free. Fillings of layer polyominoes generalize inversions/co-inversions and crossings/nestings to chains allowing us to see relations with other patterns and structures. We'll conclude with two simple bijections extending the symmetry of the joint statistic (ne, se). (Received July 07, 2014)

1102-05-45 **Mihai Ciucu** and **Tri Lai*** (tmlai@indiana.edu), 831 East 3rd Street, Bloomington, IN 47405. *Proof of Blum's conjecture on hexagonal dungeons.*

Matt Blum conjectured that the number of tilings of the hexagonal dungeon of sides a, $2a$, b, a, $2a$, b (where $b \geq 2a$) is $13^{2a^2}14^{\lfloor \frac{a^2}{2} \rfloor}$. We present a proof for this conjecture using Kuo's Graphical Condensation Theorem. (Received July 09, 2014)

1102-05-47 **Paul E Becker*** (peb8@psu.edu), School of Science, Penn State Erie, 4701 College Drive, Erie, PA 16563, and **Martin Derka**, **Sheridan Houghten** and **Jennifer Ulrich**. *A natural two-generator presentation of the sporadic Mathieu group M_{24}.*

We will discuss two constructions for the extended binary Golay code. One of these appears to be new to the literature. We will combine the constructions to provide a natural two-generator presentation of the sporadic Mathieu group M_{24}. (Received July 09, 2014)

1102-05-50 **William J Keith*** (wjkeith@mtu.edu). *Colored partitions with restrictions on the colors appearing.*

Overpartitions, which have attracted much study and have many useful features, can be considered 2-colored partitions in which only 1 color may be used per size of part. The natural generalization is to k colors, of which j colors may appear per size of part. We consider such partitions and find many pleasing results, such as congruences, connections to divisor sums, and a relationship with the hooklength formula. A wealth of interesting questions present themselves. (Received July 10, 2014)

1102-05-55 **Jie Han*** (jhan22@gsu.edu). *Near Perfect Matchings in k-uniform Hypergraphs.*

Let H be a k-uniform hypergraph on n vertices where n is a sufficiently large integer not divisible by k. We prove that if the minimum $(k-1)$-degree of H is at least $\lfloor n/k \rfloor$, then H contains a matching with $\lfloor n/k \rfloor$ edges. This confirms a conjecture of Rödl, Ruciński and Szemerédi, who proved that minimum $(k-1)$-degree $n/k + O(\log n)$ suffices. More generally, we show that H contains a matching of size d if its minimum codegree is $d < n/k$, which is also best possible. (Received July 12, 2014)

1102-05-56 **Steven V Sam*** (svs@math.berkeley.edu). *Gröbner bases, formal languages, and applications.*

I'll begin by recalling the combinatorial proof of the Hilbert basis theorem using Dixon's lemma (which says, for fixed r, that the poset of r-tuples of nonnegative integers does not contain any infinite antichains under termwise comparison) and how reinterpreting monomial ideals in terms of regular languages recovers the result on rationality of Hilbert series. Then I'll mention a more general combinatorial setup and some applications in algebra and topology (buzzphrases might include "syzygies of Segre varieties" and "generic representations of finite general linear groups and the Steenrod algebra").

Joint work with Andrew Snowden. (Received July 13, 2014)

1102-05-59 **Bruce E Sagan*** (sagan@math.msu.edu). *Pattern avoidance and quasisymmetric functions.* Preliminary report.

Let S_n denote the nth symmetric group. Given a set Π of permutations we let $S_n(\Pi)$ be all permutations in S_n which avoid all elements of Π. Following a suggestion of Woo, we look at the associated generating function defined by $Q_n(\Pi) = \sum_{\sigma \in S_n(\Pi)} F_{\mathrm{Des}\ \sigma}$ where Des σ is the descent set of σ and F is the associated fundamental quasisymmetric function. In particular, we investigate when it is a symmetric function and, in such cases, try to determine the coefficients of its expansion in the Schur basis. This leads to an interesting problem in the representation theory of S_n. (Received July 13, 2014)

1102-05-60 **Joel H. Spencer*** (spencer@cims.nyu.edu). *Erdos Magic.*

The twentieth century saw the elevation of Discrete Mathematics from "the slums of topology" to its current highly regarded position in the mathematical pantheon. Paul Erdős played a key role in this transformation. We call discuss some key results, possibly including:

i) Ramsey Theory. In 1946 Erdős showed that you could two-color the complete graph on n vertices so as to avoid a monochromatic clique of size k, where n was exponential in k. To do it, he introduced The Probabilistic Method.
ii) Random Graphs. The "phase transition" at $e = v/2$ edges.
iii) Crossing Number. We give a probabilistic argument to bound the crossing number of a graph on v vertices and e edges.
iv) 2-Coloring. Given m sets, each of cardinality n, one wants to two-color the underlying points so that no set is monochromatic. In 1963 Erdős showed that this can be done if $m < 2^{k-1}$ (color randomly!) and it remains an open question what is the largest $m = m(n)$ for which such a coloring can always be found. We give a striking new argument of Kozik and Cherkashin, finding the best (so far!) lower bound on $m(n)$.
Anecdotes and personal recollections of Paul Erdős will be sprinkled liberally throughout the presentation. (Received July 14, 2014)

1102-05-61 **Joel Brewster Lewis*** (jblewis@math.umn.edu) and **Alejandro H. Morales**.
Combinatorics of diagrams of permutations.
The combinatorics of the totally nonnegative part of the Grassmannian involves a variety of objects associated to a Grassmannian permutation. Many of these objects can be defined for permutations that are not necessarily Grassmannian by an appropriate choice of associated diagram. We study several such objects and their q-analogues, including acyclic orientations of inversion graphs, rook placements avoiding a diagram, intervals in the strong Bruhat order, and invertible matrices over a finite field with restricted support. (Received July 14, 2014)

1102-05-65 **H. Kierstead**, **A. Kostochka**, **T. Molla** and **E. Yeager*** (yeager2@illinois.edu).
Disjoint Cycles and Equitable Coloring.
In 1963, Corrádi and Hajnal famously proved the following: If a graph has minimum degree at least $2k$, and at least $3k$ vertices, then it contains a set of k vertex-disjoint cycles. The degree bound is sharp, but has been improved by considering Ore-type conditions. That is, by bounding the minimum degree sum of nonadjacent vertices.

An *equitable coloring* of a graph is a proper vertex coloring where no two color classes differ in size by more than one. The most obvious relation between equitable coloring and the problem of finding disjoint cycles is this: A graph G on $3k$ vertices contains a set of k disjoint cycles if and only if the complement of G is equitably k-colorable. Chen, Lih, and Wu conjectured in 1994 that a connected graph G is $\Delta(G)$-equitably colorable if it is different from K_m, C_{2m+1}, and $K_{2m+1,2m+1}$ for every $m \geq 1$. We discuss an Ore-type analog to this conjecture: that every k-colorable graph G with maximum degree sum of adjacent vertices at most $2k + 1$ is equitably k-colorable unless it contains $K_{1,2k} + K_{k-1}$; $K_{c,2k-c} + K_k$ for odd c; or a third graph in the case $k = 3$. (Received July 15, 2014)

1102-05-66 **Steve Butler*** (butler@iastate.edu), 396 Carver Hall, Ames, IA 50011. *Comments on cospectral graphs.*
Given a graph G we can associate it to a matrix in several different ways, e.g., the adjacency matrix, Laplacian, signless Laplacian, normalized Laplacian, and so on. The eigenvalues of each matrix has the ability to give some information about the graph, and at the same time each matrix has limitations into what it can say about the graph. This is because of the existence of distinct graphs which have the same eigenvalues, also known as cospectral graphs. In this talk we will give a brief introduction to this subject, as well as present some simple and surprising constructions of cospectral graphs for the normalized Laplacian matrix. (Received July 15, 2014)

1102-05-71 **T. Kyle Petersen*** (tpeter21@depaul.edu), DePaul University, Department of Mathematical Sciences, 2320 N. Kenmore, Chicago, IL 60614. *Characterizing depth in a Coxeter group.*
The *depth* of an element in a Coxeter group is the minimal cost of a reflection factorization of the element, where each reflection is assigned a cost in a natural way. Depth of an element w is bounded above by the length of w and below by the average of length and reflection length.

In the case of the symmetric group, the depth of a permutation is a measure of the cost of sorting the permutation with transpositions, and we can characterize depth quite simply. This allows us to characterize, via pattern avoidance, the permutations for which depth equals length and for which depth equals reflection length. This is joint work with Bridget Tenner. More recently, Mathieu Guay-Paquet and I computed the generating function for depth in the symmetric group.

There are many open questions related to depth. Notably we have no combinatorial description of depth for the Coxeter group of type B, i.e., for signed permutations. (Received July 16, 2014)

1102-05-72 **Kirsten Hogenson*** (kahogens@iastate.edu), **Ryan Martin** and **Yi Zhao**. *Tiling tripartite graphs with 3-colorable graphs: The extreme case.*

Let N be sufficiently large and divisible by h. If G is a tripartite graph with N vertices in each vertex class such that every vertex is adjacent to at least 2N/3+2h-1 vertices in each of the other classes, then G can be tiled perfectly by copies of $K_{h,h,h}$. This extends work by two of the authors [Electron. J. Combin, 16(1), 2009] and also gives a sufficient condition for tiling by any fixed 3-colorable graph. Furthermore, the minimum-degree 2N/3+2h-1 in our result for $K_{h,h,h}$ can not be replaced by 2N/3+h-2, and if N is divisible by 6h, then the required minimum degree is 2N/3+h-1 for N large enough and this is tight. (Received July 16, 2014)

1102-05-74 **Andrew Beveridge*** (abeverid@macalester.edu), Macalester College, 1600 Grand Avenue, Saint Paul, MN 55105, and **Andrzej Dudek**, **Alan Frieze**, **Tobias Mueller** and **Miklos Stojakovic**. *Maker-Breaker Games on Random Geometric Graphs.*

In a Maker-Breaker game on a graph G, Breaker and Maker alternately claim edges of G. Maker wins if, after all edges have been claimed, the graph induced by his edges has some desired property. We consider three Maker-Breaker games played on the Random Geometric Graph. For each game, we show that if we add edges between n points chosen uniformly at random in the unit square by order of increasing edge-length then, with probability tending to one as $n \to \infty$, the graph becomes Maker's win at the very moment that it satisfies a simple necessary condition. In particular, with high probability, Maker wins the connectivity game as soon as the minimum degree of is at least 2; Maker wins the Hamilton cycle game as soon as the minimum degree is at least 4; and Maker wins the perfect matching game as soon as the minimum degree is at least 2 and every edge has at least 3 neighboring vertices. (Received July 16, 2014)

1102-05-79 **Maria Axenovich*** (maria.aksenovich@kit.edu) and **Torsten Ueckerdt**. *Density of range capturing hypergraphs.*

For a finite set X of points in the plane, a set S in the plane, and a positive integer k, we say that a k-element subset Y of X is captured by S if there is a homothetic copy S' of S such that $X \cap S' = Y$, i.e., S' contains exactly k elements from X. A k-uniform S-capturing hypergraph $H = H(X, S, k)$ has a vertex set X and a hyperedge set consisting of all k-element subsets of X captured by S. In case when $k = 2$ and S is convex these graphs are planar graphs, known as *convex distance function Delaunay graphs*.

We prove that for any $k \geq 2$, any X, and any convex compact set S, the number of hyperedges in $H(X, S, k)$ is at most $(2k-1)|X| + O(k^2)$. Moreover, this bound is tight up to an additive $O(k^2)$ term. This refines a general result of Buzaglo, Pinchasi and Rote stating that every pseudodisc topological hypergraph with vertex set X has $O(k^2|X|)$ hyperedges of size k or less. (Received July 17, 2014)

1102-05-81 **Lucas Kramer** and **Ryan R. Martin*** (rymartin@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011, and **Michael Young**. *Recent Progress on Diamond-free Families.*

In the Boolean lattice, a diamond is a subposet of four distinct subsets A, B, C, D such that $A \subset B, C$ and $D \supset B, C$. One of the most well-studied problems in extremal poset theory is determining the size of the largest diamond-free family in the n-dimensional Boolean lattice. We will discuss some recent progress on this problem. (Received July 18, 2014)

1102-05-85 **Jane V Butterfield***, jvbutter@uvic.ca. *Online Ramsey games in random graphs.*

In the online F-avoidance edge-coloring game with r colors, Builder places edges on an n-vertex graph one at a time while Painter colors them. Painter's goal is to avoid creating a monochromatic copy of F, but we know from graph Ramsey theory that if n is sufficiently large then she will be unable to do so. We therefore need to handicap Builder, for example by restricting the graph he builds to have bounded degree (or density, or genus, etc.). A different way to handicap Builder is to require him to play at random: edges of an n-vertex graph are randomly generated one at a time while Painter colors them. The threshold function for the number of edges that Painter is asymptotically almost surely able to paint before she loses is known to exist for any fixed F and r, proven by Marciniszyn, Spöhel, and Steger in 2010. Belfrage, Mütae, and Spöhel proved a connection between this random game and a deterministic two-player game, which has been used to improve known bounds on this threshold. In this problem-oriented talk accessible to a younger audience, we will discuss the results that are currently known, the tools that have been used to produce them, and the problems that are still open. (Received July 28, 2014)

1102-05-86 **Lara Pudwell*** (lara.pudwell@valpo.edu), Department of Mathematics and Statistics, 1900 Chapel Drive, Valparaiso, IN 46383. *Pattern avoidance in double lists.*

In this talk, we consider pattern avoidance in a subset of words on $\{1, 1, 2, 2, \ldots, n, n\}$ called double lists. In particular, a double list is a sequence π, π where $\pi \in \mathcal{S}_n$. Double lists have similarities with centrosymmetric words and with circular permutations, where pattern avoidance has already been studied. We enumerate double lists avoiding a single pattern of length 1, 2, 3, or 4 and completely determine the corresponding Wilf classes. This is joint work with Charles Cratty, Samuel Erickson, and Frehiwet Negassi. (Received July 21, 2014)

1102-05-88 **Daniela Kühn**, **Deryk Osthus**, **Timothy Townsend** and **Yi Zhao*** (yzhao6@gsu.edu). *On the structure of oriented graphs and digraphs with forbidden tournaments or cycles.*

Motivated by his work on the classification of countable homogeneous oriented graphs, Cherlin asked about the typical structure of oriented graphs (i) without a transitive triangle, or (ii) without an oriented triangle. We give an answer to these questions (which is not quite the predicted one). Our approach is based on the recent 'hypergraph containers' method, developed independently by Saxton and Thomason as well as by Balogh, Morris and Samotij. Moreover, our results generalize to forbidden transitive tournaments and forbidden oriented cycles of any order, and also apply to digraphs. Along the way we prove several stability results for extremal digraph problems, which we believe are of independent interest. (Received July 22, 2014)

1102-05-92 **Oliver Pechenik** (pecheni2@illinois.edu) and **Alexander Yong*** (ayong@illinois.edu). *Equivariant and K-theoretic Schubert calculus.*

Hugh Thomas and the speaker gave a combinatorial rule for equivariant Schubert calculus on Grassmannians; this rule was conjecturally extended to one for equivariant K-theory. I will explain the conjecture as well report on work-in-progress towards its solution. This is joint work with Oliver Pechenik. (Received July 22, 2014)

1102-05-93 **Benjamin Wyser** (bwyser@illinois.edu) and **Alexander Yong*** (ayong@illinois.edu). *Polynomials for symmetric orbit closures in the flag variety.*

We introduce polynomial representatives of cohomology classes of orbit closures in the flag variety, for the symmetric pairs $(GL(p+q), GL(p) \times GL(q))$, $(GL(n), O(n))$ and $(GL(2n), Sp(2n))$. These polynomials provide our analogues of the polynomials introduced by A. Lascoux and M.-P. Schützenberger for Schubert varieties. This is joint work with Benjamin Wyser. (Received July 22, 2014)

1102-05-100 **Lowell W Beineke*** (beineke@ipfw.edu), Indiana U. - Purdue U. Fort Wayne, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805, and **Jay S. Bagga** (jbagga@bsu.edu). *Super line graphs and an elementary problem in number theory.*

As a generalization of the line graph, the super line graph of index k of a graph G has the sets of k edges of G as its vertices, with two being adjacent if some edge in one of the sets is adjacent in G to some edge in the other set. After reviewing some of the properties on super line graphs, we will focus on a simple question (one that does not have a simple answer) in number theory: Given two integers $m \geq 2$ and $n \geq 2$, what is the maximum of $\min\{ij, (m-i)(n-j)\}$ with $1 \leq i \leq m-1$ and $1 \leq j \leq n-1$? Although we do not have a complete solution, we have solutions for some interesting cases. The problem that this arises from is to find the minimum index for which the super line graph of a graph is complete. (Received July 23, 2014)

1102-05-102 **Sylwia Cichacz*** (cichacz@agh.edu.pl), Solon Campus Center 170, Duluth, MN 55812, and **Mateusz Nikodem** (nikodem@agh.edu.pl), al. Mickiewicza 30, 30-059 Kraków, Poland. *Union of distance magic graphs.*

A distance magic labeling of a graph $G = (V, E)$ with $|V| = n$ is a bijection ℓ from V to the set $\{1, \ldots, n\}$ such that the weight $w(x) = \sum_{y \in N_G(x)} \ell(y)$ of every vertex $x \in V$ is equal to the same element μ, called the *magic constant*.

In the talk, we present some results on union of distance magic graphs that is distance magic as well. Moreover we also show some properties of such graphs. (Received July 23, 2014)

1102-05-109 **A. V. Kostochka** and **B. M. Reiniger*** (reinige1@illinois.edu). *The minimum number of edges in a 4-critical graph that is bipartite plus 3 edges.*

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

every $(B+3)$-graph has at least $2n-3$ edges. Our proof uses a potential function and the connection between orientations and colorings of graphs. (Received July 24, 2014)

1102-05-110 **Oliver Pechenik*** (pecheni2@illinois.edu) and **Alexander Yong**. *Genomic tableaux and Schubert calculus.*

I will introduce genomic tableaux and show how they give a new rule to compute structure constants in the K-theory of a complex Grassmannian. A special feature of this rule is that it generalizes to equivariant K-theory (for which there is currently no proven non-cancellative rule). I will explain this generalization and sketch the in-progress proof, joint with Alexander Yong. (Received July 24, 2014)

1102-05-113 **Gergely T. Balint** and **Robert B. Ellis*** (rellis@math.iit.edu), Applied Mathematics, 10 W 32nd St, E1 Rm 208, Chicago, IL 60637. *Group testing matrices via latin hypercube-based MDS codes.* Preliminary report.

The point of group testing, or pooling, is to reduce the cost of finding defective items in a population by testing pools of items rather than each individually. A binary group testing matrix has rows indexed by tests and columns by items, with a 1 indicating an item is included in the pool for the corresponding test. The defective items are identified from the binary test results, each of which is positive exactly when the corresponding pool contains a defective item. Group testing matrices can be obtained from Steiner systems, constant-weight codes, and superimposed codes, for example.

We introduce a new "Latin Square" construction for producing new group testing matrices from old, which amounts to code concatenation with an outer maximum distance separable (MDS) code over $\mathbb{Z}_n$, and an inner code consisting of the columns of the base matrix. We also discuss two ways of improving the resulting matrix, one more coding-theoretic and one more graph-theoretic. Several best-known matrices for real-world parameters result.

This is joint work with Gergely Bálint. (Received July 25, 2014)

1102-05-114 **Brian K. Miceli*** (bmiceli@trinity.edu), One Trinity Place, Mathematics Deptartment, San Antonio, TX 78213, and **Jay Pantone**. *Shift Equivalence in Consecutive Pattern Avoidance.*

Let a word w be comprised of letters in $\mathbb{N} = \{1, 2, \ldots\}$, and define the $\mathbb{N}^* = \{w = w_1 \cdots w_n \mid n \geq 0 \text{ and } w_i \in \mathbb{N} \text{ for all } i\}$. Let $|w|$ denote the number of letters in w, $\Sigma w = \sum_{i=1}^{|w|} w_i$, and set the *weight of* w to be $\mathrm{wt}(w) = t^{|w|}x^{\Sigma w}$. We say that w *embeds* u, written as $u \leq w$, if there is a string, v, of $|u|$ consecutive letters in w such that for all $1 \leq i \leq |u|$, $u_i \leq v_i$, and we define the embedding set of a word u to be $\mathcal{E}(u) = \{w \in \mathbb{N}^* \mid u \leq w\}$. The words u and v are *Wilf equivalent* if $\mathcal{E}(u;t,x) = \mathcal{E}(v;t,x)$, where

$$\mathcal{E}(u;t,x) = \sum_{w \in \mathcal{E}(u)} \mathrm{wt}(w).$$

Many facts about Wilf equivalent words have been proved in this setting, yet one of the most fundamental questions remains, "Do two Wilf equivalent words need to be rearrangements of one another," which has come to be known as the Rearrangement Conjecture. We give two operations on words that equate to Wilf equivalence, and we show how these operations point to proofs of conjectures of Wilf equivalence class size in the case of permutations and also toward the Rearrangement Conjecture. (Received July 25, 2014)

1102-05-117 **Daniel A Daly*** (ddaly@semo.edu) and **Lara K Pudwell** (lara.pudwell@valpo.edu). *Rook monoid pattern avoidance and connections to other combinatorial objects.*

The rook monoid is the set of $0-1$ $n \times n$ matrices with at most one 1 in every row and column. We generalize the notion of pattern avoidance for permutations to the setting of rook monoids and present some enumeration results that lead to connections with other objects. In particular, A-reducible elements of type B and rc-invariant permutations are in bijection with certain classes of rook monoid elements avoiding certain patterns. (Received July 25, 2014)

1102-05-118 **Eric S. Egge*** (eegge@carleton.edu), Department of Mathematics and Statistics, Carleton College, Northfield, MN 55057. *Catalan Combinatorics of Borel Ideals and Generalizations.* Preliminary report.

A *Borel ideal* in $\mathbb{C}[x_1, \ldots, x_n]$ is an ideal which is closed under the natural action of the upper triangular matrices in $M_n(\mathbb{C})$. Motivated by their study of these ideals, Francisco, Mermin, and Schweig have recently introduced an algebraic transformation on number triangles which models the transformation carrying numbers of minimal generators of a Borel ideal to its Betti numbers. In this context the triangle of ballot numbers (which is sometimes called Catalan's triangle) occurs for the Borel ideal generated by the monomial $x_1 \cdots x_n$, and when

Francisco, Mermin, and Schweig apply their transformation to this triangle they obtain a new number triangle, which they call *Borel's triangle*. Francisco, Mermin, and Schweig have given combinatorial interpretations of the entries of Borel's triangle in terms of binary trees, triangulations of an $n+2$-gon, and parenthesizations. I will discuss a variety of additional combinatorial interpretations of the entries of Borel's triangle, along with several generalizations. (Received July 25, 2014)

1102-05-119 **Eric S. Egge*** (eegge@carleton.edu), Department of Mathematics and Statistics, Carleton College, Northfield, MN 55057. *Introducing 05A06: Patterns in Permutations and Words.* Preliminary report.

In his keynote address at the 12th International Permutation Patterns Conference in July, Sergey Kitaev noted that each year more than 100 papers are published on patterns in permutations and words, and he suggested the subject should have its own AMS subject classification. In this survey I will give an introduction to the area, starting with the definitions and eventually reaching some of the ongoing lines of research, landmark results, and major open problems. I'll have to leave out much more than I include, but I hope that by the end you'll agree that 05A06: Patterns in Permutations and Words should be a thing. (Received July 25, 2014)

1102-05-123 **Michael Young*** (myoung@iastate.edu). *Rainbow arithmetic progressions in the integers.*

A k-term arithmetic progression is a sequence of the form $a, a+d, a+2d, ..., a+(k-1)d$, where a and d are nonegative integers. Van der Waerden's Theorem states that given a set of colors there exists an interval $[1,n]$ such that any coloring of the integers, using all the colors, will contain a k-term arithmetic progression with each term having the same color. Given a set of colors and $k>0$, actually determining n, called a *van der Waerden number* has proven to be a very challenging problem. In this talk, we will discuss some known results about van der Waerden numbers and introduce anti-van der Waerden numbers. An *anti-van der Waerden number* is the number of colors needed to guarantee that any coloring of the interval $[1,n]$ with all the colors must contain a k-term arithmetic progression with each term having a distinct color. (Received July 25, 2014)

1102-05-129 **Kailee Rubin*** (kailee.rubin@gmail.com), 10 N. Livingston St., Apt. #913, Madison, WI 53703, and **Jon Ver Steegh**, **Ben Caffrey**, **Gregory Michel** and **Eric Egge**. *Baxter Permutations, Snow Leopard Permutations, and Restricted Catalan Paths.*

As introduced by Chung, Graham, Hoggatt, and Kleiman in 1978, complete Baxter permutations are those that have even entries in even positions, odd entries in odd positions, and satisfy certain conditions related to the placement of entries between consecutive numbers. The permutation induced on the odd (resp. even) entries of a complete Baxter permutation is commonly called a Baxter (resp. anti-Baxter) permutation, meaning it avoids the generalized patterns $2-14-3$ and $3-14-2$ (resp. $2-41-3$ and $3-41-2$). We call a pair of Baxter and anti-Baxter permutations compatible whenever they form a complete Baxter permutation. We define a snow leopard permutation as one which is compatible with a doubly alternating Baxter permutation. We use a recursive decomposition and natural bijection to Catalan paths to show that the snow leopard permutations are counted by the Catalan numbers. Like the complete Baxter permutations, the snow leopard permutations preserve parity. We show that the permutations they induce on their odd (resp. even) entries are in bijection with the set of Catalan paths which avoid $NEEN$ (resp. contain no ascent of length exactly 2). Finally, we study the relationship between the permutations induced on the odd and even entries of a snow leopard permutation. (Received July 26, 2014)

1102-05-130 **Lauren Keough** and **Jamie Radcliffe*** (aradcliffe1@math.unl.edu), Lincoln, NE 68502. *The maximum number of j-independent sets in an r-graph with given number of edges.*

There has been a variety of recent work on extremal problems for the enumeration of special subsets of graphs, such as independent sets, perfect matchings, etc. The Kruskal-Katona theorem immediately answers the question of which graph on n vertices having m edges has the most independent sets (indeed it answers the question for each size of independent set separately). I will discuss recent work with Lauren Keough on the corresponding problem for r-uniform hypergraphs. In this context there are various possible notions of independent set: we say that I is a j-independent set of G if no edge of G meets I in as many as j vertices. For all values of the parameters we determine the extremal graph. (Received July 26, 2014)

1102-05-133 **Adam M Goyt***, goytadam@mnstate.edu, and **Lara K Pudwell**, lara.pudwell@valpo.edu. *Packing the Smallest Non layered Set Partition Pattern.*

Set partitions of $[n]=\{1,2,\ldots,n\}$ can be thought of words called restricted growth functions. A *restricted growth function* is a word $w=w_1w_2\ldots w_n$ where $w_1=1$ and $1\leq w_i\leq \max\{w_1,w_2,\ldots,w_{i-1}\}+1$.

For any word w, let the *canonization* of w be w' formed by replacing each copy of the first occurring letter of w by 1, each copy of the second occurring letter of w by 2, etc. We will say that w *contains* a copy u if there is a subsequence w' of w whose canonization is u. Otherwise, w *avoids* u.

The packing density $\delta(w)$ of w of length k is defined to be $\delta(w) := \lim_{n\to\infty} \frac{\mu(w,n)}{\binom{n}{k}}$, where $\mu(w,n)$ is the maximum number of copies of w in any restricted growth function of length n.

A restricted growth function is called layered if it is of the form $11\ldots122\ldots2\ldots jj\ldots j$. The packing densities for the layered restricted growth functions of length are $\delta(123) = 1$, $\delta(122) = \delta(112) = 2\sqrt{3} - 3$, and $\delta(111) = 1$. The only non layered pattern of length three is 121, and its packing density remained an open problem for three years. We show that the packing density for 121 is $\delta(121) = 1/4$. (Received July 26, 2014)

1102-05-138 **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, and **Songling Shan**, Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *Vizing 2-factor Conjecture with large maximum degrees.* Preliminary report.

In 1968, Vizing conjectured that, if G is an edge chromatic critical graph with $\chi'(G) = \Delta(G)+1$, then G contains a 2-factor. In this talk, we will discuss recent progress involving to this conjecture, in particular, the verification of the conjecture for graphs with maximum degree at least $|G|/2$. (Received July 27, 2014)

1102-05-140 **Jeremy L. Martin*** (jmartin@math.ku.edu), **Molly Maxwell**, **Victor Reiner** and **Scott O. Wilson**. *Pseudodeterminants and perfect square spanning tree counts.*

The *pseudodeterminant* of a square matrix is the last nonzero coefficient in its characteristic polynomial. When X is an antipodally self-dual CW-sphere of odd dimension $2k-1$, the pseudodeterminant of its kth cellular boundary matrix can be interpreted directly as a torsion-weighted generating function both for k-trees and for $(k-1)$-trees, complementing the analogous result for even-dimensional spheres given by the second author. The argument relies on the topological fact that any self-dual even-dimensional CW-ball can be oriented so that its middle boundary map is skew-symmetric. (Received July 27, 2014)

1102-05-143 **Oliver Pechenik** (pecheni2@illinois.edu) and **Dominic Searles*** (searles2@illinois.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Root-system combinatorics and the Belkale-Kumar product on cohomology of flag varieties.*

Using the combinatorial model of root-theoretic Young diagrams (RYDs), we investigate the Belkale-Kumar deformation of the cohomology of generalized flag varieties. We present a new rule in terms of RYDs, due to the second author, for the Belkale-Kumar product for flag varieties of type A (after the puzzle rule of Knutson-Purbhoo). In general type, we give an RYD criterion for vanishing of the Belkale-Kumar structure constants. Inspired by recent work of Evens-Graham, we also give a new proof that this product is well-defined in general type, using root-system combinatorics of K. Purbhoo. (Received July 27, 2014)

1102-05-146 **Michael Albert**, **Cheyne Homberger** and **Jay Pantone*** (jay.pantone@gmail.com). *Equipopularity in the Separable Permutations.*

When two patterns occur equally often in a set of permutations, we say that these patterns are equipopular. Using both structural and analytic tools, we classify the equipopularity classes in the set of separable permutations. In particular, we show that the equipopularity classes of length n patterns are in bijection with the partitions of the integer n. (Received July 27, 2014)

1102-05-148 **Hemanshu Kaul***, Kaul@iit.edu, and **Christodoulos Mitillos**. *Fall Coloring of Graphs.* Preliminary report.

Fall Coloring of graph asks for a partition of its vertex set into independent sets that are also dominating sets. Unlike typical graph theoretic invariants, the fundamental question is that of existence of such a coloring. Note that any such coloring requires at least chromatic number of colors. We will construct graphs with arbitrary large difference between their chromatic number and the minimum number of colors in any of their fall colorings, answering a question of Dunbar et al. (2000). We will also give construction of graphs that can be fall colored with many different pre-specified number of colors. We will describe the fall colorings for some basic graph classes, graph products, and give a sharp sufficient condition on the minimum degree of a graph that guarantees its fall coloring. (Received July 27, 2014)

1102-05-154 **Jozsef Balogh**, **Ping Hu**, **Bernard Lidicky*** (lidicky@iastate.edu), **Florian Pfender**, **Jan Volec** and **Michael Young**. *Maximizing the number of rainbow triangles.*

Erdős and Sós proposed a problem of maximizing the number $F(n)$ of rainbow triangles in 3-edge-colored complete graphs on n vertices. They conjectured that $F(n) = F(a) + F(b) + F(c) + F(d) + abc + abd + acd + bcd$, where $a + b + c + d = n$ and a, b, c, d are as equal as possible and $F(0) = 0$. We prove that the conjectured recurrence holds for sufficiently large n. We also prove the conjecture if $n = 4^k$ for all $k \geq 0$. These results imply that $\lim \frac{F(n)}{\binom{n}{3}} = 0.4$, and determine the unique limit object. In the proof we use flag algebras combined with stability arguments. (Received July 28, 2014)

1102-05-155 **A. V. Kostochka**, **Xiangwen Li**, **W. Ruksasakchai**, **M. Santana**, **Tao Wang** and **Gexin Yu***, Department of Mathematics, College of William and Mary, Williamsburg, VA 23188. *Strong Chromatic Index of Subcubic Planar Multigraphs.* Preliminary report.

The strong chromatic index of a multigraph is the minimum k such that the edge set can be k-colored requiring that each color class induces a matching. We verify a conjecture due to Faudree, Gyárfás, Schelp, and Tuza, showing that every planar multigraph with maximum degree at most three has strong chromatic index at most 9. (Received July 28, 2014)

1102-05-156 **Gregory S. Warrington*** (gswarrin@uvm.edu), Department of Mathematics & Statistics, University of Vermont, Burlington, VT 05401. *Patterns and supersequences.*

We present enumerative results relating pattern avoidance and the length of the shortest word containing every element of a given set of permutations as a subsequence. (Received July 28, 2014)

1102-05-158 **Ben Barber**, **Daniela Kühn**, **Allan Lo*** (s.a.lo@bham.ac.uk) and **Deryk Osthus**. *Edge-decompositions of graphs with high minimum degree.*

A fundamental theorem of Wilson states that, for every graph F, every sufficiently large F-divisible clique has an F-decomposition. Here a graph G is F-divisible if $e(F)$ divides $e(G)$ and the greatest common divisor of the degrees of F divides the greatest common divisor of the degrees of G, and G has an F-decomposition if the edges of G can be covered by edge-disjoint copies of F. We extend this result to graphs which are allowed to be far from complete: we show that every sufficiently large F-divisible graph G on n vertices with minimum degree at least $(1 - |F|^{-4})n$ has an F-decomposition. Our main contribution is a general method which turns an approximate decomposition into an exact one. (Received July 28, 2014)

1102-05-168 **Jed Yang*** (jedyang@umn.edu). *Tiling by triangles and rhombi is hard.*

In 2001, Knutson, Tao, and Woodward introduced puzzle pieces: two triangles and a rhombus (with edge labels). They proved that tilings by these puzzle pieces (allowing rotations) of triangular regions (with edge labels) are counted by Littlewood–Richardson coefficients. These numbers appear naturally in many contexts, including multiplication of Schur functions, intersection of Schubert varieties, and tensor products of irreducible representations of general linear groups.

Together with the saturation conjecture, proved by Knutson and Tao in 1998, this means, in particular, that tileability of triangular regions by puzzle pieces can be decided in polynomial time. In this talk, we will discuss the problem of tiling arbitrary regions with these puzzle pieces, which is NP-complete. If time permits, we will also consider tilings where reflections are allowed.

(Joint work with Igor Pak.) (Received July 28, 2014)

1102-05-171 **Brant Jones*** (jones3bc@jmu.edu). *Affine permutation patterns.* Preliminary report.

In analogy with a classical question, we consider the number of affine permutations that avoid a finite permutation pattern. This subject was introduced by Andrew Crites and has been investigated in papers of Hanusa-Jones and Biagioli-Jouhet-Nadeau. Since the affine symmetric group is infinite we use an additional statistic, known as Coxeter length, to refine our counting. In this talk, we will survey prior results and present a new methodology for obtaining these counting sequences. (Received July 28, 2014)

1102-05-172 **Michael Chmutov*** (mchmutov@umich.edu). *Parallel transport in the Kazhdan-Lusztig W-graph and Green's $0-1$ conjecture in Lie type B.*

In 1979 Kazhdan and Lusztig introduced for each Coxeter group a family of polynomials which have numerous deep applications in representation theory and geometry. While these polynomials are difficult to compute, they are not so difficult to recover from a certain weighted directed graph known as the Kazhdan-Lusztig W-graph. The vertices of this graph are the elements of the Coxeter group.

There was a long-standing conjecture, later disproved by McLarnan and Warrington, that in Lie type A, the weights of the edges are always 0 or 1. Green has proposed a weaker version of the conjecture that the same

is true for edges starting at so-called fully-commutative elements of the Coxeter group. This conjecture may hold in the generality of all Coxeter groups. Green himself proved the conjecture in Lie types A and $\widetilde{A}$ in 2009. The proof in type D has been carried out by Gern in 2013. We prove the conjecture in type B. The main new ingredient of the proof is a certain relation among the edge weights which we refer to as "parallel transport." (Received July 28, 2014)

1102-05-185 **Elizabeth Drellich***, drellich@math.umass.edu, and **Julianna Tymoczko**. *A Module Isomorphism between $H_T^*(G/P) \otimes H_T^*(P/B)$ and $H_T^*(G/B)$.*

We give an explicit (new) morphism of modules between $H_T^*(G/P) \otimes H_T^*(P/B)$ and $H_T^*(G/B)$ and prove (the known result) that the two modules are isomorphic. Our map identifies submodules of the cohomology of the flag variety that are isomorphic to each of $H_T^*(G/P)$ and $H_T^*(P/B)$. With this identification, the map is simply the product within the ring $H_T^*(G/B)$. Using this map we describe module bases for $H_T^*(G/B)$ that are different from traditional Schubert classes and from each other, and give an application to representation theory. (Received July 28, 2014)

1102-05-191 **William Slofstra*** (wslofstra@math.ucdavis.edu). *Root system pattern avoidance and free inversion arrangements.* Preliminary report.

Root system pattern avoidance was introduced by Billey-Braden and Billey-Postnikov to study singularities of Schubert varieties in any Cartan type. I will give a root system pattern avoidance criterion for Terao freeness of inversion hyperplane arrangements, and sketch some connections with the pattern avoidance criterion for rationally smooth Schubert varieties. (Received July 28, 2014)

1102-05-194 **Dong Ye*** (dong.ye@mtsu.edu), Department of Mathematical Sciences, Middle Tennessee State University, Murfreesboro, TN 37132. *Spanning subgraphs and cycle covering.*

The well-known Cycle Double Cover Conjecture says that every bridgless graph has a family of cycles which cover every edge twice. By Fleischner's splitting lemma, it suffices to prove the Cycle Double Cover Conjecture for all 2-edge-connected cubic graphs. If a 2-edge-connected cubic graph with a nice spanning subgraph, then it has a cycle double cover. In this talk, I will talk the connections between the spanning subgraphs and cycle covers and some recent results. (Received July 28, 2014)

1102-05-196 **Jacob Manske***, 1979 Milky Way, Verona, WI 53595, and **Jeremy Alm**, Jacksonville, IL 62650. *Highly constrained edge-colorings of complete graphs, part II.*

In this continuation of Part I, we discuss recent progress on several problems.

Let $\mathcal{C} = \{r, b_1, \ldots, b_n\}$ and let $\mathcal{T} = \mathcal{C}^3 \backslash \{b_1, \ldots, b_n\}^3$. Thus r is a *flexible color* in $\mathcal{T}$. Alm, Maddux, and Manske showed in 2007 that $\mathcal{T}$ was realizable for all n using probabilistic methods. Recently, Alm and Sexton showed that for $n = 2$, $\mathcal{T}$ is realizable on K_{8192}.

For $\mathcal{T}_1$, it was known until recently only that $\mathcal{T}_1$ was realizable for $1 \leq n \leq 7$. The authors showed in 2013-14 that $\mathcal{T}_1$ is realizable for all $n \leq 400$, except possibly $n = 8$ and $n = 13$. Finally, the authors solved one of the two remaining minimal cases of the *flexible color conjecture*, where there are two colors, *red* and *directed blue*, and the only triangle that is forbidden is the "cycle" $\langle \overleftarrow{b}, \overrightarrow{b}, \overrightarrow{b} \rangle$.

All of these recent results were obtained using computational methods on finite groups. (Received July 28, 2014)

1102-05-200 **Sara Billey** and **Zachary Hamaker***, Institute for Mathematics and its Application, University of Minnesota, 306 Lind Hall, 207 Church Street SE, Minneapolis, MN 55455, and **Austin Roberts** and **Benjamin Young**. *Insertion algorithms and Little maps.*

The Little map sends reduced decompositions of permutations to standard Young tableaux, bijectively realizing an algebraic approach to enumerating reduced decompositions. I will present joint work with Sara Billey, Austin Roberts and Benjamin Young wherein we demonstrate a Little map for signed permutations and characterize each map in terms of Edelman-Greene insertion and Kraskiewicz insertion, respectively. This leads to new insights about the insertion algorithms, previously conjectured by Thomas Lam. (Received July 28, 2014)

1102-05-203 **Andrew P. Dove** and **Jerrold R. Griggs*** (j@sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Packing Posets in the Boolean Lattice.*

Consider copies of a poset P in the family of all subsets of $[n] := \{1, \ldots, n\}$. It remains open to determine asymptotically the largest size $\mathrm{La}(n, P)$ of a family of subsets of $[n]$ that contains no subposet P, as $n \to \infty$. Here we consider a new packing problem, which is to maximum the number of pairwise unrelated copies of P in the Boolean lattice of all subsets of $[n]$. When P is a chain on k elements, and the answer is asymptotic to

$\frac{1}{2^{k-1}}\binom{n}{\lfloor n/2 \rfloor}$, as $n \to \infty$, by a result of Griggs, Stahl, and Trotter. We can solve this new problem asymptotically for any P: The maximum is $\sim \frac{1}{c(P)}\binom{n}{\lfloor n/2 \rfloor}$, where the integer $c(P)$ relates to embeddings of P into the Boolean lattice. This problem was independently posed and solved by Katona and Nagy. (Received July 28, 2014)

1102-05-205 **Jennifer Diemunsch**, **Michael Ferrara*** (michael.ferrara@ucdenver.edu), **Sogol Jahanbekam** and **James Shook**. *New Results on Packing Graphic Sequences.*

A sequence $\pi = (d_1, \ldots, d_n)$ is graphic if there is a simple graph G with vertex set $\{v_1, \ldots, v_n\}$ such that the degree of v_i is the ith entry of π. We say that graphic sequences $\pi_1 = (d_1^{(1)}, \ldots, d_n^{(1)})$ and $\pi_2 = (d_1^{(2)}, \ldots, d_n^{(2)})$, *pack* if there exist edge-disjoint n-vertex graphs G_1 and G_2 such that for $j = 1, 2$, $d_{G_j}(v_i) = d_i^(j)$ for all $i = 1, \ldots, n$.

In this talk, we give several conditions that ensure a pair of sequences pack. In particular, if Δ_j be the maximum degree of π_j for $j = 1, 2$ and $(\Delta_1 + 1)(\Delta_2 + 1) \leq n + 1$ then π_1 and π_2 pack. This result is a degree sequence analogue to the well-studied Bollobás-Eldridge-Catlin graph packing conjecture. We also discuss applications of degree sequence packing to discrete imaging science, along with some results on packing degree sequences of uniform hypergraphs. (Received July 28, 2014)

1102-05-207 **Kaisa Taipale*** (taipale@math.umn.edu), **Anna Bertiger** and **Elizabeth Beazley**. *Polynomials from the Grassmannian and the affine Grassmannian.* Preliminary report.

The Peterson isomorphism relates the homology of the affine Grassmannian and the quantum cohomology of flag varieties. Both sides carry rich symmetric function theories, but it is not trivial to see how they are related. This talk will discuss preliminary results relating "cyclic factorial Schur" polynomials with k-double Schur functions: geometry rules that the two must be related, but the symmetric function side is only recently unfolding. (Received July 28, 2014)

1102-05-208 **Brian K Nakamura*** (bnaka@dimacs.rutgers.edu) and **Elizabeth Yang**. *Competition graphs induced by permutations.* Preliminary report.

Given a directed graph D, its corresponding competition graph G is the undirected graph with the same vertex set as D and the edge set $E(G)$ where there exists an edge uv in $E(G)$ if and only if there exists a vertex w such that arcs (u, w) and (v, w) are both in $V(D)$. Competition graphs have been studied since 1968, when Cohen introduced the notion as a method to study food webs in ecology. In this talk, we will introduce the notion of permutations inducing competition graphs. We will show interesting connections that these competition graphs have with patterns in permutations. (Received July 28, 2014)

1102-05-209 **Aba Mbirika*** (mbirika@uwec.edu), **Thomas Pietraho** and **William Silver**. *A Robinson-Schensted correspondence on complex reflection groups G(r,p,n).*

The classical Robinson-Schensted algorithm establishes a bijection between permutations in the symmetric group $\mathfrak{S}_n$ and ordered pairs of same-shape standard Young tableaux of size n. This map has proven particularly well-suited to certain questions in the representation theory of both $\mathfrak{S}_n$ and the semisimple Lie groups of type A. For instance, Kazhdan-Lusztig cells as well as the primitive spectra of semisimple Lie algebras can be readily described in terms of images of this correspondence.

Other sometimes more elementary representation-theoretic information requires more work to extract from standard Young tableaux. For instance, in independent work, Reifegerste and Sjöstrand developed a method for reading the value of the sign representation of a permutation in $\mathfrak{S}_n$. In this talk, we extend this result to the imprimitive complex reflection groups $G(r, p, n)$ via a generalized Robinson-Schensted algorithm. (Received July 29, 2014)

1102-05-210 **Jessica Striker*** (jessica.striker@ndsu.edu). *Rowmotion and generalized toggle groups.* Preliminary report.

We extend the notion of the toggle group (as defined by P. Cameron and D. Fon-der-Flaass and further explored by the author with N. Williams) from the set of order ideals of a poset to any set of subsets $\mathcal{L}$ of the power set on a countable set E. Interesting special cases of this general setting include chains, antichains, and interval closed sets of a poset, independent sets on a graph, matroids, and antimatroids (also called convex geometries or meet-distributive lattices). We study the structure and actions of these toggle groups. If there is a well-defined closure operation on $\mathcal{L}$, we can also generalize rowmotion from the set of order ideals of a poset to this setting. (Received July 29, 2014)

1102-05-213 **N. Warnberg*** (njwarnberg@gmail.com), **S. Butler**, **L. Hogben**, **R. Martin**, **D. Stolee**, **M. Young**, **C. Erickson**, **K. Hogenson**, **J. Lin**, **R. Kramer** and **L. Kramer**. *Coloring the integers modulo n.* Preliminary report.

A k-term arithmetic progression in $\mathbb{Z}_n$ is a set of distinct elements of the form

$$a \mod n, a+d \mod n, a+2d \mod n, \ldots, a+(k-1)d \mod n$$

where $d \geq 1$ and $k \geq 2$. An r-coloring of $\mathbb{Z}_n$ is a function $c : \mathbb{Z}_n \to [r]$ where $[r] = \{1, 2, \ldots, r\}$. We say such a coloring is exact if c is surjective and an arithmetic progression is rainbow if the image of the progression is injective. The anti-van der Waerden number, $\mathrm{aw}(\mathbb{Z}_n, k)$, denotes the smallest number of colors with which elements of the cyclic group of order n can be colored and still guarantee there is a rainbow arithmetic progression of length k. In this setting, arithmetic progressions can "wrap around." We will concentrate on results with $k = 3$. (Received July 29, 2014)

1102-05-215 **Alexander Burstein*** (aburstein@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *Unbalanced Wilf-equivalence.* Preliminary report.

A Wilf-equivalence of two sets of patterns is called *unbalanced* if the sets do not contain the same number of patterns of each length. We present a few cases of unbalanced Wilf-equivalence, either proved or conjectured, where both sets of patterns are finite. We also show or conjecture equidistribution of some permutation statistics on those sets. This is joint work with Jonathan Bloom and Jay Pantone. (Received July 29, 2014)

1102-05-218 **Timothy Goodrich**, **Drew Groth**, **Lauren Knop**, **William Olson**, **Lara Pudwell**, **Ruyue (Julia) Yuan**, **Jinseok (Ray) An** and **Thomas Langley*** (langley@rose-hulman.edu). *Sorting permutations with finite-depth stacks.* Preliminary report.

We investigate a variety of sorting operators involving finite-depth stacks. In particular, Pudwell *et al.* recently characterized and enumerated those permutations that are sortable with one pass through a stack of arbitrary depth, an arbitrary number of passes through a stack of depth 2, and two passes through a stack of depth 3. We review these results and then examine those permutations that are sortable with one pass through two parallel finite-depth stacks of arbitrary depths, and an arbitrary number of passes through two parallel stacks of small depths. We also investigate the limitations that a finite stack imposes on sorting operators involving compositions of the stack sorting operator with dihedral group symmetries. (Received July 29, 2014)

1102-05-219 **Jeremy F Alm*** (alm.academic@gmail.com), 1101 W. College Ave., Jacksonville, IL 62650, and **Jacob Manske**, Verona, WI 53593. *Highly constrained edge-colorings of complete graphs, part I.*

Given a finite set $\mathcal{C}$ of colors, let $\mathcal{T}$ be a set of triangles with edges colored from colors in $\mathcal{C}$, i.e., $\mathcal{T} \subseteq \mathcal{C}^3$ and $\mathcal{T}$ is closed under permutation of coordinates. $\mathcal{T}$ is *realizable* if there is some $N \leq \omega$ such that there exists an edge-coloring of K_N with colors from $\mathcal{C}$ such that

- every triangle appearing in K_N is in $\mathcal{T}$, and
- if uv is colored a and $\langle a, b, c\rangle \in \mathcal{T}$, then there is a vertex w such that uw is colored b and vw is colored c, i.e., "Whatever can happen, must happen".

Let $\mathcal{C} = \{a_1, \ldots, a_n\}$, and let $\mathcal{T}_m = \{\langle a_i, a_j, a_k\rangle : |\{i, j, k\}| \neq m\}$, $(m = 1, 2, 3)$. Then

- It is an open problem whether $\mathcal{T}_1$ is realizable for all n. Erdős, Szemerédi, and Trotter once gave a purported proof, but it was wrong.
- If $\mathcal{T}_2$ is realizable on K_N, then there is a projective plane of order $n - 1$.
- If $\mathcal{T} \subseteq \mathcal{T}_3$, then it is decidable whether $\mathcal{T}$ is realizable, realizable over finite sets only, etc.

In Part II, Manske will discuss some recent progress on open problems. (Received July 29, 2014)

1102-05-227 **Saad I El-Zanati*** (saad@ilstu.edu), Campus Box 4520, Mathematics Department, Illinois State University, Normal, IL 61790-4520. *On digraph labelings and cyclic digraph decompositions.*

It is known that an ordered ρ-labeling of a bipartite graph G with n edges yields a cyclic G-decomposition of K_{2nx+1} for every positive integer x. We extend the concept of an ordered ρ-labeling to bipartite digraphs and show that an ordered directed ρ-labeling of a bipartite digraph D with n arcs yields a cyclic D-decomposition of K^*_{nx+1} for every positive integer x. We also find several classes of bipartite digraphs that admit an ordered directed ρ-labeling. (Received July 29, 2014)

1102-05-232 **Mihai Ciucu*** (mciucu@indiana.edu), Department of Mathematics, Indiana University, 831 East 3rd Street, Rawles Hall, Bloomington, IN 47405, and **Ilse Fischer** (ilse.fischer@univie.ac.at), Institut für Mathematik, Universität Wien, Oskar-Morgenstern-Platz 1, 1090 Wien, Austria. *A triangular gap of size two in a sea of dimers on a 60 degree angle.*

We consider a triangular gap of side two in a 60 degree angle on the triangular lattice whose sides are zig-zag lines. We study the interaction of the gap with the corner as the rest of the angle is completely filled with lozenges. We show that the resulting correlation is governed by the product of the distances between the gap and its five images in the sides of the angle. This provides a new aspect of the parallel between the correlation of gaps in dimer packings and electrostatics developed by the first author in previous work. (Received July 29, 2014)

1102-05-233 **Jerrold R. Griggs*** (j@sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29212. *Tiling the n-cube Graph with Copies of a Given Graph.* Preliminary report.

We say that a graph G tiles the n-cube graph Q_n if $V(Q_n)$ can be partitioned into blocks $V_1, V_2, \ldots$ so that for all i, the induced subgraph on V_i is isomorphic to G. We then propose this graph packing problem: For which graphs G does there exist an n such that G tiles Q_n? Easily, when G tiles Q_n, it tiles $Q_{n'}$ for all $n' > n$, so a more precise question is to determine the minimum value of n, denote it $t(G)$, such that G tiles Q_n. While these general questions remain open, we have several results to share, using techniques that include linear algebra, coding theory, and matching theory. This is joint work with Kevin Milans, David Offner, and David Stoner. (Received July 29, 2014)

1102-05-238 **Younjin Kim**, **Mohit Kumbhat*** (mohitkumbhat@gmail.com), **Zoltan Lorant Nagy**, **Balazs Patkos**, **Alexey Pokrovskiy** and **Mate Vizer**. *Searching with balls in graphs.* Preliminary report.

Given a graph G, a positive integer R and an unknown vertex $v \in V(G)$, we discuss the following combinatorial search theoretic problem: What is the minimum number of queries of the form "Does v belong to the ball of radius r with center u (where $u \in V(G)$ and $r \leq R$) ?" to identify v. We consider both the adaptive case when a query might depend on the answers to the previous queries and the non-adaptive case when all queries must be made at once. In this talk we discuss the bounds on the minimum number of queries for hypercubes, the Erdos-Renyi random graphs and graphs of bounded maximum degree. (Received July 29, 2014)

1102-05-242 **Megan Martinez*** (megan.a.martinez.gr@dartmouth.edu). *Patterns in Random Walks.*

In this talk, we explore patterns in one-dimensional random walks on the real number line. A set of n consecutive values in the random walk is associated to a permutation in S_n using relative ordering. With this setup, it is clear that patterns will not occur with equal probability; however, there are some instances where two patterns will occur with equal probability given any probability distribution. A permutation and its reverse complement will always have the same probability, but this is not the only case. The permutations 612435 and 354612 are a nontrivial example of this phenomenon.

We are interested in permutations $\pi, \tau \in S_n$ such that the probability π occurs in a random walk is equal to the probability τ occurs in a walk, regardless of probability distribution. Our goal is to completely characterize the classes of permutations with equal probabilities. This is joint work with Sergi Elizalde. (Received July 29, 2014)

1102-05-245 **Rodrigo Ferraz de Andrade***, Department of Mathematics, Purdue University, 150 N. University Street, Office: MATH 633, West Lafayette, IN 47907, and **Erik Lundberg** and **Brendan Nagle**. *Asymptotics of the Extremal Excedance Set Statistic.* Preliminary report.

Let $[1, n] = \{1, 2, .., n\}$. An excedance of a permutation p on $[1, n]$ is a value j in the domain whose image $p(j)$ is larger than j. A classical problem is to study the number of excedances of a permutation. A more modern topic is to study the set of excedances and the number of permutations with a prescribed excedance set. In particular, the question of what is the most common excedance set was answered by Ehrenborg and Steingrimsson in 2000; it turns out that the most common is to have half excedances and all at the beginning, that is, $[1, [n/2]]$: a single run of excedances at the beginning with length that is (the integer part of) half the length of the permutation. A formula for the number of permutations with such excedance set was also provided by Ehrenborg and Steingrimsson, and the problem of determining the asymptotics was posed in 2010 by Clark and Ehrenborg. In this talk I will discuss an answer to this problem while also providing a more general bivariate

asymptotic. I will also mention applications to generalized pattern avoidance and so-called "stretching pairs" in n-cycles. (Received July 29, 2014)

1102-05-267 **Nathaniel Dean*** (nd17@txstate.edu), Department of Mathemetics, 601 University Drive, San Marcos, TX 78666. *Finite Solutions to Infinite Graph Problems.*

A graph is a combinatorial structure consisting of a set of objects called vertices and a set of edges defined as unordered pairs of vertices. We consider certain unsolved problems where length is associated with the edges of an infinite graph (i.e., chromatic number of the plane and integer distances). Then we investigate the number theoretic and geometric structure of related finite graphs (i.e., unit and rational distance graphs). Finally, we discuss how attempts to solve these problems and generalize them lead to ongoing research in mathematical programming, algebraic geometry, data visualization, statistical clustering, and other areas. (Received July 29, 2014)

1102-05-269 **Michael W Schroeder*** (schroederm@marshall.edu), One John Marshall Drive, Huntington, WV 25705. *New Constructions for Symmetric Hamilton Cycle System of Complete Multipartite Graphs.*

In a graph G, a subgraph H is *symmetric* with respect to a permutation ϕ of $V(G)$ if for every $xy \in E(H)$, $\phi(x)\phi(y) \in E(H)$. A Hamilton cycle system of G is symmetric with respect to ϕ if each Hamilton cycle is itself symmetric. In this talk, a classification for the existence of such systems will be presented for complete multi graphs for appropriate permutations ϕ through the use of some new constructions. (Received July 29, 2014)

06 ► Order, lattices, ordered algebraic structures

1102-06-221 **Christine T. Cheng*** (ccheng@uwm.edu), 3200 N. Cramer St., Milwaukee, WI 53211, and **Eric McDermid** and **Ichiro Suzuki**. *The center stable matchings and the centers of cover graphs of distributive lattices.*

Since the 1970's, it has been known that the set of stable matchings of a stable marriage instance form a distributive lattice. A center stable matching is a center of this lattice's cover graph. It is of interest to us because center stable matchings can be thought of as a fair stable matching in the same way that a center of a graph is a fair location in a facility location problem. In the talk, we present an efficient algorithm for computing a center stable matching given only the stable marriage instance. (Received July 29, 2014)

11 ► Number theory

1102-11-104 **David Penniston*** (pennistd@uwosh.edu). *Congruences for k-regular partition functions.* Preliminary report.

Classically k-regular partitions appear as labelings of certain representations of the symmetric group. More recently the arithmetic of k-regular partition functions has received attention, in particular divisibility properties similar to those of Ramanujan for the unrestricted partition function (with some interesting connections to objects from arithmetic geometry appearing along the way). In this talk we present recent work on congruences for k-regular partition functions. (Received July 24, 2014)

1102-11-106 **Paul Garrett*** (garrett@math.umn.edu), 127 Vincent Hall, 206 Church St. SE, School of Mathematcs, Univ of MN, Minneapolis, MN 55455. *Self-adjoint operators on spaces of automorphic forms.*

Compact periods of Eisenstein series extend Y. Colin de Verdiere's example of a self-adjoint operator on automorphic forms whose discrete spectrum, if any, is parametrized by zeros of a zeta function. We show that pair-correlation for zeros of Euler products give the negative result: at most a limited fraction of on-line zeros s can appear as eigenvalues $s(s-1)$ for corresponding pseudo-Laplacians, contrary to a speculation of Colin de Verdiere. However, this sparsity may facilitate a subtler approach to the situation. Part of ongoing work with E. Bombieri. (Received July 24, 2014)

1102-11-116 **Wade Hindes*** (whindes@math.brown.edu). *Galois uniformity in quadratic dynamics over k(t).*

We prove that the arboreal Galois representation attached to a large class of quadratic polynomials defined over a field of rational functions in characteristic zero has finite index in the full automorphism group of the associated

preimage tree. Moreover, we compute effective bounds for this index and show that in the generic case it is bounded independently of the polynomial. (Received July 25, 2014)

1102-11-124 **Jeremy Rouse***, rouseja@wfu.edu, and **David Zureick-Brown**. *Elliptic curves over $\mathbb{Q}$ and 2-adic images of Galois.*

We give a classification of all possible 2-adic images of Galois representations associated to elliptic curves over $\mathbb{Q}$. To this end, we compute the 'arithmetically maximal' tower of 2-power level modular curves, develop techniques to compute their equations, and classify the rational points on these curves. (Received July 26, 2014)

1102-11-134 **Jennifer Paulhus*** (paulhusj@grinnell.edu). *Decomposing Jacobian varieties.*

Jacobian varieties which have many elliptic curves as factors in their decompositions have interesting applications to rank and torsion questions. Given a curve X with automorphism group G, idempotent relations in the group ring $\mathbb{Q}G$ lead to decompositions of the Jacobian of X. In this talk we explain techniques used to decompose these Jacobians if the monodromy of the covering $X \to X/G$ is known. We also discuss some recent results obtained from these techniques. Particularly, new computational advances allow us to determine these decompositions for curves in high genus, and we use that to find new examples of completely decomposable Jacobians. (Received July 26, 2014)

1102-11-145 **Christelle Vincent***, Department of Mathematics, 450 Serra Mall; Building 380, Stanford, CA 94305. *Weierstrass points on Drinfeld modular curves.* Preliminary report.

We consider the so-called Drinfeld setting, a function field analogue of some aspects of the theory of modular forms, modular curves and elliptic curves. In this setting Drinfeld constructed families of modular curves defined over a complete, algebraically closed field of characteristic p. We are interested in studying their Weierstrass points, a finite set of points of geometric interest. In this talk we will present the modular Wronskian, which is the main tool we use to compute the image of these points modulo a prime ideal of the base ring, as well as our results. (Received July 27, 2014)

1102-11-151 **Arindam Roy***, Department of Mathematics, Urbana, IL 61801. *Zeros of partial sums of the Dedekind zeta function of a Galois extension.*

We study the zeros of the partial sums of the Dedekind zeta function of a Galois extension K defined by the truncated Dirichlet series

$$\zeta_{K,X}(s) = \sum_{\|\mathfrak{a}\| \leq X} \frac{1}{\|\mathfrak{a}\|^s},$$

where the sum is to be taken over nonzero integral ideals $\mathfrak{a}$ of K and $\|\mathfrak{a}\|$ denotes the absolute norm of $\mathfrak{a}$. Specifically, we estimate the number of zeros of $\zeta_{K,X}(s)$ up to height T. We also study the zero density results for the truncated sum

$$\zeta_{K,X}(s) + B^{2s-1}\frac{A(1-s)}{A(s)}\zeta_{K,X}(1-s),$$

where $A(s) = \Gamma^{r_1}(s/2)\Gamma^{r_2}(s)$, $B = 2^{r_2}\pi^{n_0/2}/\sqrt{|d_K|}$, $r = r_1 + r_2$ (with r_1 being the number of real embeddings and r_2 being the number of complex conjugate pairs of complex embeddings of K), $n_0 = [K\colon \mathbb{Q}]$ denotes the degree of $K/\mathbb{Q}$, and d_K denotes the discriminant of K. (Received July 27, 2014)

1102-11-161 **Silas Johnson*** (sjohnson@math.wisc.edu). *Alternate Discriminants and Mass Formulas for Number Fields.* Preliminary report.

Kedlaya and Wood have explored alternate invariants for number fields, with the idea of replacing the discriminant in standard field-counting questions with one of these alternate invariants. We further explore the space of "reasonable" invariants, expanding on Kedlaya and Wood's definition. We also discuss a theorem on mass formulas for these invariants. (Received July 28, 2014)

1102-11-164 **Amy T DeCelles*** (adecelles@stthomas.edu). *Zeros of Zeta Functions and Eigenvalues of Pseudo-Laplacians.*

The occurrence of zeros of the Riemann zeta function in a list (Haas, 1977) of parameter values $\{s : \lambda_s = s(s-1)\}$ for purported eigenvalues λ_s of the Laplacian on $SL_2(\mathbb{Z})\backslash\mathfrak{H}$ raised hopes that a proof of the Riemann Hypothesis might be within reach, prompting a flurry of activity, trying first to reproduce, then correct or modify Haas' results. Although Hejhal showed that Haas' methods were flawed, the intriguing fact that his error would produce exactly the zeros of zeta led to related investigations (Hejhal, 1981, Colin de Verdière 1981 and 1983.) Recent work of Garrett and Bombieri sheds light on the previously hidden difficulties inherent this approach, opening the door to new constructions which avoid these difficulties. We will discuss some of these new constructions. (Received July 28, 2014)

1102-11-169 **Lavinia Ciungu*** (lavinia-ciungu@uiowa.edu), The University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52245. *Results on Rotation Symmetric Boolean Functions.*

Boolean functions, which are functions from the vector space F_2^n to the two element field F_2, are an important tool in Cryptography, a few of their applications including pseudo-random generators in stream ciphers, S-boxes in block ciphers, error correcting codes etc. We focus on a particular class of Boolean functions, namely Rotation Symmetric Boolean functions, which are invariant under circular translation of indices. Consider the action of Z_n on F_2^n under cyclic permutation, and let S be the set of orbits of this action. Denote (a_i) a set of representatives of this action, and consider the matrix $A = (\sum_{O(a_i)} x_{a_j})_{i,j}$. This matrix has been intensely studied by authors such as J. Clark, M. Hell, S. Maitra, A. Maximov, P. Stănică. Here we answer an open question regarding the form of the matrix for n even. In fact we find several properties of this matrix that hold for any n, such as $A^2 = 2^n I$ and we prove that the matrix has a general block structure given by its eigenvalues. (Received July 28, 2014)

1102-11-178 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53705. *An Introduction to Galois Representations.*

This talk will give an introduction to Galois representations and provide some background for other talks in the session. (Received July 28, 2014)

1102-11-179 **Scott Ahlgren*** (sahlgren@illinois.edu), Department of Mathematics, 1409 W. Green St, Urbana, IL 61801, and **Nickolas Andersen** (nandrsn4@illinois.edu), Department of Mathematics, 1409 W. Green St., Urbana, IL 61801. *Weak harmonic Maass forms of weight* 5/2.

We construct a natural basis for the space of weak harmonic Maass forms of weight 5/2 on the full modular group. The non-holomorphic part of the first element of this basis encodes the values of the ordinary partition function $p(n)$. We obtain a formula for the coefficients of the mock modular forms of weight 5/2 in terms of regularized inner products of weakly holomorphic modular forms of weight $-1/2$, and we obtain Hecke-type relations among these mock modular forms. (Received July 28, 2014)

1102-11-180 **Martin T Luu*** (mluu@math.stanford.edu). *From a Langlands Duality to a Duality of Quantum Field Theories.*

I will discuss a relation between a Langlands duality (specifically the numerical local Langlands correspondence) and a duality of two-dimensional quantum field theories. The key is switching from the ell-adic to the complex version of Laumon's local Fourier transform. (Received July 28, 2014)

1102-11-182 **Nickolas Andersen*** (nandrsn4@illinois.edu), 1409 W Green St, Urbana, IL 61801. *Singular invariants, mock modular forms of weight* 5/2*, and partitions.*

We study the coefficients of an infinite basis for the space of mock modular forms of weight 5/2 on the full modular group (these mock modular forms are the subject of Scott Ahlgren's talk). The "shadow" of the first element of this basis is the generating series for partitions. We show that the coefficients of these mock modular forms are given by traces of singular invariants. These are values of non-holomorphic modular functions at CM points or their real quadratic analogues: cycle integrals of such functions along geodesics on the modular curve. The real quadratic case relates to recent work of Duke, Imamoglu, and Toth on cycle integrals of the j-function, while the imaginary quadratic case recovers the algebraic formula of Bruinier and Ono for the partition function. (Received July 28, 2014)

1102-11-201 **Jeff Achter*** (achter@math.colostate.edu), Department of Mathematics, Fort Collins, CO 80523-1874, and **Julia Gordon**. *Local heuristics and exact formulas for elliptic curves over finite fields.* Preliminary report.

An isogeny class of elliptic curves over a finite field is determined by a quadratic Weil polynomial. Gekeler has given a beautiful product formula, purely in terms of congruence considerations involving that polynomial, for the size of such an isogeny class; an equidistribution hypothesis too strong to be true apparently calculates this cardinality. I will give a new explanation for this phenomenon. (Received July 28, 2014)

1102-11-222 **Joshua A. Day*** (dayja10@uww.edu) and **Ki-Bong Nam**. *Observing Integer Solutions of Various Algebraic Equations with Modular Congruences.*

Mathematicians thrive when it comes to solving new and different kinds of puzzles. The key is to approach any given question from as many ways possible; this often results in unique and creative solutions. Diophantine equations are a classic kind of problem that challenge a mathematician to answer a few basic questions: Are

there any nontrivial solutions? And if so, can we find out what they are? Can all the solutions to the equation even be found?

Classic examples of these types of equations are Pythagoras' Theorem and Fermat's Last Theorem. We will be using Diophantine equations of this form $ax^2+by^2=cz^2$, as well as different Pell equations as examples in order to make conclusions about the solutions to the generalized form $ax^\ell+by^m=cz^n$. Our theory that we will be using is that if there is a nontrivial solution to this equation in the set of integers modulo r ($\boldsymbol{Z}_r$), then there is a solution in the set of all integers ($\boldsymbol{Z}$).

With our proposed method, we hope to be able answer the above questions in a quick and simple way, while drawing conclusions about the integer solutions of various types of equations. (Received July 29, 2014)

1102-11-225 **Ben Brubaker***, 206 Church St. SE, Minneapolis, MN 55455. *Automorphic forms and statistical mechanics.*

Automorphic L-functions result from applying linear functionals to nice functions in an automorphic representation – generalizing the idea of taking Fourier coefficients of modular forms in the classical case.

I'll explain how the local output of one such functional for GL(n) is expressible in terms of the six vertex model from statistical mechanics, and how one can attempt to generalize this result to other classical groups.

This is based on joint work with A. Schultz, building on earlier work with D. Bump and S. Friedberg. (Received July 29, 2014)

1102-11-243 **Alain Togbe*** (atogbe@pnc.edu), 1401 S. U.S. 421, Westville, IN 46391, and **Shichun Yang**, Wenchuan, Sichuan, Peoples Rep of China. *On the P-integer conjecture of Pomerance.*

Let $k>1$ be an integer. Moreover, let $\varphi(k)$ denote Euler's totient function and $\omega(k)$ the number of distinct prime divisors of k. An integer k is a P-integer if the first $\varphi(k)$ primes coprime to k form a reduced residue system modulo k. In 1980, Pomerance proved the finiteness of the set of P-integers. Moreover, he proposed the following conjecture.

Conjecture. If k is a P-integer, then $k\leq 30$.

In this talk, we will mention the progress made to obtain a proof of this conjecture. (Received July 29, 2014)

1102-11-252 **Beth Malmskog*** (beth.malmskog@gmail.com) and **Christopher Rasmussen**. *Picard curves over $\mathbb{Q}$ with good reduction away from $p=3$.*

Following a similar project by Smart, we describe an algorithm to determine all Picard curves over $\mathbb{Q}$ with good reduction away from 3, by establishing a correspondence between the isomorphism classes of such curves and equivalence classes of certain quintic binary forms possessing a rational linear factor. An exhaustive list of integral models is determined. As part of this algorithm, we find all S-unit solutions to $x+y=1$ within relevant number fields and where the finite primes in S divide 3. We include new results that apply to solving S-unit equations under some conditions. (Received July 29, 2014)

1102-11-261 **Jennifer Berg*** (jberg@math.utexas.edu). *Brauer Manin obstruction for a family of affine surfaces.* Preliminary report.

Manin showed that the Brauer group of a variety can obstruct the existence of rational points and weak approximation. In order to compute this obstruction, however, explicit representatives of the Brauer classes are necessary. I will discuss recent work on the Brauer Manin obstruction to the existence of integral points for a family of surfaces over the rationals. I will briefly describe the obstruction, and discuss the methods used to obtain the Brauer group for this family. (Received July 29, 2014)

1102-11-265 **J. Athreya**, **S. Chaubey** and **Amita Malik*** (amalik10@illinois.edu), 1409 W Green Street, Urbana, IL 61801, and **A. Zaharescu**. *Geometric statistics of Ford circles.*

In this talk, we compute the distributions and some moments of certain statistics of geometric quantities associated to Ford circles. Our methods to compute distributions use the equidistribution of periodic orbits of the BCZ map, while our methods to compute moments are based in analytic number theory. (Received July 29, 2014)

13 ► Commutative rings and algebras

1102-13-14 **Jesse Gerald Smith*** (jgsmith.math@gmail.com), 13105 Buttermilk Rd, Knoxville, TN 37932. *When $\Gamma_I(R)$ is Complemented, Uniquely Complemented, or has Ends.* Preliminary report.

Let R be a commutative ring with nonzero identity and I a proper ideal of R. Define the *ideal-based zero-divisor graph* of R with respect to the ideal I, denoted $\Gamma_I(R)$, to be the graph on vertices $\{x \in R \setminus I \mid xy \in I$ for some $y \in R \setminus I\}$, where distinct vertices x and y are adjacent if and only if $xy \in I$. We consider $\Gamma_I(R)$ to be nontrivial if $I \neq 0$ and I is not a prime ideal. This preliminary report considers the concepts of a graph being complemented or uniquely complemented (Levy and Shapiro 2002 and Anderson et. al. 2003) for ideal-based zero-divisor graphs of commutative rings. In the 2003 paper, the authors classify when a zero-divisor graph of a commutative ring is complemented or uniquely complemented. This research extends the preceding classification to ideal-based zero-divisor graphs. In addition, we give a classification when nontrivial ideal-based zero divisor graphs have ends. (Received May 14, 2014)

1102-13-15 **Nicholas J Werner*** (nwerner@newark.osu.edu). *Covering Numbers of Finite Rings.*

Any finite non-cyclic group G is equal to a union of its proper subgroups. The covering number of G is the minimum number of subgroups necessary to cover G. Covering numbers are known for several classes of finite groups, and the computation covering numbers is a problem of current interest.

In this talk, we discuss the analogous question for finite rings. In general, not much is known. We say that a finite (associative, unital) ring R is coverable if it is equal to a union of its proper subrings, and the covering number of R is the minimum number of subrings required to cover R. Not every finite ring is coverable, and it is nontrivial to decide whether R is coverable. We will determine the covering number for R when R is coverable and equal to a direct product of finite fields. We will also present other examples and mention some avenues for further research. (Received May 26, 2014)

1102-13-22 **Hailee Peck*** (hpeck@millikin.edu). *An extension of central set results on zero-divisor graphs to ideal-divisor graphs.*

In 1988, I. Beck introduced the concept of the zero-divisor graph, which was then modified by Anderson and Livingston in 1999. In 2003, Redmond generalized this concept to an ideal-based zero-divisor graph, commonly referred to as an ideal-divisor graph, and in 2006 he proved results concerning central sets of zero-divisor graphs. We investigate properties of ideal-divisor graphs and extend many of Redmond's results from zero-divisor graphs to ideal-divisor graphs. In particular, we provide a complete classification of the radius and center of ideal-divisor graphs. (Received June 19, 2014)

1102-13-23 **Najat M. Muthana*** (nmuthana@kau.edu.sa), P.O.Box1859, Jeddah, 21441, Saudi Arabia. *On generalized Jordan triple (α, β)-derivations of rings.*

Let R be a ring and I be a nonzero ideal of R. Suppose that α, β be endomorphisms of R. An additive mapping $d : R \longrightarrow R$ is said to be a Jordan triple (α, β)-derivation if $d(xyx) = d(x)\alpha(yx)+\beta(x)d(y)\alpha(x)+\beta(xy)d(x)$ holds for all $x, y \in R$. An additive mapping $F : R \longrightarrow R$ is called a generalized Jordan triple (α, β)-derivation if there exists a Jordan triple (α, β)-derivation $d : R \longrightarrow R$ such that $F(xyx) = F(x)\alpha(yx) + \beta(x)d(y)\alpha(x) + \beta(xy)d(x)$, holds for all $x, y \in R$. In the present paper, we study Jordan triple (α, β)-derivation, generalized Jordan triple (α, β)-derivation on prime rings and find the necessary and sufficient conditions under which any Jordan triple (α, β)-derivation (resp. generalized Jordan triple (α, β)-derivation) becomes an (α, β)-derivation on I (resp. a generalized (α, β)-derivation on I). (Received June 22, 2014)

1102-13-24 **Olivier A. Heubo-Kwegna*** (oheubokw@svsu.edu), 7400 Bay Road, University Center, MI 48710. *Star Colon-Multiplication Ideals.*

In this talk, we consider a star operation $\star$ on an integral domain R. We define an ideal A of R to be a $\star$-colon-multiplication ideal if $A^\star = (B(A : B))^\star$ for all fractional ideal B of R. We prove that every maximal ideal of R is a $\star$-colon-multiplication ideal if and only if R is a $\star$-Completely Integrally Closed Domains (for short $\star$-CICD) or R is a local domain satisfying the $\star$-maximal trace property. We also show that every ideal of R is $\star$-colon-multiplication if and only if R is a $\star$-CICD. (Received June 23, 2014)

1102-13-37 **Uwe Nagel*** (uwe.nagel@uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506. *The Lefschetz Properties.* Preliminary report.

An artinian graded algebra is said to have the Weak Lefschetz property if multiplication by a general linear form has maximal rank in every degree. At first glance this might seem to be a simple problem of linear algebra, but instead it has proven to be extremely elusive, even in the case of very natural families of algebras. In this talk

we present some results and challenging problems. We also discuss some of the many connections to seemingly unrelated problems. (Received July 02, 2014)

1102-13-38 **Christopher Park Mooney*** (christopher.mooney@westminster-mo.edu), Westminster College, 501 Westminster Ave., Fulton, MO 65251. *τ-Complete factorization in commutative rings with zero-divisors.*

We consider extending τ-factorization, first introduced for integral domains by D.D. Anderson and A. Frazier in 2011, to rings with zero-divisors by way of complete factorizations. Instead of looking at factorization into a particular type of irreducible or prime element, we instead study factorizations which cannot be refined any further into any properly longer factorization. We take this notion and extend definitions using generalized factorization techniques. We then study the relationship between rings satisfying various τ-finite factorization properties, which have been studied previously, and τ-complete finite factorization properties. (Received July 03, 2014)

1102-13-43 **Dan Anderson*** (dan-anderson@uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242, and **Jason Juett**. *Length functions for factorization in commutative rings.*

Let R be a commutative ring, not necessarily an integral domain. We investigate several functions which measure the length of factorizations of an element of R; namely, maximal length, minimal length (of an atomic factorization), ordinal-valued length, and minimal (resp., maximal) length of the essential part of a U-decomposition (resp, U-factorization). We also consider the corresponding elasticities. (Received July 07, 2014)

1102-13-48 **Jay A Shapiro*** (jshapiro@gmu.edu), George Mason University, Dept. of Mathematics, Fairfax, VA 22030. *The Ohm-Rush content function.*

The content of a polynomial over a ring R is a well understood notion. Ohm and Rush generalized this concept of a content map to an arbitrary ring extension of R, although it can behave quite badly. We examine certain properties an algebra may have with respect to this function – content algebra, weak content algebra, semicontent algebra (our own definition), and Ohm-Rush algebra. We show that the weak content and semicontent algebra properties are transitive. However, transitivity is unknown for the content algebra property. Given time we will then compare the Ohm-Rush notion with the more usual notion of content in the power series context. (Received July 11, 2014)

1102-13-58 **Steven V Sam*** (svs@math.berkeley.edu). *Infinite-dimensional combinatorial commutative algebra.*

A recent trend in commutative algebra has been to prove uniform properties of a family of algebraic objects X_n by studying a suitable limit X_∞ and proving finiteness properties for it. I will illustrate this by surveying two recent results about Segre varieties: (1) the result of Draisma and Kuttler which shows that there exists a universal bound $d(r)$ such that the rth secant variety of any Segre variety is set-theoretically defined by equations of degree at most $d(r)$, and (2) the theory of Δ-modules (introduced by Snowden) which shows that each Tor module of a Segre variety is finitely generated by certain functorial operations, and hence has a finite description (the key point is that both results are independent of the dimensions of the projective space factors and the number of factors). (Received July 13, 2014)

1102-13-67 **Kyle A Roy*** (royka@miamioh.edu), 325 Foxfire Drive #111, Oxford, OH 45056. *Facet ideals of trees and free resolutions of Stanley-Reisner ideals.*

Given a simplicial complex Δ we can associate to Δ a certain sqaure-free monomial ideal commonly called the Stanley-Reisner ideal of Δ. In general, Hochster's Formula gives a way to compute the betti numbers of these ideals. For certain simplicial complexes, we compute the graded betti numbers of these Stanley-Reisner ideals, by observing that Hochster's Formula takes a particularly nice form in these cases. (Received July 15, 2014)

1102-13-68 **Susan Morey*** (morey@txstate.edu), Department of Mathematics, 601 University Dr., San Marcos, TX 78666. *Square-free Monomial Ideals: Where Commutative Algebra, Graph Theory and Combinatorics Meet.*

In this talk, the direction presented will be toward the intersection of Commutative Algebra and Discrete Mathematics. There is a natural one-to-one correspondence between square-free monomial ideals and clutters, which are also called simple hypergraphs. Using this correspondence, algebraic properties of ideals can be translated into graph theoretic or combinatorial properties, thus allowing techniques from one field of mathematics to be used to answer questions from another. When the ideal is generated in degree two, the corresponding clutter is a graph. The Past for this talk will start with the introduction of edge ideals of graphs in 1990. Exploiting

the dual algebraic and combinatorial natures of square-free monomial ideals has proven to be a fertile source of mathematical results in recent years. A survey of some recent results in this area, including examples of how both algebraic and combinatorial proof techniques can be used to extract information about edge ideals, will constitute the Present. The Future will consist of a discussion of a few of the open problems in this area. Results presented will focus on algebraic invariants, such as depth, projective dimension, and associated primes of square-free monomial ideals and their powers. (Received July 15, 2014)

1102-13-70 **Richard Erwin Hasenauer*** (rhasenauer@eureka.edu), Eureka College, 300 E. College Ave., Eureka, IL 61530. *The topology of factorization properties.*

Classifications of bounded and finite factorization domains are given using topological notions. An unbounded almost Dedekind finite factorization domain is constructed following the method of Grams. For a class of almost Dedekind (not Dedekind) domains it is shown that ACCP and BFD are equivalent. (Received July 15, 2014)

1102-13-77 **Thomas Marley** and **Marcus Webb*** (mwebb4@math.unl.edu). *The Frobenius Functor and Flat and Injective Dimension.*

We investigate the action of the Frobenius functor on flat and injective resolutions. We show that a result of Peskine and Szpiro for modules of finite projective dimension extends to modules of finite flat dimension and use this to extend a result of Marley characterizing the Gorenstein property in terms of the Frobenius functor. We also show by example that, unlike the projective case, the Frobenius functor need not preserve the finiteness of the injective dimension of a finitely generated R-module - even if $F_R(I) \cong I$ for every injective module I. (Received July 17, 2014)

1102-13-83 **Sankar P Dutta*** (dutta@math.uiuc.edu). *On the Edge Homomorphism of a Spectral Sequence.* Preliminary report.

The purpose of this talk is to present a connection between the non-vanishing of a specific edge homomorphism of a spectral sequence originating from the associativity property of Hom and Tensor product and several homological conjectures. Ramifications of this observation will be discussed. Recent advances on Serre's conjecture on Intersection Multiplicity will also be mentioned if time permits. (Received July 20, 2014)

1102-13-90 **Simplice Tchamna*** (simplice.tchamna@gcsu.edu), Department of Mathematics, Georgia College & State University, Milledgeville, GA 31061, and **Lokendra Paudel** (lokendra@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003. *Kronecker function rings of ring extensions.*

Let R be a subring of S. We introduce the notion of S-star operation for the ring extension $R \subseteq S$ and we define a Kronecker function ring of R with respect to S. The goal of this work is generalize the concept of Kronecker function rings from integral domains to commutative ring extensions. In particular, we focus on the case where the extension $R \subseteq S$ is a Prüfer or a Bézout. We show that most of the results obtained in the classical case can be generalized to rings extensions. We also study the relation between the pullback diagrams and Kronecker function rings. (Received July 22, 2014)

1102-13-94 **Shane P Redmond*** (shane.redmond@eku.edu), Richmond, KY 40475, and **S Pirzada** and **Rameez Raja**. *Finding locating sets and locating numbers of zero-divisor graphs of commutative rings.* Preliminary report.

For an ordered set $W = \{w_1, w_2, \cdots, w_k\}$ of vertices of G and a vertex v of G, the locating code of v with respect to W is the k-vector $c_W(v) = (\ d(v, w_1), d(v, w_2), \cdots, d(v, w_k))$. The set W is a locating set for G if distinct vertices have distinct codes. A locating set containing a minimum number of vertices is a minimum locating set for G. The locating number, denoted by $loc(G)$, is the number of vertices in the minimum locating set for G. This talk explores the role locating sets play in zero-divisor graphs of commutative rings. Specifically, equivalence relations among the vertices of the zero-divisor graph, cut vertices and locating sets, and locating numbers of products of rings will be discussed. (Received July 22, 2014)

1102-13-105 **Amy Schmidt*** (aschmid9@masonlive.gmu.edu), Department of Mathematics, 4400 University Drive, MS: 3F2, Fairfax, VA 22030. *Fixed Rings: FIP, FCP, and Complete Rings of Quotients.*

Let $R \subset T$ be a unital extension of commutative rings. Let G be a subgroup of the automorphism group of a ring T such that R is G-invariant. We say a property of the extension $R \subset T$ is *invariant (under G)* if the extension of fixed rings $R^G \subset T^G$ has the property. We continue the investigation of determining such invariant properties. We consider the finite chain property (FCP) and finite intermediate algebra property (FIP) and related properties of ring extensions. We also determine that the fixed ring of the complete ring of quotients is

the compete ring of quotients of the fixed ring, i.e., $Q(R)^G = Q(R^G)$ where G acts on R via automorphisms. (Received July 24, 2014)

1102-13-108 **Hannah L Altmann*** (hannah.altmann@ndsu.edu). *Semidualizing modules over tensor products.* Preliminary report.

Let R be a commutative, noetherian ring with identity. A finitely generated R-module C is *semidualizing* if the homothety map $\chi_C^R : R \to \mathrm{Hom}_R(C, C)$ is an isomorphism and $\mathrm{Ext}^i_R(C, C) = 0$ for all $i > 0$. For example, R is semidualizing over R, as is a dualizing module, if R has one. In some sense the number of semidualizing modules gives a measure of the "complexity" of R. We are interested in that number. We will discuss constructing semidualizing modules over tensor products of rings over a field. In particular, this gives us a lower bound on the number of semidualizing modules over the tensor product. (Received July 24, 2014)

1102-13-112 **Jason R Juett*** (jason.juett@gmail.com), 4513 Lyons Drive, Marion, IA 52302. *Spectral Partially Ordered Sets.*

We characterize the partially ordered sets that are isomorphic to the prime spectra of rings satisfying the ascending (resp., descending) chain condition on radical ideals. We also discuss partial order topics related to G-ideals, and show that a dual of a tree is isomorphic to the Goldman spectrum of a ring if and only if every nonempty chain has an upper bound. Lastly, we give some new methods for constructing (gold)spectral partially ordered sets. (Received July 24, 2014)

1102-13-128 **Luchezar L Avramov*** (avramov@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Hans-Bjørn Foxby's work in commutative algebra.*

A survey of major themes and contributions in Foxby's work. (Received July 26, 2014)

1102-13-141 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu), **Benjamin Anderson**, **Anders Frankild**, **Richard Wicklein** and **Roger Wiegand**. *Two questions about Ext.* Preliminary report.

Let k be a field, and consider the localized polynomial ring $R = k[x_1, \dots, x_d]_{(x_1,\dots,x_d)}$ with $\widehat{R} = k[\![x_1, \dots, x_d]\!]$. We consider the following two questions about $\mathrm{Ext}^i_R(-, R)$.

Question 1. For which values of i do we have $\mathrm{Ext}^i_R(\widehat{R}, R) \neq 0$? It is known that $\mathrm{Ext}^i_R(\widehat{R}, R) = 0$ for $i = 0$ and for $i > d$. And it is known that $\mathrm{Ext}^i_R(\widehat{R}, R) \neq 0$ for at least one value of i, necessarily between 1 and d. In particular, a complete answer is known for $d = 1$.

Question 2. For which prime ideals $\mathfrak{p} \subset R$ does there exist an integer i such that $\mathrm{Ext}^i_R(\kappa(\mathfrak{p}), R) \neq 0$? It is known that the maximal ideal $\mathfrak{m} = (x_1, \dots, x_d)R$ satisfies this condition: one has $\mathrm{Ext}^i_R(\kappa(\mathfrak{m}), R) \neq 0$ if and only if $i = d$. A complete answer is known for $d = 1$, and partial answers are known for $d > 1$. (Received July 27, 2014)

1102-13-142 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu). *Derived category techniques in commutative algebra.*

A fundamental idea in homological algebra is to consider a complex of R-modules as a single object to be acted on and studied as a whole, rather than as a combination of separate pieces. For instance, this allows one to study the modules $\mathrm{Ext}^i_R(M, N)$ by studying any of the complexes that give rise to these modules. Hans-Bjørn Foxby was a pioneer in this area, with his coauthors, students, and colleagues. I will discuss several results (past and recent) about modules where the only proofs I know require one to use derived categories, and some future directions in this area. (Received July 27, 2014)

1102-13-176 **Catalin Ciuperca*** (catalin.ciuperca@ndsu.edu), Department of Mathematics 2750, North Dakota State University, PO Box 6050, Fargo, ND 58108. *Asymptotic growth of multiplicity functions.*

A well know result of Rees shows that if $J \subseteq I$ are $\mathfrak{m}$-primary ideals in a formally equidimensional local ring $(R, \mathfrak{m})$, then J is a reduction of I if and only if the ideals I and J have the same Hilbert-Samuel multiplicity. In the literature there are results in several directions that generalize this numerical characterization of reductions to the situation when the ideals are not necessarily $\mathfrak{m}$-primary, in which case the classical Hilbert-Samuel multiplicity is no longer defined. One such direction was initiated by Amao and Rees who showed that if $J \subseteq I$ are ideals such that the length $\lambda(I/J)$ is finite, then the function $\lambda(I^n/J^n)$ is eventually a polynomial function whose degree is at most $\dim R - 1$ if and only if J is a reduction of I.

In this talk we review results originated by the work of Amao and Rees and present a generalization of them in the case when the length $\lambda(I/J)$ is not necessarily finite by considering several multiplicity functions associated with the pair of ideals $J \subseteq I$. (Received July 28, 2014)

1102-13-223 **Sean Sather-Wagstaff** and **Jonathan Totushek*** (jonathan.totushek@ndsu.edu). *Finiteness of Homological Dimensions with Respect to a Semidualizing Complex.* Preliminary report.

A result of Foxby states: If there exists a complex with finite depth, finite flat dimension, and finite injective dimension over a local ring R, then R is Gorenstein. In this talk we will investigate some homological dimensions involving a semidualizing complex and improve upon Foxby's result by answering a question of Takahashi and White. In particular we prove for a semidualizing complex C, if there exists a complex with finite depth, finite $\mathcal{F}_C$-projective dimension, and finite $\mathcal{I}_C$-injective dimension over a local ring R, then R is Gorenstein. (Received July 29, 2014)

1102-13-241 **Christine Berkesch Zamaere*** (cberkesc@math.umn.edu), **Daniel Erman** and **Gregory G. Smith**. *Free complexes on smooth toric varieties.*

I will discuss work in progress related to strengthening homological tools over Cox rings of smooth toric varieties. (Received July 29, 2014)

1102-13-255 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu). *Homology of tensor product complexes.*

H.-B. Foxby was a pioneer in the study of homological properties of complexes of modules over commutative noetherian rings. In a paper from 1979 he includes a *derived depth formula,*

$$\operatorname{depth}_R(M \otimes^{\mathbf{L}}_R N) = \operatorname{depth}_R M + \operatorname{depth}_R N - \operatorname{depth} R\,,$$

that holds for complexes M and N of modules over a local ring R, provided that they have non-zero homology in only finitely many degrees and one of them is isomorphic in the derived category to a bounded complex of flat R-modules. The *Auslander–Buchsbaum formula* (1957) is a special case of this formula, and so is Auslander's *depth formula* for Tor-independent modules (1961).

Over the past 35 years, a number of authors have revisited Foxby's derived depth formula and generalized it in several directions. I'll survey these developments up to and including work in progress with Celikbas, Liang, and Piepmeyer. (Received July 29, 2014)

1102-13-256 **Kevin Tucker*** (kftucker@uic.edu) and **Milena Hering**. *F-splitting ratio of monoid algebras.*

The F-splitting ratio and dimension are invariants first defined by I. Aberbach and F. Enescu that govern the asymptotic number of splittings of the iterates of Frobenius for a local ring. In this talk, I will discuss joint work with M. Hering giving a combinatorial formula for the F-splitting ratio and dimension of monoid algebras. Our characterization builds up the work M. Von Korff in the normal setting, and realizes the F-splitting ratio as the (appropriately scaled) lattice volume of particular polytope. In particular, this makes it rather easy to produce many examples of local rings of various F-splitting dimensions. (Received July 29, 2014)

1102-13-264 **Mathias Lederer** and **Jenna Rajchgot*** (rajchgot@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *The "T-complex" of a Hilbert scheme.*

A Grothendieck Hilbert scheme parametrizes ideals with a given Hilbert polynomial. It carries a natural torus action, and the T-graph of a Hilbert scheme records the data of the zero and one-dimensional torus orbits. Algorithms are known for computing the schemes representing the edges of the graph (due to Altmann and Sturmfels), and combinatorial necessary conditions are known for the existence of an edge connecting two particular vertices (eg. due to Hering and Maclagan).

After reviewing this story, I will offer possible definitions of a "T-complex" which records the data of higher dimensional torus orbits, and will discuss some results about the T-complex in analogy with known results about the T-graph.

This work is joint with Mathias Lederer. (Received July 29, 2014)

1102-13-266 **Neil Epstein*** (nepstei2@gmu.edu), Department of Mathematical Sciences, 4400 University Drive, Fairfax, VA 22030. *Closure operations in commutative algebra.*

Closure operations on ideals (and submodules) have grown to be a central characteristic of commutative algebra. I will touch on connections with many other notions that come up in the field, such as multiplicities, ring extensions, homological conjectures, matroids, cores, torsion theories and star operations. Some representative closure operations may be given special attention during the talk, but the perspective will remain broad. (Received July 30, 2014)

1102-13-272 **Pye Phyo Aung*** (pye.aung@ndsu.edu). *Gorenstein Dimensions over Some Rings of the Form $R \oplus C$.*

Given a semidualizing module C over a commutative noetherian ring R, Holm and Jørgensen investigate some connections between C-Gorenstein dimensions of an R-complex M and Gorenstein dimensions of M viewed as a complex over the "trivial extension" $R \ltimes C$. We will discuss generalizations of some of their results to a certain type of retract diagram. We will also discuss some examples of such retract diagrams, namely D'Anna and Fontana's amalgamated duplication and Enescu's pseudocanonical cover. (Received July 30, 2014)

14 ► Algebraic geometry

1102-14-32 **Jason A. Miller*** (millerj@math.osu.edu), 100 Math Tower, 231 West 18th Avenue, Columbus, OH 43210. *Okounkov Bodies of Borel Orbit Closures.*

The theory of Okounkov bodies generalizes the relationship between toric geometry and polytopes. The theory associates to a valuation v and line bundle $\mathcal{L}$ on a projective variety, a convex body $\Delta_v(\mathcal{L})$, which encodes information about the variety and line bundle. Spherical varieties are a generalization of certain classes of varieties with group actions such as toric and flag varieties. For these varieties, Okounkov theory can be used to encode information about the G-orbits via faces on an associated polytope. However, much of the structure of these varieties is determined by the Borel orbit structure which is generally not well understood. I will discuss original work examining an extension of this correspondence for a certain class of spherical varieties, wonderful group compactifications. Given any Borel orbit closure Z of a wonderful group compactification, the Okounkov construction gives a finite union of faces of the Okounkov polytope. This correspondence enjoys the same properties as in the case of G-orbits. The dimension of the space of global sections $H^0(Z, \mathcal{L})$ is given by the number of lattice points in the union of faces. One can then calculate the degree of $\mathcal{L}$ by taking the sum of the volume of these faces. (Received June 27, 2014)

1102-14-40 **Ivan E. Horozov*** (horozov@math.wustl.edu), Washington University in t. Louis, One Brookings Dr., Campus Box 1146, Saint Louis, MO 63130. *Reciprocity Laws on Algebraic Surfaces via Iterated Integrals.*

In this talk we will introduce new local symbols, which we call 4-function local symbols. We formulate reciprocity laws for them. These reciprocity laws are proven using a new method - multidimensional iterated integrals. Besides providing reciprocity laws for the new 4-function local symbols, the same method works for proving reciprocity laws for the Parshin symbol. Both the new 4-function local symbols and the Parshin symbol can be expressed as a finite product of newly defined bi-local symbols, each of which satisfies a reciprocity law. The K-theoretic variant of the first 4-function local symbol will be defined. It differs by a sign from the one defined via iterated integrals. Both the sign and the K-theoretic variant of the 4-function local symbol satisfy reciprocity laws, whose proof is based on Milnor K-theory. The relation of the 4-function local symbols to the double free loop space of the surface (the space of maps from a torus to the surface) is given by iterated integrals over membranes. (Received July 05, 2014)

1102-14-44 **Frédéric Bihan** and **Kaitlyn Phillipson*** (kaitlyn@math.tamu.edu), College Station, TX 77845, and **Erika Refsland**, **Robert Rennie** and **J. Maurice Rojas**. *Linear Forms in Logarithms and Fast Topology Computation for Positive Zero Sets of Sparse Polynomials.*

Let K be any field. Suppose $f \in K[x_1, \ldots, x_n]$ has exactly $n + k$ terms and its set of exponent vectors does not lie in any affine hyperplane. We call f an honest n-variate $(n + k)$-nomial and let Z denote the zero set of f in K^n. The case where $k = 1$ and K is a finite field formed the genesis of the Weil Conjectures in 1940.

We study the case $K = \mathbb{R}$ and focus on the complexity of computing the topology of Z. We show that Baker's Theorem on Linear Forms in Logarithms implies that, for $k \leq 2$ and n fixed, the isotopy type of the positive part of Z can be computed in polynomial time. (In particular, this means time polynomial in the log of the degree of f.) This result has many practical implications, including strengthening the known bounds for isotopy types and connected components of positive zero sets of sparse polynomials. We also show that the underlying algorithm can be sped up to complexity polynomial in n if Baker's refinement of the abc-Conjecture is true. As a consequence, we obtain that a particular complexity lower bound in real algebraic geometry presents an obstruction to a strengthening of the abc-Conjecture. (Received July 08, 2014)

1102-14-57 **Steven V Sam*** (svs@math.berkeley.edu). *Hyperplane arrangements and classical moduli spaces.*

Given a finite collection of hyperplanes in V, associate to each hyperplane its defining linear form and to each flat (intersection of hyperplanes) the corresponding product of linear forms. After a suitable reembedding of the hyperplane arrangement into a larger space V', each flat has associated to it a monomial map, and so a choice of flats gives a toric variety (the closure of the image of V' by the monomial map) with a distinguished linear section (the image of the original space V). I'll give some examples of flats in Coxeter arrangements of types E_6 and E_7 where the linear sections give classical moduli spaces (of cubic surfaces and plane quartics) and some partial results on the ambient toric varieties.

Joint work with Qingchun Ren, Gus Schrader, and Bernd Sturmfels. (Received July 13, 2014)

1102-14-91 **Nathan Ilten*** (nilten@sfu.ca) and **Hendrik Suess** (hendrik.suess@ed.ac.uk). *Frobenius Splitting of Varieties with Torus Action.*

The property of an algebraic variety being Frobenius split has many strong consequences, including certain cohomological vanishing. While normal toric varieties are always Frobenius split, varieties with more general torus actions need not be.

In this talk, I will relate the existence of a Frobenius splitting for a normal variety with torus action to the existence of a Frobenius splitting for a suitable quotient. This leads to a complete characterization of which normal varieties with complexity-one torus action are Frobenius split, as well as a reinterpretation of Payne's characterization of diagonally split toric varieties. (Received July 22, 2014)

1102-14-98 **Joseph Gubeladze*** (soso@sfsu.edu), Department of Mathematics, San Francisco State University, San Francisco, CA 94132. *Higher K-theory of toric varieties.*

We report on recent progresses in understanding higher K-theory of general toric varieties, accomplished in a series of works of several people. In the second half of the talk we will discuss a conjectural description of higher K-groups of these varieties, representing a far reaching – in a sense the ultimate extension of the known results. In general terms, the theory develops around controlling the failure of homotopy invariance of Quillen's theory and the conjecture is a multi-graded refinement of the previously known results. The starting point is the positive results for the Grothendieck group of vector bundles on toric varieties, known since the 1980s. (Received July 23, 2014)

1102-14-107 **Steven Sperber*** (sperber@math.umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455, and **Alan Adolphson** (adolphs@math.okstate.edu), Oklahoma State University, Department of Mathematics, Stillwater, OK 74078. *Hasse Invariants and Mod p Solutions of A-Hypergeometric Systems.*

The Hasse invariant of a family of elliptic curves defined over a finite field of characteristic p, distinguishes the ordinary curves in the family from the supersingular ones. Igusa noted that the Hasse invariant of the Legendre family of elliptic curves is a solution mod p of a Gauss hypergeometric differential equation. We consider general families of (twisted) exponential sums defined on the n-fold torus over the finite field; we define and give an algorithm for determining the Hasse invariant of the family; and we relate the Hasse invariant to a suitable sum of products of mod p solutions of A-hypergeometric systems. (Received July 24, 2014)

1102-14-152 **Laurentiu Maxim*** (maxim@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Dr, Madison, WI 53706, and **Joerg Schuermann**. *Characteristic classes of singular toric varieties.*

We discuss the computation of the homology Hirzebruch characteristic classes of (possibly singular) toric varieties. We present two different perspectives for the computation of these characteristic classes. First, we take advantage of the torus-orbit decomposition and the motivic properties of the homology Hirzebruch classes to express the latter in terms of the (dual) Todd classes of closures of orbits. The obtained formula is then applied to weighted lattice point counting in lattice polytopes. Secondly, in the case of simplicial toric varieties, we make use of the Lefschetz-Riemann-Roch theorem in the context of the geometric quotient description of such varieties. In this setting, we define mock Hirzebruch classes of simplicial toric varieties and investigate the difference between the (actual) homology Hirzebruch class and the mock Hirzebruch class. We show that this difference is localized on the singular locus, and we obtain a formula for it in which the contribution of each singular cone is identified explicitly. This is joint work with Joerg Schuermann. (Received July 27, 2014)

1102-14-157 **Alexandra Seceleanu*** (aseceleanu@unl.edu). *Configurations of points and lines with interesting algebraic properties.*

Symbolic powers of ideals have long played a significant part in algebraic geometry and in commutative algebra, where containment relations between symbolic powers and ordinary powers have become a focus of interest. This area has seen exciting new developments recently. It had been expected that $I^{(Nr-N1)} \subseteq I^r$ should hold for the ideal I of any finite set of points in $\mathbb{P}^N$ and all $r > 0$, but in the last years various counterexamples to this conjecture have been constructed, many involving point sets arising as intersections of line arrangements in the plane. The talk will give an overview of some interesting algebraic features of these counterexamples. (Received July 29, 2014)

1102-14-195 **Xin Zhou*** (paulxz@umich.edu), 40 Newport Parkway, Apt 2107, Jersey City, NJ 07310. *Asymptotics of toric syzygies.*

In this talk, I will discuss results on the asymptotics of toric syzygies. We give a sharp asymptotic description of the distribution of torus weights for syzygies of toric varieties. In particular, I will focus on the special case of projective spaces. (Received July 28, 2014)

1102-14-211 **Brooke Ullery*** (brookeullery@gmail.com), Department of Mathematics, 530 Church Street, Ann Arbor, MI 48109. *Normality of Secant Varieties.*

If X is a smooth variety embedded in projective space, we can form a new variety by looking at the closure of the union of all the lines through 2 points on X. This is called the secant variety to X. Similarly, the Hilbert scheme of 2 points on X parametrizes all length 2 zero-dimensional subschemes. I will talk about how these two constructions are related. More specifically, I will show how we can use certain vector bundles on the Hilbert scheme to help us understand the geometry of the secant variety, leading to a proof that for sufficiently positive embeddings of X, the secant variety is a normal variety. (Received July 29, 2014)

1102-14-220 **Claudiu Raicu*** (craicu@nd.edu). *Characters of equivariant D–modules on Veronese cones.* Preliminary report.

Equivariant local systems on orbits of a group action give rise via the Riemann–Hilbert correspondence to equivariant D–modules, which are typically hard to describe. I will explain how to compute explicitly the characters of the GL–equivariant D–modules supported on the Veronese cones. In particular, I will appeal to recent results of de Cataldo, Migliorini and Mustaţă on the Decomposition Theorem for toric maps, and show how representation theoretic stabilization results are used in a crucial way in the calculation. (Received July 29, 2014)

1102-14-224 **Corey Irving** and **Hal Schenck*** (schenck@math.uiuc.edu). *Geometric modeling and barycentric coordinates for polygons.*

Let P_d be a convex polygon with d vertices. The associated Wachspress surface W_d is a fundamental object in approximation theory, defined as the image of the rational map w_d from P^2 to P^{d-1}, determined by the Wachspress barycentric coordinates for P_d. We show w_d is a regular map on a blowup X_d of P^2, and if $d > 4$ is given by a very ample divisor on X_d, so has a smooth image W_d. We determine generators for the ideal of W_d, and prove that in graded lex order, the initial ideal of $I(W_d)$ is given by a Stanley-Reisner ideal. As a consequence, we show that the associated surface is arithmetically Cohen-Macaulay, of Castelnuovo-Mumford regularity two, and determine all the graded betti numbers of $I(W_d)$. (Received July 29, 2014)

1102-14-239 **Sandra Di Rocco**, Royal Institute of Technology (KTH), **Kelly Jabbusch**, University of Michigan—Dearborn, and **Gregory G. Smith***, Queen's University, Kingston. *Positivity properties of vector bundles on smooth toric varieties.* Preliminary report.

Extending the well-known dictionary between line bundles and polytopes, we will explain how to associate a collection of polytopes to a torus-equivariant vector bundle on a smooth complete toric variety. Using this collection, we will compare and contrast various positivity properties for vector bundles such as ample, nef, globally generated, and very ample. (Received July 29, 2014)

1102-14-250 **Matthew Satriano***, 117 West 27th Street, Baltimore, MD 21218. *Which varieties are global quotients by finite groups?*

If a variety X is a global quotient of a smooth variety by a finite group, it has quotient singularities. In this talk we address whether the converse is true, a question posed by Fulton. We show that the answer is "yes" for a large class of varieties, and give an explicit algorithm for toric varieties. This is joint work with Anton Geraschenko. (Received July 29, 2014)

1102-14-254 **Maria Angelica Cueto*** (macueto@math.columbia.edu), Department of Mathematics, Columbia University, 2990 Broadway - MC 4403, New York, NY 10027, and **Hannah Markwig**. *Repairing tropical curves by means of linear tropical modifications.* Preliminary report.

Tropical geometry is a piecewise-linear shadow of algebraic geometry that preserves important geometric invariants. Often, we can derive classical statements from these (easier) combinatorial objects. One general difficulty in this approach is that tropicalization strongly depends on the embedding of the algebraic variety. Thus, the task of finding a suitable embedding or of repairing a given "bad" embedding to obtain a nicer tropicalization that better reflects the geometry of the input curve becomes essential for many applications. In this talk, I will show how to use linear tropical modifications and Berkovich skeleta to achieve such goal.

I will focus on examples, especially of plane elliptic cubics defined over the field of Puiseux series. In the latter case, good embeddings are characterized by the classical j-invariant. Given a plane elliptic cubic whose tropicalization contains a cycle, we present an effective algorithm to linearly re-embed the curve so that its tropicalization reflects the j-invariant. I will present an elementary proof, by interpreting the initial terms of the discriminant of the cubic as products of the discriminants of all 2-cells in the induced Newton subdivision of the input plane cubic. This is joint work, in progress, with Hannah Markwig. (Received July 29, 2014)

1102-14-258 **Laura Felicia Matusevich*** (laura@math.tamu.edu) and **Jens Forsgård**. *Transformations of A-hypergeometric functions.* Preliminary report.

We explore how the automorphisms of a toric variety induce transformations of the corresponding hypergeometric functions. In this way we are able to reinterpret some classical transformation formulas. (Received July 29, 2014)

1102-14-270 **Sheamin Khyeam** (sheaminkhyeam@gmail.com), 29 Washington St., Tenafly, Tenafly, NJ 07670, and **Jin Lee*** (nycrick@gmail.com), 29 Washington St, Tenafly, NJ 07670. *Vertex Diagonal Sequence (VDS) Patterns in the Polygons and Polyhedrons.*

A Vertex Diagonal Sequence (VDS) is a geometrical term used for a group of numbers that each represents the number of edges that meet at each vertex. Also, it is possible to triangulate a given plane or volume by connecting vertices with lines that don't already meet. The purpose of this research is to find VDS patterns between a triangulated polyhedron and its VDS sequence. This paper shows that both any polygons with two dimensional shape and certain polyhedrons will have a pattern in their VDS. Polyhedrons such as pyramids were analyzed by assuming that they have vertex diagonals depending on whether one allows three or more lines to meet at a point. These results can help find new properties of complicated structures with polygons and polyhedrons by setting up generalized formula for the patterns. Also finding a pattern in the VDS could help mathematicians and engineers efficiently analyze and develop new geometrical shapes, with more stable triangular elements. (Received July 30, 2014)

15 ► Linear and multilinear algebra; matrix theory

1102-15-101 **Eric Weber*** (esweber@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011, **Dorin Dutkay** (dorin.dutkay@ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816, and **John Haussermann** (jhaussermann@knights.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Spectral Properties of Small Hadamard Matrices.*

A Hadamard matrix is a unitary matrix with entries which all have the same complex modulus. We endeavor to calculate the spectrum of a given Hadamard matrix. As a first step, we prove that if A and B are Hadamard matrices which are both of size 4×4 or 5×5 and in dephased form, then $tr(A) = tr(B)$ implies that A and B have the same eigenvalues, including multiplicity. We calculate explicitly the spectrum for some subclasses of these matrices. We also extend these results to larger Hadamard matrices which are permutations of the Fourier matrix. (Received July 23, 2014)

16 ► Associative rings and algebras

1102-16-13 **Xueqing Chen*** (chenx@uww.edu), Department of Mathematics, 800 West Main Street, Whitewater, WI 53190, and **Jie Xiao** and **Fan Xu**. *"Hall algebras and quantum groups arising from 2-periodic derived categories".* Preliminary report.

Inspired by the recent work of Bridgeland [1], we extend the derived Hall algebras defined in [2] and [3] to that from a period 2 derived category. This provides a successful model to realize the quantum groups globally. The talk is based on a joint work with J. Xiao and F.Xu. 1 T.Bridgeland, Quantum groups via Hall algebras of complexes, Annals of Math. 177 (2013), 739-759. 2 B.Toen, Derived Hall algebras, Duke Math.J. 135 (2006), 587-615 3 J.Xiao and F.Xu, Hall algebras associated to triangulated categories, Duke Math.J. 143 (2008), 357-373. (Received May 05, 2014)

1102-16-64 **Wee-Liang Gan** and **Liping Li***, 900 University Avenue, Surge 243, Riverside, CA 92521. *Noetherian Property of infinite EI categories.*

Recently a few infinite EI categories are used to study representations of families of finite groups (for instance, symmetric groups, general linear groups) simultaneously. Particular examples include the category of finite sets and injections between them (called *FI category*), the category of finite dimensional spaces over a finite field and linear embeddings, etc. These categories are shown to have many nice properties such as local Noetherian property and representation stability.

In this talk we consider arbitrary infinite EI categories $\mathcal{C}$ of type A_∞, and show that certain combinatorial assumptions imply the local Noetherian property of the category algebra $k\mathcal{C}$ where k is a field of characteristic 0. This gives a uniform proof of the local Noetherian property for many interesting examples.

This is a joint work with Wee-Liang Gan. (Received July 14, 2014)

1102-16-131 **Alison Gordon Lynch*** (gordon@math.wisc.edu). *Finite-dimensional irreducible modules for an even subalgebra of $U_q(\mathfrak{sl}_2)$.* Preliminary report.

In this talk, we consider a subalgebra of the quantum algebra $U_q(\mathfrak{sl}_2)$. In 2006, Ito, Terwilliger, and Weng gave a presentation for $U_q(\mathfrak{sl}_2)$ in generators x, y, y^{-1}, z, called the *equitable presentation*, and showed that $\{x^r y^s z^t : r, t \in \mathbb{N}, s \in \mathbb{Z}\}$ is a basis for $U_q(\mathfrak{sl}_2)$. In 2013, Bockting-Conrad and Terwilliger introduced a subalgebra $\mathcal{A}$ of $U_q(\mathfrak{sl}_2)$ spanned by the elements $\{x^r y^s z^t : r, s, t \in \mathbb{N}, r + s + t \text{ even}\}$. We give a presentation for the algebra $\mathcal{A}$ and we show that, for every $d \geq 1$, there exists a unique irreducible $\mathcal{A}$-module of dimension d. (Received July 26, 2014)

1102-16-197 **Hui Chen*** (hchen@math.ksu.edu). *Finite dimensional representations of Weyl algebra.* Preliminary report.

We all know the Weyl algebra has no finite dimensional representations over characteristic 0 field. What I'll talk about is its finite dimensional representations over characteristic p field, and this is actually a special case of Nakajima quiver variety. This is a joint work with Zongzhu Lin. (Received July 28, 2014)

1102-16-214 **Aaron Lauve*** (lauve@math.luc.edu), Loyola University Chicago, Department of Math, 1032 W. Sheridan Road, Chicago, IL 60660, and **Franco Saliola** (saliola.franco@uqam.ca). *Hopf algebra structure of the ring of k-Schur functions.* Preliminary report.

The k-Schur functions have many conjecturally equivalent definitions—as well as t-variants, noncommutative and quasisymmetric variants, and even torus-equivariant variants—and arise in a variety of settings, including (co)homology of the affine Grassmannian, Macdonald/Schur positivity, and more. We highlight some of these. Additionally, the ring $\Lambda_{(k)}$ of k-Schur functions is realized as a Hopf subalgebra of the Hopf algebra Λ of symmetric functions.

Some have found it easier to study the graded dual $\Lambda^{(k)}$, a quotient Hopf algebra of Λ, and its dual k-Schur functions (which happen to be a generalization of Stanley symmetric functions). These two modes of study are equivalent—products being exchanged for coproducts, etc. In this talk, we show that they are in fact *the same:* $\Lambda_{(k)} \cong \Lambda^{(k)}$ as Hopf algebras. We give several variants of this result, then frame it in the context of important open problems in the area. (Received July 29, 2014)

1102-16-216 **Vyacheslav Futorny**, **Jonas Hartwig*** (hartwig@math.ucr.edu) and **Evan Wilson**. *Irreducible completely pointed modules over quantum groups of type A.*

We give a classification of all irreducible $U_q(\mathfrak{sl}_n)$-modules which are completely pointed (meaning that all weight spaces are one-dimensional) over a characteristic zero field in which q is not a root of unity. This generalizes the classification result of Benkart, Britten and Lemire in the non quantum case. Different techniques are necessary in

the quantum case. We also show that any infinite-dimensional irreducible completely pointed $U_q(\mathfrak{sl}_n)$-module can be obtained from some irreducible completely pointed module over the quantized Weyl algebra A_n^q. (Received July 29, 2014)

1102-16-237 **Emily Norton***, Mathematics Dept, Kansas State University, 138 Cardwell Hall, Manhattan, KS 66506. *Irreducible Representations of Rational Cherednik Algebras for Exceptional Coxeter Groups.* Preliminary report.

Category $\mathcal{O}$ for rational Cherednik algebras $H_c(W)$, W a complex reflection group, is a highest weight category with simple and standard objects indexed by the irreducible representations of W. A basic problem is to describe the multiplicities of simples in standards. I will give answers to this question for the rational Cherednik algebras of the Coxeter groups $W = H_4$, F_4 with equal parameters, E_6, E_7, and E_8, with the exception of a few parameters c where the denominator of c is small. I will also give a list of the finite-dimensional representations of $H_c(W)$, their graded characters, and their dimensions, where possible. As of the writing of this abstract, this list is complete except when c is a half-integer, and excepting one questionable representation for E_6, and representations at parameters $\frac{r}{3}$, $\frac{r}{4}$, and $\frac{r}{6}$ for E_8. (Received July 29, 2014)

17 ► Nonassociative rings and algebras

1102-17-27 **Paul M Terwilliger***, 480 Lincoln Drive, Madison, WI 53706. *Billiard Arrays and finite-dimensional irreducible $U_q(\mathfrak{sl}_2)$-modules.*

In this talk we will describe the notion of a Billiard Array. This is a triangular array of one-dimensional subspaces of a finite-dimensional vector space, subject to several conditions that specify which sums are direct. We use Billiard Arrays to characterize the finite-dimensional irreducible $U_q(\mathfrak{sl}_2)$-modules, for q not a root of unity. The equitable presentation of $U_q(\mathfrak{sl}_2)$ comes up naturally in this context. (Received June 24, 2014)

1102-17-30 **Houssein El Turkey*** (houssein.el.turkey@gmail.com). *Complexity and z-complexity over Lie superalgebras.*

We compute the complexity of certain families of modules over a classical Lie superalgebra defined over the complex numbers. Boe, Kujawa, and Nakano computed the complexity of the simple and the Kac modules over the general linear Lie superalgebra of Type A. A natural continuation to their work is computing the complexity of the same family of modules over the ortho-symplectic Lie superalgebra of Type C. We give a geometric interpretation of the complexity similar to that in Type A. The complexity is not a categorical invariant. However, we compute a categorical invariant called the z-complexity and we interpret this invariant geometrically in terms of a specific detecting subsuperalgebra. In addition, we compute the complexity and the z-complexity of the simple modules over the Lie superalgebras $\mathfrak{osp}(3|2)$, $D(2,1;\alpha)$, $G(3)$, and $F(4)$. (Received June 27, 2014)

1102-17-46 **Brian Boe**, **Jonathan Kujawa*** (kujawa@math.ou.edu) and **Daniel Nakano**. *Tensor Triangular Geometry for Lie Superalgebras.*

Axiomatizing previous results in the setting of commutative Noetherian rings and the modular representations of finite groups, Balmer introduced the notion of the spectrum of a tensor triangulated category. It is analogous to the spectrum of a ring but in this case the tensor product and direct sum play the role of multiplication and addition. It is an open question to compute the Balmer spectrum for interesting categories. We successfully answer this question for the finite dimensional representations of the Lie superalgebra gl(m,n) using support varieties of the detecting subalgebra of gl(m,n). (Received July 09, 2014)

1102-17-49 **Wayne Johnson*** (waj@uwm.edu). *A multi-variate generating function for the Weyl Dimension Formula.*

We present a closed form for a multi-variate generating function for the dimensions of the irreducible representations of a semisimple, simply connected linear algebraic group over $\mathbb{C}$ whose highest weights lie in a finitely generated lattice cone in the dominant chamber. This result generalizes the formula for the Hilbert series of an equivariant embedding of a homogeneous projective variety. (Received July 10, 2014)

1102-17-52 **Apoorva Khare*** (khare@stanford.edu). *Faces and standard parabolic subsets of highest weight modules.*

We report on recent progress in the study of arbitrary highest weight modules $\mathbb{V}^\lambda$, for all highest weights λ and over any complex semisimple Lie algebra $\mathfrak{g}$. The results in our talk are threefold. First, we present three formulas to compute the set of weights of all simple highest weight modules (and others) over $\mathfrak{g}$. These formulas

are direct and do not involve cancellations. Our results extend the notion of the Weyl polytope to general highest weight $\mathfrak{g}$-modules (and the Weyl Character Formula to most simple modules). Second, we classify and describe the vertices, faces, and their symmetries for a very large class of highest weight modules, including all parabolic Verma modules and their simple quotients. Third, we completely classify inclusion relations between standard parabolic faces of arbitrary modules $\mathbb{V}^{\lambda}$, in the process extending results of Vinberg, Chari, Cellini, and others from finite-dimensional modules to all highest weight modules. (Received July 11, 2014)

1102-17-84 **Alex P. Babinski*** (alex.babinski@tufts.edu). *Levi decomposition of nilpotent centralizers in classical groups over fields of bad characteristic.* Preliminary report.

In studying the representation theory of Lie algebras, it becomes important to understand the structure of orbits and centralizers of nilpotent elements. Using $\mathfrak{sl}_2$-triples in characteristic zero, and an analogue in arbitrary good characteristic, it can be shown that such a centralizer has a Levi decomposition. Unfortunately, in bad characteristic, this analogue could fail to exist.

In this talk, we will discuss some constructions of M. Liebeck and G. Seitz which provide a "hands-on" approach to building a subgroup of the centralizer isomorphic to the reductive quotient when $G = Sp(V)$ or $O(V)$. In bad characteristic, though, this is not enough to ensure a Levi decomposition; the projection map must be an isomorphism infinitesimally as well. In many cases, we verify that this potential Levi subgroup gives a direct sum decomposition in the Lie algebra, and hence an honest Levi decomposition of the centralizer. (Received July 21, 2014)

1102-17-170 **Emilie B Wiesner*** (ewiesner@ithaca.edu), Ithaca College, 953 Danby Rd, Ithaca, NY 14850, and **Matthew Ondrus**. *Whittaker modules for the Insertion-Elimination Algebra.* Preliminary report.

The insertion-elimination algebra can be realized in terms of insertion and elimination actions on the set of rooted trees. First defined by Connes and Kreimer (2002) in relation to Feynman graphs, the insertion-elimination algebra is an infinite-dimensional Lie algebra with a triangular decomposition. As such, it provides an interesting example for study in representation theory. Some work on lowest weight modules for this algebra has been carried out by Szcsesny (2007). I'll present results, done jointly with Matt Ondrus, on Whittaker modules for this algebra, another class of modules that takes advantage of the triangular decomposition of the Lie algebra. (Received July 28, 2014)

1102-17-193 **Cuipo (Cuibo) Jiang** and **Zongzhu Lin***, Department of Mathematics, Kansas State University, Manhattan, KS 66506. *Schur-Weyl duality, level-rank duality, and duality pairs for vertex operator algebras.* Preliminary report.

We study the decomposition of tensor powers $L_{\widehat{\mathfrak{sl}}_n}(1,0)^{\otimes l}$ of the basic representations of the affine Lie algebra $\widehat{\mathfrak{sl}}_n$. Each of these representations carry a simple rational vertex operator algebra structure and the coefficient space of the trivial representation is a vertex operator algebra called commutant subalgebra. Other coefficient spaces of irreducible components are representations of this commutant vertex operator algebra. One of the main result shows that this commutant vertex operator algebra is isomorphic to the parafermion in $L_{\widehat{\mathfrak{sl}}_l}(n,0)$. The decompositions of the more general tensor product $L_{\widehat{\mathfrak{sl}}_n}(l_1,0)\otimes L_{\widehat{\mathfrak{sl}}_n}(l_2,0)\otimes\cdots\otimes L_{\widehat{\mathfrak{sl}}_n}(l_1,0)$ give the commutants of aLevi type vertex operator subalgebras of type $(l_1,\cdots,l_s)$ in $L_{\widehat{\mathfrak{sl}}_{l_1+\cdots+l_s}}(n,0)$. These results resemble the level-rank duality and Howe duality pairs. Further Howe duality pairs in vertex operator algebras are also discussed. (Received July 28, 2014)

1102-17-217 **Vyjayanthi Chari*** (chari@math.ucr.edu). *BGG Reciprocity for Current Algebras.*

Given any affine Lie algebra the associated current algebra is a particular maximal parabolic subalgebra. The category of graded representations of the current algebra have close connections with the category of finite–dimensional representations of the quantum affine algebra.

In this talk, we shall first review these connections. We then discuss a BGG type reciprocity result for current algebras and the relationship with Macdonald polynomials. (Received July 29, 2014)

1102-17-230 **Hongjia Chen** and **Jie Sun*** (sjie@mtu.edu), Mathematical Sciences, Fisher Hall 319, 1400 Townsend Drive, Houghton, MI 49931. *Universal central extensions of $\mathfrak{sl}_{m|n}$ over $\mathbb{Z}/2\mathbb{Z}$-graded algebras.*

In this talk central extensions of the Lie superalgebra $\mathfrak{sl}_{m|n}(A)$ are constructed, where A is a $\mathbb{Z}/2\mathbb{Z}$-graded superalgebra over a commutative ring K. The Steinberg Lie superalgebra $\mathfrak{st}_{m|n}(A)$ plays a crucial role. We show that $\mathfrak{st}_{m|n}(A)$ is a central extension of $\mathfrak{sl}_{m|n}(A)$ for $m+n\geq 3$. We use a $\mathbb{Z}/2\mathbb{Z}$-graded version of cyclic homology to show that the center of the extension is isomorphic to $\mathrm{HC}_1(\mathrm{A})$ as K-modules. For $m+n\geq 5$, we

prove that $\mathfrak{st}_{m|n}(A)$ is the universal central extension of $\mathfrak{sl}_{m|n}(A)$. For $m+n=3,4$, we prove that $\mathfrak{st}_{2|1}(A)$ and $\mathfrak{st}_{3|1}(A)$ are both centrally closed. The universal central extension of $\mathfrak{st}_{2|2}(A)$ is constructed explicitly. (Received July 29, 2014)

1102-17-231 **Anthony P. van Groningen*** (vangroningen@msoe.edu), Mathematics Department, 1025 N Broadway Ave, Milwaukee, WI 53202, and **Jeb F. Willenbring**. *The cubic, the quartic, and the exceptional group G_2.*

In 1949, J. A. Todd obtained a complete system of generators for the covariants of the double binary forms of degree $(3,1)$. We reconsider Todd's results by relating it to split G_2. This analysis involves considering the branching rule from the rank two complex symplectic Lie algebra to a principally embedded $\mathfrak{sl}_2$. Special cases of this branching rule are related to the covariants for the cubic and quartic binary forms. (Received July 29, 2014)

1102-17-236 **Hyunsuk Moon**, WI , South Korea, and **Moon-Ok Wang**, **Woo Jeon** and **Ki-Bong Nam*** (namk@uww.edu), 2211 Laurentide, Dept. of Math., UW-Whitewater, Whitewater, WI 53190. *Automorphism group of a general Lie algebra and Jacobian Conjecture I.* Preliminary report.

It is well known that the Jacobian conjecture holds on the polynomial ring F[x]. It is also well known that if the automorphism groups of Weyl algebras or the Witt algebras are known, then we can know the validity of the Jacobian conjecture. In this work, we find the automorphism group of the general Lie algebra $W^+(2)$. We also prove that every non-zero endomorphism of the algebra $W^+(2)$ is surjective in this work. This implies that the Jacobian conjecture holds on the polynomial ring $\mathbb{F}[x,y]$. Since the special type Lie algebra $S^+(3)$ has two ad-diagonal elements, we can find the automorphism group of the Lie algebra $S^+(3)$ as $W^+(2)$. (Received July 29, 2014)

1102-17-247 **Vera Serganova*** (serganov@math.berkeley.edu), Department of Mathematics, UC Berkeley, Berkeley, CA 94720. *Deligne's tensor categories and classical Lie superalgebras.* Preliminary report.

Deligne's categories Rep GL(t) and Rep O(t) are Karoubian tensor categories generated by one object and satisfying natural universality conditions. When t is not an integer Deligne's categories are semisimple. For integral t there exist natural functors from Deligne's categories to the categories of representations of the classical Lie supergroups GL(m,n) and OSP(m,n) with t=m-n.

We use representation theory of classical supergrous to construct new abelian tensor categories and fully faithful tensor functors form Deligne's categories to these abelian categories. We also discuss a new universal tensor category related to the strange Lie superalgebra P(n). (Received July 29, 2014)

1102-17-249 **Jean Auger*** (auger1@ualberta.ca). *Extension blocks for finite dimensional representations of Twisted Current Algebras.*

Recently, the simple finite dimensional modules of the Lie algebras called the Twisted Current Algebras have been classified. Also based on previous work on Equivariant Map Algebras, the work presented in this talk will lead to a similar description of the block decomposition of the category of finite dimensional modules in the case of Twisted Current Algebras. The Twisted Current Algebras include the Twisted Forms of Lie algebras and therefore, the so-called Margaux algebras. (Received July 29, 2014)

18 ► Category theory; homological algebra

1102-18-21 **Bethany Kubik*** (bethany.kubik@usma.edu), 601 Thayer Road, West Point, NY 10996, and **Sean Sather-Wagstaff**. *Path Ideals of Weighted Graphs.* Preliminary report.

We explore weighted graphs and their "path ideals" which are ideals in polynomial rings that are defined based on the existing paths of the graphs. We discuss the decomposition of a path ideal and the relation to minimal vertex covers for paths. We examine Cohen-Macaulay weighted graphs in the case of K_3. (Received June 18, 2014)

1102-18-229 **Cihan Bahran*** (bahra004@umn.edu). *Modules over EI-categories with finite projective dimension.*

Given a finite group and a family of subgroups, we can construct various categories like the orbit category, fusion category, transporter category. Modules over these categories with finite projective dimension are of interest, for example when studying obstructions for the group acting on a space with a given family of stabilizer subgroups.

In this talk, using the general framework of EI-categories, we will consider the question of detecting the finiteness of the projective dimension by restriction to subcategories. (Received July 29, 2014)

1102-18-253 **Terry Gannon*** (tgannon@math.ualberta.ca), Math Department, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Subfactor-like realisations of nonunitary fusion categories.*

Fusion categories are the categorification of finite-dimensional reps of finite groups, and correspond to categories of bimodules (or endomorphisms) of subfactors, as well as modules of rational vertex operator algebras (in the latter case the categories are in fact the much richer modular tensor categories). Unitary fusion categories can always be realised by endomorphisms on some C*-algebra. These realisations are very convenient, e.g. for constructing and classifying those categories, and also for determining the corresponding modular tensor category. Using these methods we find for example many modular tensor categories which don't correspond to any known VOA — these VOAs probably exist, they just haven't been constructed yet. All this sounds like abstract nonsense, but it tells where to look for new classes of VOAs. Unfortunately those methods until now have been inherently unitary, while most fusion categories are nonunitary. In my talk however, I will explain how the endomorphism methods can be extended to nonunitary fusion categories. My emphasis will be on the underlying ideas, rather than the technical details. This is joint work with David Evans. (Received July 29, 2014)

1102-18-273 **Brandon G Goodell***, bggoode@g.clemson.edu. *Connections between partially ordered groups, factorization, and homological algebra.*

The factorization behavior of a ring is, in a sense, encoded into the partial ordering imposed on the group of divisibility associated with that ring. Several fruitful results can be obtained by examining the group of divisibility, the induced partial order on that group, and some naturally induced subgroups. The iterative application of projections yields cochain complexes and a wealth of cohomological information. Our results include hints at order-sensitive structure theorems in general integral domains. Interestingly, our approach is fruitless in the classical atomic setting, so we go to great lengths to provide examples of settings in which our approach yields non-trivial information. (Received July 30, 2014)

19 ► K-theory

1102-19-174 **William Graham** and **Amber Russell*** (arussell@math.uga.edu). *Staggered Sheaves and K-Theory of Toric Varieties.* Preliminary report.

Staggered sheaves were first defined by Achar in 2009 as a generalization of the perverse coherent sheaves of Bezrukavnikov and Deligne. In 2010, Treumann described a way to define these objects for toric varieties. Then, in a joint paper appearing in 2012, Achar and Treumann defined a concept of purity for staggered sheaves similar to Deligne's for perverse sheaves. They further used their purity results to give a basis in K-theory for smooth toric varieties which exhibits a particular positivity condition. Recently, William Graham and I have been exploring this basis further, and the results of our project will be the focus of my talk. (Received July 28, 2014)

20 ► Group theory and generalizations

1102-20-41 **Matthew D Welz*** (mwelz@uwsp.edu), 2001 Fourth Avenue, Stevens Point, WI 54481, and **Richard M Foote** (foote@math.uvm.edu), 16 Colchester Avenue, Burlington, VT 05405. *Finite Groups with p-Fusion of Squarefree Type.*

For G a finite group and p a prime, we discuss two theorems under hypotheses that restrict the index of the subgroup generated by every p-element x in certain subgroups generated by pairs of its conjugates. Under one set of hypotheses G is shown to be supersolvable. Simple groups satisfying a complementary fusion-theoretic hypothesis are classified. (Received July 05, 2014)

1102-20-53 **Christopher P Bendel**, **Daniel K Nakano** and **Cornelius Pillen*** (pillen@southalabama.edu), Department of Mathematics and Statistics, University of South Alabama, Mobile, AL 36608. *Cohomology for Algebraic Groups and Frobenius Kernels.* Preliminary report.

Let G be a simple simply connected algebraic group defined over an algebraically closed field of characteristic $p > 0$. Let B be a Borel subgroup of G and U its unipotent radical. In this talk we introduce some new results

describing the cohomology of these groups and their Frobenius kernels. Also included are calculations of ordinary Lie algebra cohomology for Lie(U). (Received July 11, 2014)

1102-20-73 **Ibrahim A Saleh*** (ibrahim.saleh@uwc.edu), 5508 Arbor CT, Wausau, WI 54401.
Representations of some generalized Weyl algebras arising from non-commutative cluster structure.

In this talk we will introduce a class of non-commutative algebras that carry cluster structure. These algebras are related to generalized weyl algebras. The cluster structure gives rise to combinatorial data which will be used to construct decomposable and irreducible representations of some generalized Weyl algebras. (Received July 16, 2014)

1102-20-89 **Brian Parshall*** (bjp8w@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22903. *Structure of cohomology for restricted Lie algebras.*

Let G be a semisimple algebraic group, defined and split over $\mathbb{F}_p$, and let u be its restricted enveloping algebra. Irreducible u-modules L, L' are naturally rational G-modules and thus, for any positive integer n, $\mathrm{Ext}^n_u(L, L')$ has a natural structure as a rational G-module. After untwisting, this G-module has been recently shown to have a good filtration, at least when p is large. We discuss this result (due to the speaker and Leonard Scott), indicating what is involved in its proof. We also speculate how the result might be extended to the case in which u is replaced by higher infinitesimal subgroups. (Received July 22, 2014)

1102-20-99 **Bhama Srinivasan** and **C. Ryan Vinroot*** (vinroot@math.wm.edu). *Jordan decomposition of real-valued characters of finite reductive groups with connected center.*

Let $\mathbf{G}$ be a reductive group with connected center defined over a finite field $\mathbb{F}_q$ with q elements, and let $G = \mathbf{G}(\mathbb{F}_q)$ be the finite group of $\mathbb{F}_q$-points. We classify all irreducible complex characters of G which are real-valued through the Jordan decomposition of characters. The main tool is a uniqueness result of Digne and Michel for the Jordan decomposition of characters in the case of a connected center. (Received July 23, 2014)

1102-20-111 **Leonard L. Scott*** (lls2l@virginia.edu). *Q-Koszul algebras and small prime considerations in the homological algebra of algebraic groups.*

Recently, Brian Parshall and I have made three conjectures in "Q-Koszul algebras and three conjectures" [arXiv:1405.4419]. Two of the conjectures assert, conceptually, that much of the homological apparatus of Kazhdan-Lusztig theory should apply for p>0 to modules arising appropriately from irreducible quantum enveloping algebra modules (at a root of unity). This is asserted, and in a precise sense, even when the latter irreducible modules do not reduce irreducibly (as they do when p is large enough so that the Lusztig conjecture holds, and the weights are p-regular and in the Jantzen region). The conjectures place no restriction on weights and few restrictions on p (none for type A). I intend to discuss topics related to these conjectures. As time permits, this will include the notions of Q-Koszul and standard Q-Koszul algebras, the subject of the first conjecture in the preprint cited above. (Received July 24, 2014)

1102-20-132 **Amanda A. Schaeffer Fry*** (aschaef6@msudenver.edu), Denver, CO 80217.
Self-Normalizing Sylow 2-Subgroups and Galois Automorphisms: Type A in Characteristic 2.

A recent refinement, due to G. Navarro, of the McKay conjecture would yield a way to read off from the character table of a finite group G whether a Sylow subgroup of G is self-normalizing. Thanks to the work of G. Navarro, P.H. Tiep, and A. Turull, this consequence has been proven for odd primes without assuming Navarro's refinement of the McKay conjecture. I will discuss my progress on the case $p = 2$. Namely, I will briefly discuss my reduction of the statement to simple groups before discussing the situation for certain simple groups, in particular $PSL_n^{\pm}(2^a)$. (Received July 26, 2014)

1102-20-136 **Peter Webb*** (webb@math.umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455, and **Serge Bouc** and **Radu Stancu**. *The projective dimension of Mackey functors.*

Following on from work presented in St. Louis in 2013 in which it was determined which groups have cohomological Mackey functors which are Gorenstein, we determine when cohomological Mackey functors have finite global dimension. We also show that the the only Mackey functors of finite projective dimension are projective, establishing this over a field as well as over rings of integers. This extends a theorem of Greenlees, at this same time giving a new proof of his theorem. (Received July 27, 2014)

1102-20-147 **Danny Calegari*** (dannyc@math.uchicago.edu), University of Chicago, Department of Mathematics, 5734 S. University Avenue, Chicago, IL 60637. *Random groups, diamonds and glass.*

Random groups are full of diamonds and glass.

First the diamonds: for every dimension d, there is an infinite family of convex cocompact reflection groups of isometries of hyperbolic d-space — the superideal reflection groups — with the property that a random group at any density less than a half (or in the few relators model) contains quasiconvex subgroups commensurable with some member of the family, with overwhelming probability.

Next the glass: there is a heuristic construction of random subgroups of random groups which should have different but controlled properties at different parameters of the theory. And (again, heuristically), there is a thermodynamic landscape in which groups can be tempered by repeated melting and freezing, thereby turning glass into diamonds. (Received July 27, 2014)

1102-20-159 **David J Hemmer*** (dhemmer@math.buffalo.edu), 244 Math Building, Buffalo, NY 14260. *A Burnside-type theorem for faithful characters of the symmetric group.* Preliminary report.

Let G be a finite group and let U be a faithful irreducible representation of G over the complex numbers. In his 1911 book Burnside proved that every irreducible representation of G appears as a constituent of some tensor power of U. In 1964 Brauer refined the theorem by giving a specific d so each irreducible occurs inside one of $\mathbb{C}, U, U^{\otimes 2}, \ldots, U^{\otimes d}$.

As the tensor algebra $T(U)$ is infinite-dimensional, this theorem is perhaps not surprising. The exterior algebra $\Lambda(U)$ has finite dimension $2^{\dim U}$, and Burnside's theorem does not hold for exterior powers.

We prove a strengthened exterior power version for the symmetric group Σ_n. The theorem is true only for $n \geq 9$ and it is easy to see one must exclude the faithful irreducible given by the natural representation $\chi^{(n-1,1)}$ and its twist by the sign representation. Then $\Lambda^n(U)$ contains a free module, in particular contains every irreducible character. (Received July 28, 2014)

1102-20-160 **Michael Geline*** (geline@math.niu.edu), Watson Hall, DeKalb, OH 60115. *Rank varieties for reductions of cyclic Knörr lattices.* Preliminary report.

If R is the usual dvr and G is a finite group, a Knörr RG-lattice is an RG-module, free and finitely generated over R, whose invertible endomorphisms have traces generating a strictly larger ideal of R than traces of the non-invertible endomorphisms.

Indecomposable lattices of R-rank not divisible by the residue class field of R are important examples of Knörr lattices. When reduced (mod p), such lattices yield modules whose support variety is as large as possible. We believe this to hold for reductions of Knörr lattices of rank divisible by p as well, and will discuss certain examples in the talk. (Received July 28, 2014)

1102-20-163 **George McNinch*** (george.mcninch@tufts.edu), Department of Math, Tufts University, 503 Boston Ave, Medford, MA 02155. *Central subalgebras of the centralizer of a nilpotent element.* Preliminary report.

Let G be a connected and semisimple group over the field k, and suppose that the characteristic of k is *very good* for G. Suppose that $X \in \mathrm{Lie}(G)$ is *nilpotent*, write $C_G(X)$ for the centralizer of X, and write Z for the *center* of $C_G(X)$.

When X is *even*, Lawther and Testerman have shown that the dimension of Z coincides with the dimension d of the center of L, where L is a Levi factor of the parabolic subgroup P which is attached to X (recall that P is described by choosing an $\mathfrak{sl}_2$-triple in characteristic 0, and by geometric invariant theory in general).

In some recent work, we give an argument deforming the *Lie algebraic center* $\mathfrak{z}(\mathrm{Lie}(L))$ to a subspace of the center of $\mathfrak{c}_{\mathfrak{g}}(X)$. With some further work, this deformation may be used to show that $\dim Z \geq d$. The main reason for the interest in our work is that it avoids the extensive case-checking carried out by Lawther-Testerman. (Received July 28, 2014)

1102-20-173 **Terrell L. Hodge*** (terrell.hodge@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008, **Paramasamy Karappuchamy** (paramasamy.karappuchamy@utoledo.edu), Department of Mathematics, University of Toledo, Toledo, OH 43606, and **Leonard L. Scott** (lls2l@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22903. *Truncation and the Induction Theorem.* Preliminary report.

A key result in a 2004 paper by S. Arkhipov, R. Bezrukavnikov, and V. Ginzburg compares the bounded derived category $D^b(block(\mathbb{U}))$ of finite dimensional modules for the principal block of a Lusztig quantum algebra $\mathbb{U}$ at

a root of unity with a special full subcategory $D_{triv}(\mathbb{B})$ of the bounded derived category of integrable type 1 modules for a Borel part $\mathbb{B} \subset \mathbb{U}$. Specifically, the right derived functor of induction yields a category equivalence $\mathrm{RInd}_{\mathbb{B}}^{\mathbb{U}} : D_{triv}(\mathbb{B}) \xrightarrow{\sim} D^b(block(\mathbb{U}))$. An analog of this *Induction Theorem* holds for positive characteristic representations of algebraic groups:$\mathrm{RInd}_B^G : D_{triv}(B) \xrightarrow{\sim} D^b(block(G))$, relating an analog of $D_{triv}(\mathbb{B})$, for B a Borel subgroup of a connected, semisimple simply connected algebraic group G, and the bounded derived category of the principal block of finite dimensional rational G-modules. We prove this equivalence behaves well with respect to certain weight poset 'truncations', using van der Kallen's *excellent order*. Consequently, this equivalence can be reformulated in terms of derived categories of finite dimensional algebras. (Received July 28, 2014)

1102-20-181 **Theresa Brons*** (theresabrons@gmail.com). *Parabolic Subgroups and the Line-Bundle Cohomology over the Flag Variety G/B.* Preliminary report.

H.H. Andersen determined the socle of $\mathcal{H}^1(\lambda)$, which is potentially non-zero only when there exists a unique simple root α such that $\langle \lambda, \alpha^\vee \rangle < 0$. In this work he did so by first determining the socle in the case when G is of type A_1 where $\mathcal{H}^1(\lambda)$ a Weyl module and λ an anti-dominant weight, and later extended this to the case when $P(\alpha)$ is a minimal parabolic subgroup. In this talk, this approach will be generalized, leading to some new vanishing results and some interesting avenues for further study. (Received July 28, 2014)

1102-20-199 **Moon Duchin***, Math Department, Tufts University, Medford, MA 02155. *Some new work in random groups.* Preliminary report.

I will report on some progress made by students and faculty working in a research cluster in Random Groups. Our work dealt with variations on the standard Gromov density model– choose more and more relators of longer and longer length, with d as a parameter controlling the rate of exponential growth of the number of relators. There are remarkable results finding density thresholds for the appearance and disappearance of various group properties as relator length goes to infinity.

In the main project I will describe, we consider random nilpotent groups. A second project investigates the sharpness of the famous phase transition from infinite hyperbolic groups ($d < 1/2$) to trivial groups ($d > 1/2$).

Time permitting, I will survey some of the other projects as well.

Participants and contributing visitors include: Cordes, Coulon, Delp, Duchin, Duong, Dymarz, Gupta, Ho, Jankiewicz, Kahle, Kilmer, Kozma, Lelièvre, Mackay, Manning, Meckler, Sánchez, Schaffer-Cohen, Tamuz, and Walker. (Received July 28, 2014)

22 ► Topological groups, Lie groups

1102-22-20 **Benjamin L Harris*** (benjaminlharris@outlook.com), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *On the Asymptotics of Plancherel Formulas for Reductive Homogeneous Spaces.*

Let G be a real, reductive algebraic group, and let X be a homogeneous space for G with an invariant measure. We give an asymptotic result on the occurrence of tempered representations in the decomposition of $L^2(X)$ into irreducibles. In particular, we find a large number of spaces X for which harmonic analysis on X "asymptotically looks like" harmonic analysis on G.

This talk is partially based on joint work with Hongyu He and Gestur Olafsson. (Received June 17, 2014)

1102-22-25 **William M. McGovern*** (mcgovern@math.washington.edu), Box 354350, University of Washington, Seattle, WA 98195. *Upper semicontinuity of Kazhdan-Lusztig-Vogan polynomials for certain blocks of Harish-Chandra modules.*

We show that the coefficients of Kazhdan-Lusztig-Vogan polynomials attached to certain blocks of Harish-Chandra modules satisfy a monotonicity property relative to the closure order on K-orbits in the flag variety. (Received June 24, 2014)

1102-22-80 **Bruce K. Driver**, **Brian C. Hall*** (bhall@nd.edu) and **Todd Kemp**. *The heat equation on unitary groups in the large-N limit.*

I will describe results about the heat equation on the unitary group U(N), in the limit as N tends to infinity. A key result is that in this limit, the Laplacian, acting on certain natural types of functions, behaves like a first-order differential operator. The heat kernel, meanwhile, is concentrating onto a single conjugacy class in the limit. I will then discuss applications of these results to the large-N limit of the generalized Segal-Bargmann transform for U(N). (Received July 17, 2014)

1102-22-115 **Richard C Penney*** (rcpmathpurdue@gmail.com), West Lafayette, IN 47906, and **Roman Urban** (roman.f.urban@gmail.com). *The Poisson kernel on k-meta-abelian NA groups.*

A solvable Lie group S is an NA group if $S = N \rtimes A$ where N is a c.s.c nilpotent Lie group and A is isomorphic with $\mathbb{R}^k$. We say that S is k-meta-abelian if there is a sequence of closed, abelian subgroups $N_j \subset N$ such that

$$S = N_1 \rtimes (N_2 \rtimes (\cdots \rtimes (N_{k-1} \rtimes (N_k \rtimes A))).$$

Examples of k-meta-abelian groups include the NA part of the automorphism group of any bounded homogeneous tube domain in $\mathbb{C}^n$ and the NA part of a classical Lie group of type D_ℓ, $\ell \geq 3$, B_ℓ, and A_ℓ. In this talk we describe an explicit probabilistic formula for the heat kernel for "the Laplacian" of a k-meta-abelian NA group and use it to produce growth estimates for the Poisson kernels in several special classes of k-meta-abelian NA groups. (Received July 25, 2014)

1102-22-122 **S. Merigon**, **H.K. Neeb** and **Gestur Olafsson*** (olafsson@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Integrability of unitary representations on reproducing kernel spaces and reflection positivity.*

Let G be a connected Lie group, possibly infinite dimensional, with Lie algebra $\mathfrak{g}$ Let $\tau : G \to G$ be non-trivial involution. Then $\mathfrak{g}$ decomposes into eigenspaces $\mathfrak{g} = \mathfrak{h} + \mathfrak{q}$ with respect to the derived involution. Let $\mathfrak{g}^c = \mathfrak{h} + i\mathfrak{q}$ and let G be a simply connected Lie group with Lie algebra $\mathfrak{g}^c$. We will discuss new result, joint with S. Merigon and K-H. Neeb how to transform unitary representations from G to G^c. We will also describe some applications of of those results in quantum field theory. (Received July 25, 2014)

1102-22-150 **Hassan Lhou** and **Jeb F. Willenbring*** (willenbring@gmail.com), University of Wisconsin - Milwaukee, Department of Mathematical Sciences, 3200 North Cramer Street, Milwaukee, WI 53211-3029. *Progress on a classification of small subgroups of a compact group.* Preliminary report.

Let $\mathbb{G}$ be a connected reductive algebraic group, and let G be a real form, with a maximal compact subgroup K. Denote the Lie algebra of $\mathbb{G}$ by $\mathfrak{g}$. To an irreducible, unitary G-representation, $\mathcal{H}$, one associates an underlying Harish-Chandra module $\mathcal{M}$ for the pair ($\mathfrak{g}$,K). The action of $\mathfrak{g}$ on $\mathcal{M}$ is irreducible, and K acts locally finitely. Furthermore, $\mathcal{M}$ is *admissible* for K. That is, all irreps of K occur in $\mathcal{M}$ with finite multiplicity. The classification of admissible Harish-Chandra modules is a major step toward finding the unitary dual of G.

This talk concerns the irreps of K and its subgroups. Given a closed subgroup S of K, every irrep of K can be regarded as a S-representation by restriction. We say that S is *small* in K if there exists $b > 0$ such that for all K-irreps, V, there exists an S-irrep, W, with dimension at most b and occurring in V. That is, the minimal dimension of an S-irrep occurring in a K-irrep is bounded by b.

One can ask, is $\mathcal{M}$ admissible with respect to S? A necessary condition for this to be true is that S is not small in K. We present results toward a classification of small subgroups of K. (Received July 27, 2014)

1102-22-165 **Mark Colarusso*** (colaruss@uwm.edu) and **Jeb Willenbring** (jw@uwm.edu). *Tensor product multiplicities for rational representations of GL(n) via contingency tables.* Preliminary report.

Littlewood-Richardson theory provides a combinatorial description of the multiplicities of irreducible $GL(n, \mathbb{C})$-representations in a tensor product. Most expositions of this theory reduce to the case where all representations have polynomial matrix coefficients. Of course, many finite dimensional representations do not have this property (e.g. the adjoint representation). The usual way to make this reduction is to tensor with a sufficiently high power of the determinant. However, this is not the only way to organize the combinatorics.

We present a generalization of Littlewood-Richardson theory describing the multiplicities of irreducible $GL(n, \mathbb{C})$-representations in a tensor product of an arbitrary number of *rational* representations of $GL(n, \mathbb{C})$. Using the dual pair $(GL(n, \mathbb{C}), \mathfrak{u}(p, q))$ we show that these multiplicities are given by branching multiplicities between certain irreducible Harish-Chandra modules. These branching multiplicities are easily computed using an abstraction of what is known as a *contingency table*. This is joint work with Jeb Willenbring. (Received July 28, 2014)

1102-22-175 **Laura Rider** and **Amber Russell*** (arussell@math.uga.edu). *Lusztig's Generalized Green Functions.*

For a reductive algebraic group in good characteristic, Lusztig's generalized Springer Correspondence and his work proving the cleanness of character sheaves leads to an orthogonal decomposition of the equivariant derived category of constructible sheaves on the nilpotent cone. The orthogonal decomposition can be used to tell us about which local systems (on each orbit) appear as restrictions of the simple perverse sheaves. This information is encoded in Lusztig's generalized Green functions. In this talk, we will revisit the work of Lusztig, and explore

a new definition for the generalized Green functions, one which emphasizes their connection to stalks of simple perverse sheaves. (Received July 28, 2014)

1102-22-190 **Brad Currey*** (curreybn@slu.edu) and **Vignon Oussa** (vignon.oussa@bridgew.edu). *Weak admissibility for monomial representations of exponential Lie groups.*

Let G be an exponential solvable Lie group, let H be a connected Lie subgroup of G, and let $\tau = \mathrm{ind}_H^G(\chi_f)$ where χ_f is a unitary character of H. We prove the following.

Theorem. τ is isomorphic with a subrepresentation of the regular representation of G if and only if the restriction to H of the coadjoint action of G is free at some point of $f + \mathfrak{h}^\perp$.

A stronger condition is that τ be admissible: there is $\eta \in \mathcal{H}_\tau$ such that $V_\eta : f \longmapsto \langle f, \tau(\cdot)\eta\rangle$ is an isometry of $\mathcal{H}_\tau$ into $L^2(G)$. We discuss implications of the theorem for admissibility. (Received July 28, 2014)

1102-22-235 **Markus Hunziker**, **Mark Sepanski*** (mark_sepanski@baylor.edu) and **Ronald Stanke**. *A new Schrödinger model for unitary highest weight representations.*

It follows from the classification of unitary highest weight representations and the work of Kashiwara-Vergne that every unitary reduction point of the metaplectic group $Mp(n, \mathbb{R})$ can be embedded in $L^2(M_{n,k})$ for some $k < n$, where $M_{n,k}$ denotes the space of real $n \times k$ matrices. Furthermore, every reduction point can be embedded in a space of sections of a holomorphic vector bundle on the Segal upper halfplane or—via boundary values—in a degenerate principal series representation. In this paper, we give a new realization of unitary highest weight representations in the kernel of a system of Schrödinger equations on the space $M_{n,k} \times Sym_k$, where Sym_k denotes the space of symmetric real $k \times k$ matrices. Our realization has simple intertwining maps to the previously known realizations mentioned above. Connections with work of Enright and Wallach will also be explored. (Received July 29, 2014)

1102-22-262 **William Graham*** (wag@math.uga.edu) and **Wenjing Li** (wliwmath@gmail.com). *The smooth locus of spiral Schubert varieties in type $\tilde{A}_2$.*

Spiral Schubert varieties are a family of Schubert varieties in type $\tilde{A}_2$ that are of interest partly because computer evidence suggests the following. If X is a Schubert variety in type $\tilde{A}_2$ containing a T-fixed point p such that X is not rationally smooth at p, but the number of T-invariant curves in X passing through p equals the dimension of X, then X is spiral. (Here T is a maximal torus of the corresponding Kač-Moody group.) In other words, the only Schubert varieties in type $\tilde{A}_2$ for which the nontrivial case of the lookup conjecture of Boe-Graham occurs are the spiral ones. In previous work, we identified the rationally smooth locus of the spiral Schubert varieties and proved the lookup conjecture for these varieties. In this talk we will describe the smooth locus of these varieties (which is not the same as the rationally smooth locus). A key role is played by our previous results relating the Bruhat order to the action of the Weyl group on the plane. (Received July 29, 2014)

30 ► Functions of a complex variable

1102-30-36 **Walter M. Reid*** (reidwm@uwec.edu), 105 Garfield Avenue, Eau Claire, WI 54702-4004. *Deriving Range Circle Center and Radius from Domain Circle Center and Radius Under the Linear Fractional Transformation (LFT): $w = \dfrac{az+b}{cz+d}$.* Preliminary report.

It is well known that Linear Fractional Transformations (LFT's):

$$w = \frac{az+b}{cz+d},$$

where z, w, a, b, c, and d are all in the Complex Plane, map the set of lines and circles into itself. Then for a Domain Circle, $|z - \mathbf{C}| = \mathbf{R}$, not passing through the pole $(\frac{-d}{c})$ of the LFT, which maps to a Range Circle $|w - \mathbf{C}^*| = \mathbf{R}^*$, we derive explicit formulas for the range circle's $\mathbf{C}^*$ and $\mathbf{R}^*$ in terms of $\mathbf{C}$ and $\mathbf{R}$ from the domain circle and the coefficients a, b, c, and d of the LFT. (Received July 01, 2014)

31 ► Potential theory

1102-31-192 **Alexander (Oleksandr) V Tovstolis*** (atovstolis@math.okstate.edu), 401 Mathematical Sciences, Stillwater, OK 74078. *On Riesz Decomposition of Super-Polyharmonic Functions.*

We consider a Riesz decomposition of a function u super m-harmonic in $\mathbb{R}^n$. It is shown that u is a sum of the Riesz potential of the measure $\mu = (-\Delta)^m u$ and an m-harmonic function, if and only if a particular linear combination of spherical means for u is bounded.

The statement generalizes the results of K. Kitaura and Y. Mizuta (2006) for super-biharmonic functions. (Received July 28, 2014)

33 ► Special functions

1102-33-39 **Gopala Krishna Srinivasan*** (gopal@math.iitb.ac.in), Department of Mathematics, Indian Institute of Technology Bombay, Powai, Mumbai, 400076, India, and **Peter Zvengrowski**. *On the horizontal monotonocity of the gamma function.*

The absolute value of the gamma function when retricted to horizontal lines in the upper half plane is a monotone function as soon as the ordinate crosses a threshold value. This curious property seems to have been overlooked in the vast literature on the gamma function. A proof of this result was published in 2012 in the Canadian Mathematical Bulletin by the present author and Peter Zvengrowski. (Received July 04, 2014)

1102-33-189 **Vidya Venkateswaran*** (vidyav@math.mit.edu). *A p-adic interpretation of some integral identities for Hall-Littlewood polynomials.*

If one restricts an irreducible representation of GL_n to the orthogonal subgroup (respectively, the symplectic subgroup), classical branching rules tell us when the trivial representation is contained in the restricted representation. In both cases, the partition λ that indexes the original representation must satisfy a particular condition: in the orthogonal (respectively, symplectic) case, λ (resp. λ') must have all even parts. Using character theory, these results may be rephrased in terms of integrals involving the Schur functions. Since Hall-Littlewood polynomials are t-generalizations of Schur functions, one may consider t-analogs of these results. We will discuss these identities, focusing on an interpretation using p-adic representation theory that parallels the Schur case. (Received July 28, 2014)

1102-33-228 **Ranjan Kumar Jana*** (rkjana@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801. *On Some Properties of Konhauser Polynomial via Generalized Mittag-Leffler Function.* Preliminary report.

Several new properties of Konhauser polynomials via generalized Mittag-Leffler function will be discussed in this talk. Properties like mixed recurrence relations, Differential equations, Pure recurrence relations and Laplace transform have been obtained. This is a joint work with Dr. J. C. Prajapati and N. K. Ajudia of India. (Received July 29, 2014)

34 ► Ordinary differential equations

1102-34-7 **Eka Oche Ogbaji*** (ogbajieka@yahoo.com), Department of Mathematics and Statistics, Federal University PMB 1020 Wukari-Nigeria, Wukari, 9600001, and **A. O. Ogunmola** (adeniyiogunmola@gmail.com), Department of Mathematics and Statistics, Federal University PMB 1020 Wukari-Nigeria, Wukari. *Mathematical Model Of Depletion Of Toxic Heavy Metals Of Drinking Water In Different Storage Vessels.* Preliminary report.

We used deterministic model to determine the depletion of water storage vessels dissolving in the stored water of pH value of 6.6x10-6. Stability analysis was carried out and it showed that there is instability in the depletion of the vessels. The numerical analysis showed that the depletion is in the form of negative exponential curve. Metal Vessel depletes the most at all levels of concentration of the input of toxic metal values, followed by Earthen vessel, then Cement Reservoir and the least is Plastic vessel. Negative exponential curve well fits the generated data for each level of concentration of the input toxic metal values for each vessel. The estimated rates of depletion of vessel at each level for each vessel are also significant. The estimated rate of depletion of metal vessel is the highest, followed by the estimated rate of depletion of Earthen vessel. The least estimated rate of depletion among the four vessels is plastic. Key words: negative exponential, instability, water storage vessels and toxic metals (Received February 20, 2014)

35 ► Partial differential equations

1102-35-2 **Markus Keel*** (keel@umn.edu), University of Minnesota, School of Math, 206 Church St SE, Minneapolis, MN 55455. *Interaction Functionals in Dispersive and Hyperbolic PDE.* Preliminary report.

We will quickly and (necessarily) selectively survey the role which a long-ago-studied view on Partial Differential Equations (PDE) has played in Dispersive PDE over the past 10 years. This perspective in physical-space often presents new so-called "Interaction Functionals". We will survey some of the origins of this approach, it's discovery in the context of multi-dimensional Nonlinear Schroedinger Equations, and some applications too in the setting of Hyperbolic Systems in higher dimensions. (Received August 1, 2014)

1102-35-263 **Svitlana Mayboroda*** (svitlana@umn.edu), 206 Church st SE, Minneapolis, MN 55408. *Elliptic PDEs and localization of eigenfunctions in rough media.*

The phenomenon of wave localization permeates acoustics, quantum physics, energy engineering. It was used in the construction of noise abatement walls, LEDs, optical devices. Anderson localization of quantum states of electrons has become one of the prominent subjects in quantum physics, as well as harmonic analysis and probability. However, until recently prediction of specific regions of localization remained largely out of reach.

In this talk I will present recent results revealing a universal mechanism of spatial localization of eigenfunctions of an elliptic operator in a bounded domain. Via a new notion of "landscape" we connect localization to a certain multi-phase free boundary problem, indicate specific location, shapes, and frequencies of localized eigenmodes, and establish regularity (uniform rectifiability) of the emerging subregions. We shall more generally discuss analysis and elliptic equations on uniformly rectifiable sets and closely related solution of the David-Semmes conjecture in geometric measure theory. (Received July 29, 2014)

37 ► Dynamical systems and ergodic theory

1102-37-4 **Dylan P Thurston***, Department of Mathematics, Indiana University, Bloomington, IN 47405. *Rubber bands, square tilings, and rational maps.*

What are the different ways of tiling a rectangle by squares? If you make a graph out of rubber bands and stretch it, where do the vertices end up? These two questions turn out to have the same answer. This was used, for instance, in the 1940 solution to the "squared square" problem.

More generally, you can consider stretching a graph of rubber bands out on a groove network, or when one rubber band network is "looser" than another. This "looser" condition gives a new characterization of when a topological branched self-cover of the sphere is equivalent to a rational map. (Received June 04, 2014)

1102-37-188 **Ben Hayes***, 1326 Stevenson Center Ln, Nashville, TN 37235. *Sofic Entropy via Polish Models.*

Entropy for actions of a sofic group on a probability space or compact space has been defined by Lewis Bowen, David Kerr and Hanfeng Li. Further, there is a version of sofic measure entropy in the presence of a compact model (i.e. assuming that the probability space is a compact space with and the action is by homeomorphisms). We show how to define sofic entropy in the presence of a Polish model. Applications include the entropy of Gaussian actions, as well as deducing information about the Koopman representation from positive or complete positivity of entropy. (Received July 28, 2014)

1102-37-257 **Max Glick*** (mglick@umn.edu). *The Devron property.*

Say a discrete dynamical system possesses the Devron property if it carries a "special" class of inputs after a predictable number of steps to a class of highly degenerate outputs. This definition is inspired by a result of R. Schwartz that the $n-1$ iterate of the pentagram map takes an axis-aligned $2n$-gon to a single point. We show that this phenomenon is widespread, particularly in systems with a geometric interpretation. Known examples include both generalized pentagram maps and also seemingly unrelated systems such as Adler's polygon recutting and a new system involving circle intersection. An extra feature for the pentagram map, established by REU student Zijian Yao, is that the point of collapse for an axis-aligned polygon equals the center of mass of its vertices. (Received July 29, 2014)

39 ► Difference and functional equations

1102-39-34 **Seifedine Kadry*** (skadry@gmail.com), Egaila, Ahmadi, Kuwait, and **Abdelkhalak el Hami**. *Analytic Solution of Stochastic Fibonacci Equation.*

Stochastic Fibonacci equation is a stochastic difference equation with random parameters like the boundary values. These stochastic equations have links with many fields of sciences, including ergodic theory, dynamical systems, heavy-tailed statistics, spectral theory, continued fractions, and condensed matter physics. In this study, we use probabilistic transformation technique (PTT) to solve analytically this equation by find the probability density function (pdf), in closed form, of $X_n$where the boundary values X_0 and $X_1$are random variables with known distributions. PTT technique allows us to calculate the pdf of $X_n$after algebraic transformation of another random variable like X_0 and X_1 whose pdf, is known. In this study, we solve first the deterministic Fibonacci difference equation, in closed form, in terms of the boundary values then we apply PTT technique to find the pdf of the general solution. The obtained pdf will validated by Monte-Carlo simulation.
(Received June 29, 2014)

1102-39-127 **T. Awerbuch-Friedlander**, Harvard School of Public Health, Dept. of Population and International Health, Boston, MA 02115, **R. Levins**, Harvard School of Public Health, Dept. of Population and International Health, Boston, MA 02115, and **M. Predescu*** (mpredescu@bentley.edu), Bentley University, Department of Mathematical Sciences, Waltham, MA 02452. *A Nonlinear System of Difference Equations for Dengue Control.*

The information about a Dengue epidemic can come from various sources (the number of infected people, the abundance of mosquitoes, or the number of breeding sites for instance). This information triggers awareness and the response can be either individual and/or at the general community level. In this talk we present a nonlinear system of difference equations that describes interactions between several variables involved in a Dengue epidemic. We are concerned with the analysis of solutions of this system. We will present the global asymptotic stability of the degenerate equilibrium and propose some extensions of the model. (Received July 26, 2014)

43 ► Abstract harmonic analysis

1102-43-137 **Bradley Currey**, **Azita Mayeli** and **Vignon Oussa*** (voussa@bridgew.edu), Bridgewater, MA 02909. *Decomposition of Wavelet Representations.*

The concepts of wavelet sets were used by Lim, Packer and Taylor to obtain a direct integral decomposition of the wavelet representation of a discrete group associated to an arbitrary integer dilation matrix. The discrete group considered is the semi-direct product group : $\mathbb{Q}_A \rtimes \langle A \rangle$ where $\mathbb{Q}_A$ is a subgroup of $\mathbb{Q}^d$. In this talk, we will present decompositions of wavelet representations when it is not assumed that the normal subgroup of the semidirect product group is commutative. More precisely, let N be a simply connected connected nilpotent Lie group with a rational structure. Let Γ be a uniform subgroup of N and let $\alpha \in \mathrm{Aut}(N)$. We will obtain a decomposition of the so called wavelet representation $W : \cup_{k\in\mathbb{Z}}\alpha^k(\Gamma) \rtimes \langle\alpha\rangle \to U\left(L^2(N)\right)$ defined such that $W(\gamma, 1)$ acts by left translation and $W(1, \alpha)$ acts by dilation on $L^2(N)$. This is a joint work with Bradley Currey and Azita Mayeli. (Received July 27, 2014)

46 ► Functional analysis

1102-46-33 **Afrah Ahmad Abdou*** (fixedmathstar@hotmail.com). *One-Local Retract and Common Fixed Point in Modular Metric Spaces.*

The notion of a modular metric on an arbitrary set and the corresponding modular spaces, generalizing classical modulars over linear spaces like Orlicz spaces, were recently introduced. In this paper we introduced and study the concept of one-local retract in modular metric space. In particular, we investigate the existence of common fixed points of modular nonexpansive mappings defined on nonempty ω-closed ω-bounded subset of modular metric space. (Received June 28, 2014)

1102-46-51 **Matthew Kennedy** and **Paul Skoufranis*** (pskoufra@math.tamu.edu). *Diagonals of Certain Operators in von Neumann Algebras.*

In linear algebra there are several problems that may be formulated as, "what diagonal n-tuples may an n by n matrix have under certain fixed constraints?" Some famous results are the Schur-Horn Theorem, which describes

the possible diagonals for self-adjoint matrices with given eigenvalues, and Thompson's Theorem, which describes the possible diagonals for arbitrary matrices with given singular values.

Significant research has been done to extend the Schur-Horn Theorem to other von Neumann algebras including a Schur-Horn Theorem for II_1 factors by Ravichandran. In this talk, I will demonstrate a version of Thompson's Theorem for II_1 factors and some norm approximate results for diagonals of normal operators in arbitrary von Neumann algebras. (Received July 11, 2014)

1102-46-62 **Ioana Ghenciu*** (ioana.ghenciu@uwrf.edu), Department of Mathematics, 410 S. Third Street, River Falls, WI 54022. *Properties (V) and (wV) in projective tensor products.*

We give sufficient conditions for a subset of $K(X, Y^*) = L(X, Y^*)$ to be relatively weakly compact. A Banach space X has property (V) (resp. (wV)) if every V-subset of X^* is relatively weakly compact (resp. weakly precompact).

We prove that the projective tensor product $X \otimes_\pi Y$ has property (V) (resp. (wV)), when X has property (V) (resp. (wV)), Y has property (V), and $W(X, Y^*) = K(X, Y^*)$. (Received July 14, 2014)

1102-46-69 **Bogdan T. Udrea*** (budrea@illinois.edu), Department of Mathematics, UIUC, 1409 W. Green Street, Urbana, IL 61801, and **Marius Junge** and **Stephen Longfield**. *Some Rigidity Results for Generalized q-Gaussian Algebras.*

For any H, G countable discrete groups with H abelian and G acting on H by automorphisms, we define the generalized q-gaussian algebras $A \rtimes \Gamma_q(G, K)$, where $A = L(H)$ and K is an infinite dimensional separable Hilbert space. We then prove that if the pairs H, G and H', G' satisfy a certain "strong rigidity" assumption, the commutator subgroups $[G, G]$ and $[G', G']$ are ICC, the actions $G \curvearrowright A$, $G' \curvearrowright B$ are ergodic and G, G' belong to a fairly large class of groups (including all non-amenable groups with the Haagerup property) then $A \rtimes \Gamma_q(G, K) = B \rtimes \Gamma_q(G', K')$ implies that A and B are unitarily conjugate inside $M = A \rtimes \Gamma_q(G, K)$ and $\mathcal{R}_G \cong \mathcal{R}_{G'}$, where $\mathcal{R}_G$, $\mathcal{R}_{G'}$ are the countable, p.m.p. equivalence relations implemented by the actions of G and G' on A and B, respectively.
(Received July 15, 2014)

1102-46-76 **Nik Weaver*** (nweaver@math.wustl.edu). *A Lyapunov-type version of Kadison-Singer.*

I will present a modest extension of the recent solution of the Kadison-Singer problem. In finite dimensions it is a statement about the possible sums one can get from a set of small rank-one positive matrices; in infinite dimensions it concerns the map $x \mapsto pxp$ where p is a projection in the Calkin algebra with zero diagonal. This is joint work with Chuck Akemann. (Received July 17, 2014)

1102-46-103 **Zhe Liu*** (zhe.liu@ucf.edu). *Commutators and polytopes.*

A new proof of an old commutator theorem plus more. (Received July 23, 2014)

1102-46-184 **Thomas Sinclair*** (thomas.sinclair@math.ucla.edu) and **Isaac Goldbring**. *Existentially closed C*-algebras.*

A C*-algebra A is said to be existentially closed if, roughly, every set of equations involving norms of noncommutative $*$-polynomials which has a solution in B(H) has a sequence of approximate solutions in A. A basic result in continuous logic shows that every separable C*-algebra is contained in a separable, existentially closed C*-algebra. In this talk I will survey some basic properties of existentially closed C*-algebras. In particular I will describe how existential closure is connected to several open problems in C*-algebras such as Kirchberg's problem on whether every separable C*-algebra embeds in an ultrapower of the Cuntz algebra $\mathcal{O}_2$, as well as Kirchberg's C*-algebraic reformulation of of Connes' embedding problem. No knowledge of continuous logic will be assumed. This talk is based on joint work with Isaac Goldbring. (Received July 28, 2014)

1102-46-186 **Arnaud Brothier***, Vanderbilt University, Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240. *Weak amenability for subfactors.*

I will define the notion of weak amenability and the Cowling-Haagerup (CH) constant for subfactors. This is done via the symmetric enveloping algebra. One can prove that two subfactors with the same standard invariant have the same CH-constant. Hence this defines a CH-constant for standard invariants. I will explain how this notion is a generalization of the classical one for groups and give exotic examples of subfactors that are weakly amenable. (Received July 28, 2014)

1102-46-187 **Jan M. Cameron***, 124 Raymond Avenue, Poughkeepsie, NY 12604, and **Roger R. Smith**. *Bimodules in crossed products and regular inclusions of finite factors.*

We study bimodules over a von Neumann algebra M in two related contexts. The first is in inclusions of the form $M \subseteq M \rtimes_\alpha G$, where G is a dicrete group acting on a factor M by outer automorphisms. The second is a regular inclusion $M \subseteq N$ of finite factors. In the crossed product setting, we characterize the M-bimodules in $M \rtimes_\alpha G$ that are closed in the Bures topology, and show that this characterization extends to w^*-closed bimodules when the group G has the Approximation Property. As an application, we obtain a version for crossed products of a result of Mercer on extending certain w^*-continuous isometric bimodule maps. Similar results are obtained in the setting of a regular inclusion of finite factors, which generalizes the crossed product situation when the group G acts on a finite factor. This is joint work with Roger Smith. (Received July 28, 2014)

1102-46-202 **Ionut Chifan*** (ionut-chifan@uiowa.edu), 14 MacLean Hall, Iowa City, IA 52242, **Adrian Ioana** (aioana@math.ucsd.edu), AP&M 5210, Department of Mathematics UCSD, 9500 Gilman Drive, La Jolla, CA 92093, and **Yoshikata Kida** (kida@math.kyoto-u.ac.jp), Kyoto, 6068502, Japan. *Some structural results for the von Neumann algebras associated with braid groups.*

In this talk I will present some recent rigidity results for the von Neumann algebras associated with actions of braid groups. We will show that any free ergodic pmp action of the central quotient of the braid group with at least five strands on a probability space is virtually $W*$-superrigid; this means that any such action can be completely reconstructed from its von Neumann algebra. The proof uses a dichotomy theorem of Popa-Vaes for normalizers inside crossed products by free groups in combination with a OE-superrigidity theorem of Kida for actions of mapping class groups. Other structural results such as primeness or unique tensor factorisations for the von Neumann algebras associated with braid groups will also be discussed. This is based on an initial joint work with A. Ioana and Y. Kida and a subsequent joint work with S. Pant. (Received July 28, 2014)

1102-46-212 **Brent A Nelson*** (bnelson6@math.ucla.edu). *Applications of free monotone transport without a trace.*

In their paper, "Free monotone transport," Guionnet and Shlyakhtenko solve a free analogue of the Monge-Ampere equation to produce a non-commutative version of Brenier's monotone transport theorem. One is able to adapt this result to the non-tracial setting, specifically to the context of a free Araki-Woods factor. In this talk, we briefly outline this result and demonstrate two applications: the isomorphism of q-deformed Araki-Woods algebras to free Araki-Woods factors for small $|q|$, and free transport for finite depth subfactor planar algebras. (Received July 29, 2014)

47 ► Operator theory

1102-47-126 **Anna Skripka*** (askripka@unm.edu). *Taylor approximations of multivariate operator functions.* Preliminary report.

We will discuss Taylor-like approximations of multivariate operator functions given by power series. Power series in both commuting and noncommuting variables will be considered under appropriate assumptions. (Received July 26, 2014)

1102-47-139 **Joseph C Noles*** (jnoles@math.tamu.edu), Departmant of Mathematics, Texas A&M University, College Station, TX 77843. *Upper Triangular Forms and Spectral Orderings in a II_1-factor.*

Dykema, Sukochev and Zanin used a Peano curve covering the support of the Brown measure of an operator T in a diffuse, finite von Neumann algebra to give an ordering to the support of the Brown measure, and create a decomposition $T = N + Q$, where N is normal and Q is s.o.t.-quasinilpotent. We show that a larger class of functions can be used to order the support of the Brown measure giving normal plus s.o.t.-quasinilpotent decompositions. (Received July 27, 2014)

1102-47-183 **Alan Wiggins*** (adwiggin@umich.edu), Department of Mathematics & Statistics, 2014 CASL Building, 4901 Evergreen Road, Dearborn, MI 48128. *C^* Algebras Generated By Composition and Toeplitz Operators.* Preliminary report.

Let $\mathbb{D}$ denote the open unit disk in $\mathbb{C}$. We examine C*-algebraic properties of the algebras generated by certain composition and Toeplitz operators on either the Hardy or Bergman spaces associated to $\mathbb{D}$. This is joint work with John Clifford and Yunus Zeytuncu. (Received July 28, 2014)

1102-47-240 **Darren Creutz** and **Jesse Peterson*** (jesse.d.peterson@vanderbilt.edu). *Character rigidity for lattices and commensurators.*

We prove an operator algebraic superrigidity statement for homomorphisms of irreducible lattices, and also their commensurators, from certain higher-rank groups into unitary groups of finite factors. This extends previous work regarding non-free measure-preserving actions, and also answers a question of Connes for such groups. (Received July 29, 2014)

51 ► Geometry

1102-51-26 **Derege H Mussa*** (dhm2114@columbia.edu), Department of Mathematics, Texas A&M university Commerce, Commerce, TX 75428. *Dual Tetrahedra and their Nets.* Preliminary report.

Tetrahedron(plural Tetrahedra) is a three dimensional solid having four verties,four triangular faces and six edges whih don't lie in a single plane.If the tetrahedron T with a six tuple S=(a,b,,d,e,f)exists iff the tetrahedron is faial and the McCrea determinant is positive. If S is a six tuple for tetrahedron T S=(a,b,c,d,e,f) then the faces a,b,c;a,e,f;b,d,f and c,d,e and the edges at the vertices has the patter a,b,f;a,c,e;b,c,f and d,e,f. If the pattern of faces and vertices of a tetrahedron is interchanged then T is called the Dual of Tetrahedron T however these two tetrahedron are not congruent.Nets which are obtained by cutting three edges of the tetrahedron at a vertex of the tetrahedron or along a sequence of three edges that visits each vertex exactly once.the question is what happens to the nets if a tetrahedron with two paths of the same/different edge lengths? Theorem(Derege Mussa): If the Tetrahedron T has a six tuple S=(a,b,c,d,e,f)then the six tuple S= (f,e,d,c,b,a))give rise to the Dual Tetrahedron.The paper discusses new Mathematics questions 1.how to find the dual of Tetrahedron 2.Dual of tetrahedron 3.Nets of tetrahedron (Received June 24, 2014)

1102-51-177 **Larry Guth***, larry.guth.work@gmail.com. *Pants decompositions of random surfaces.*

A pants decomposition of a closed surface is a set of disjoint smooth curves so that each component of the complement is diffeomorphic to a pair of pants (a surface of genus zero with three boundary components). A pants decomposition is a way to break a complicated high genus surface into simpler pieces. Given a Riemannian metric on a surface, we can define the length of a pants decomposition to be the total length of all the curves in the decomposition. The pants length of a surface is the infimal length of any pants decomposition of the surface. We consider the question: what is the maximal possible pants length of a surface with area A and genus G? For large genus, this question is very poorly understood, and I think it is one of the most fundamental problems about the Riemannian geometry of high-genus surfaces.

We discuss joint work with Hugo Parlier and Robert Young, giving examples of random surfaces with pants length much larger than any known bound for any specific surface. (Received July 28, 2014)

53 ► Differential geometry

1102-53-10 **Lovejoy S Das*** (ldas@kent.edu), 330 University Dr. NE, New Philadelphia, OH 44663. *Second Order Parallel Tensors on Alpha-r-Sasakian Manifolds.*

Levy had proved that a second order symmetric parallel non–singular tensor on a space of constant curvature is a constant multiple of the metric tensor. Sharma [6] has proved that second order parallel tensor in a Kaehler space of constant holomorphic sectional curvature is a linear combination with constant coefficients of the Kaehlerian metric and the fundamental 2-form. In this paper, we show that a second order symmetric parallel tensor on a alpha-K-r contact manifold is a constant multiple of the associated metric tensor and we have also proved that there is no non–zero skew symmetric second order parallel tensor on a alpha- r-Sasakian manifold. (Received April 19, 2014)

1102-53-234 **M. T. Mustafa*** (tahir.mustafa@qu.edu.qa), Mathematics, Statistics and Physics, Qatar University, Doha, 2713, Qatar. *Symmetry classification of heat, wave and Poisson equations on surfaces of revolution.*

A classification of surfaces of revolution according to their isometries was carried out by Eisenhart in 1925. We investigate the corresponding classification question for symmetries of heat and wave equations, and obtain a complete classification of surfaces of revolution according to the symmetries of heat and wave equation. The minimal symmetry algebras are utilized in a unified manner to obtain the solutions, in general integral form, for the heat and wave equations on any surface of revolution. In particular, we compute examples of exact solutions

of heat and wave equations on surfaces in different classes of classification including surfaces admitting only minimal symmetry algebra as well as surfaces admitting extra symmetries.
The classification approach is further extended to study group classification problem for Poisson equation. The group classification question for symmetries of Poisson equation on higher dimensional manifolds was answered recently by Bozhkov-Freire. However the question was open for Poisson equation on surfaces. A complete group classification of symmetries of non-linear Poisson equations on surfaces of revolution is carried out. (Received July 29, 2014)

54 ► General topology

1102-54-31 **Diego Vela*** (dav2@rice.edu), 1402 Richmond Ave, Apt 310, Houston, TX 77006. *Infection By A String Link.* Preliminary report.

Knots and links play an important role in 3-manifolds and the equiva- lence relation of concordance of knots and links plays an important role in 4-manifolds. We will discuss our work that shows, loosely speaking, that we cannot hope to classify knot concordance without simultaneously classifying link concordance for links of an arbitrary number of components. Cochran- Friedl-Teichner considered generalized satellite operations R: SL(m)→ AS, called "infection by a string link", where SL(m) is the set of concordance classes of m-component links, AS is the set of concordance classes of al- gebraically slice knots, and the "pattern" knot R is some ribbon knot R. They proved that, for any such knot K there exists some R, m and L such that R(L)=K. We show that one cannot put an upper bound on m. Links arise from knots since the spine of a Seifert surface is essentially a link. Our obstructions are related to the Alexander polynomials of such links. (Received June 27, 2014)

55 ► Algebraic topology

1102-55-78 **JungHwan Park*** (jp35@rice.edu). *A method of constructing slice knots that may not be ribbon.*

In this talk I will present a method of constructing slice knots from a fixed slice knot by doing surgeries on two curves which bound a standard annulus in the exterior of the slice disk. (Received July 17, 2014)

57 ► Manifolds and cell complexes

1102-57-17 **Andrew Wilfong*** (awilfon2@emich.edu), Department of Mathematics, Eastern Michigan University, Ypsilanti, MI 48197. *Smooth Projective Toric Generators of Complex Cobordism.*

In 1960, Milnor and Novikov demonstrated that the complex cobordism ring is a polynomial ring with a generator in each even dimension. Since that time, convenient choices for these generators have been difficult to find. After an introduction to complex cobordism, we will explore the role that toric varieties play in this polynomial ring structure. More specifically, certain torus-equivariant blow-ups will be used to construct smooth projective toric variety polynomial generators in every complex dimension that is odd or that is one less than a prime power. A large amount of evidence suggests that smooth projective toric variety generators can be constructed for the remaining dimensions as well. These results demonstrate that convenient choices for complex cobordism generators can likely be found among smooth projective toric varieties. (Received June 05, 2014)

1102-57-63 **Margaret Doig** and **Peter Horn*** (pdhorn@syr.edu), 215 Carnegie, Syracuse, NY 13244. *Homology cobordism of graph manifolds.*

I will discuss the cohomology ring structure of graph manifolds and present an explicit example of a 3-manifold that is not homology cobordant to a 'tree like' graph manifold. (Received July 14, 2014)

1102-57-125 **Julia Collins**, **Paul Kirk** and **Charles Livingston*** (livingst@indiana.edu). *The concordance classification of low crossing number knots.*

The classification of the subgroup of the knot concordance group generated by prime knots of eight or fewer crossings has been completed. There are 36 such knots; the subgroup they generate has a free summand of rank 23 and a two-torsion summand of rank 7. The full result is placed in the context of the homomorphism of the concordance group to the algebraic concordance group. A simple algorithm that permits one to determine the order, and in particular the triviality, of any given linear combination of low crossing number knots is given.

With the exception of a small subgroup, Collins has classified the larger subgroup generated by nine crossing knots (of which there are 87 to consider) has been similarly classified. (Received July 26, 2014)

1102-57-149 **Alexander Lubotzky**, **Joseph Maher*** (joseph.maher@csi.cuny.edu) and **Conan Wu**. *The Casson invariants of random Heegaard splittings.*

The mapping class group element resulting from a finite length random walk on the mapping class group may be used as the gluing map for a Heegaard splitting, and the resulting 3-manifold is known as a random Heegaard splitting. We use these to show the existence of infinitely many closed hyperbolic 3-manifolds with any given value of the Casson invariant. (Received July 27, 2014)

1102-57-153 **Tim D Cochran*** (cochran@rice.edu), MS-136 Math. department, Rice University, PO Box 1892, Houston, TX 77251-1892, and **Christopher W Davis**. *The role of the Seifert surface in knot concordance.* Preliminary report.

In 1969 Jerome Levine successfully classified higher-odd-dimensional knot concordance in terms of simple invariants, namely linking numbers, of special links on an arbitrary Seifert surface. For knots in S^3, it was known that the situation is more complicated but this philosophy has nonetheless dominated the search for a characterization of slice knots. In this work we discuss unexpected failures of Levine's program and indicate refinements necessary to recover this strategy.

For any algebraically slice knot K and any genus g Seifert surface for K, there exists a g-component link, J, with zero pairwise linking numbers, embedded on the Seifert surface, called a *derivative of* K. If J is a slice link then K is a slice knot. The converse was conjectured by Kauffman: If K is a slice knot then one of its derivatives must be a slice link, or at least be algebraically slice. The authors recently showed this is false in some cases. Thus Levine's philosophy needs to be modified if it is to be used. In this talk we discuss precisely when and how this conjecture fails, what CAN be said about J, and give applications which are especially striking for genus one knots. (Received July 27, 2014)

1102-57-162 **Nathan M Dunfield***, Dept of Mathematics, 1409 W. Green Street, Urbana, IL 61801. *Random knots: their properties and algorithmic challenges.* Preliminary report.

I will discuss various models of random knots in S^3, surveying what is known about them theoretically and what is conjectured about them experimentally. In particular, I will discuss experiments that probe the practical/average case complexity of questions like computing the genus of a knot. (Received July 28, 2014)

1102-57-166 **Tim D Cochran** and **Arunima Ray*** (aruray@brandeis.edu), Goldsmith 218, MS 050, 415 South St., Waltham, MA 02453. *Shake-concordance of knots.*

If K is a knot in $S^3 = \partial B^4$, then the 4–manifold W_K obtained by adding a single 2–handle to S^3 along K with zero framing has $H_2(W_K) \cong \mathbb{Z}$. If a generator of $H_2(W_K)$ can be represented by an embedded sphere, K is called *shake-slice*. Any slice knot is shake-slice, but the converse is unknown. We define a relative version of this concept, known as *shake-concordance*, and construct infinite families of knots that are pairwise shake-concordant but not concordant. We show that the concordance invariants τ, s, and slice genus are not invariants of shake-concordance. We also give a characterization of shake-concordant and shake-slice knots in terms of concordance. (Received July 28, 2014)

1102-57-167 **Jennifer Hom*** (hom@math.columbia.edu) and **Zhongtao Wu**. *Four-ball genus bounds and a refinement of the Ozsvath-Szabo tau-invariant.*

Based on work of Rasmussen, we construct a concordance invariant associated to the knot Floer complex, and exhibit examples in which this invariant gives arbitrarily better bounds on the 4-ball genus than the Ozsvath-Szabo tau-invariant. This is joint work with Zhongtao Wu. (Received July 28, 2014)

1102-57-198 **Brandy Guntel Doleshal*** (bdoleshal@shsu.edu), Box 2206, Huntsville, TX 77341. *Fibered twisted torus knots.* Preliminary report.

A twisted torus knot $K(p, q, r, n)$ is obtained from a (p, q) torus knot by twisting r adjacent strands n full twists. A fibered knot is one with the property that $S^3 - K$ is homeomorphic to $(F \times I)/f$, where F is the interior of a Seifert surface for K and the map $f : F \times \{0\} \to F \times \{1\}$ is a homeomorphism. In this talk, we will discuss which twisted torus knots are fibered and which are not. (Received July 28, 2014)

1102-57-204 **Shelly Harvey*** (shelly@rice.edu) and **Thomas Cochran**. *The Geometry of Knot Concordance Spaces.*

Most of the 50-year history of the study of the set of smooth knot concordance classes, $\mathcal{C}$, has focused on its structure as an abelian group. Here we take a different approach, namely we study $\mathcal{C}$ as a metric space admitting

many natural geometric operators, especially satellite operators. We consider two metrics d_s and d_H on $\mathcal{C}$, coming from the slice genus norm and the homology norm. We establish the existence of quasi-n-flats for every n, implying that $\mathcal{C}$ admits no quasi-isometric embedding into a finite product of (Gromov) hyperbolic spaces. We show that every satellite operator is a quasi-homomorphism $P\colon \mathcal{C} \to \mathcal{C}$. We show that winding number one satellite operators induce quasi-isometries. Note that all of these results are true for either metric. In addition, we prove that if the smooth 4-D Poincare conjecture is true then strong winding number one satellite operators induce isometric embeddings for the homology metric. By contrast, winding number zero satellite operators are bounded functions and hence quasi-contractions. These results contribute to the conjecture that $\mathcal{C}$ is a fractal space. (Received July 28, 2014)

1102-57-206 **Benjamin Schweinhart*** (bschwein@math.princeton.edu), 14 Lawrence Drive, Apt 204, Princeton, NJ 08540, and **Jeremy Mason** and **Robert MacPherson**. *Topological Similarity of Random Cell Complexes and Applications to Dislocation Configurations.*

Although random cell complexes occur throughout the physical sciences, there does not appear to be a standard way to quantify their statistical similarities and differences. The various proposals in the literature are usually motivated by the analysis of particular physical systems and do not necessarily apply to general situations. The central concepts in this paper—the swatch and the cloth—provide a description of the local topology of a cell complex that is general (any physical system that may be represented as a cell complex is admissible) and complete (any statistical question about the local topology may be answered from the cloth). Furthermore, this approach allows a distance to be defined that measures the similarity of the local topology of two cell complexes. The distance is used to identify a steady state of a model dislocation network evolving by energy minimization, and then to rigorously quantify the approach of the simulation to this steady state. (Received July 28, 2014)

1102-57-246 **Katherine Vance*** (kvance@rice.edu). *Tau invariants of knotted wedges of circles.* Preliminary report.

Harvey and O'Donnol defined a combinatorial Heegaard Floer homology theory $\widehat{HFG}$ for spatial graphs. Their theory is relatively bigraded, with an integer-valued Maslov grading and a relative Alexander grading, which takes values in the first homology of the spatial graph exterior. We define a $\mathbb{Z}$-filtered $\widehat{HFG}$ for a certain class of balanced spatial graphs whose associated graded object is the $\widehat{HFG}$ defined by Harvey and O'Donnol. This class includes knotted wedges of circles. We then define a τ invariant for spatial graphs analogous to Ozsvath and Szabo's τ invariant for knots. One step in showing there is a filtration is to lift the relative Alexander grading on $\widehat{HFG}$ to an absolute grading. To do this, we use the Alexander polynomial of a spatial graph. (Received July 29, 2014)

1102-57-259 **Jen Hom**, **Tye Lidman** and **Faramarz Vafaee*** (vafaeefa@msu.edu). *Heegaard Floer theory and L-space knots.*

Heegaard Floer theory consists of a set of invariants of three- and four-dimensional manifolds. Three-manifolds with the simplest Heegaard Floer invariants are called L-spaces and the name stems from the fact that lens spaces are L-spaces. The primary focus of this talk will be on the question of which knots in the three-sphere admit L-space surgeries. We will also discuss about possible characterizations of L-spaces that do not reference Heegaard Floer homology. (Received July 29, 2014)

60 ► Probability theory and stochastic processes

1102-60-28 **Hailin Sang** and **Lin Ge*** (lge@meridian.msstate.edu), 1000 Highway 19 North, Meridian, MS 39307. *Self-normalized Cramer type moderate deviations.*

We study the self-normalized Cramer type moderate deviations for centered independent random variables with finite third or higher moments and obtain the exact self-normalized tail probabilities for all $x = o(n^{1/2})$. This is an extension of the results in Jing, Shao and Wang (2003) where at most finite third moment is assumed. In particular, if the centered independent random variables have zero third moment, the Cramer type moderate deviations hold uniformly for x in a range which is related to the moments with order between 3 and 4. Further it is proved that the range $[0, o(n^{1/4})]$ is optimal under some regular moment conditions. We also show the necessity of the zero third moment condition in Cramer type moderate deviations for x outside the range of $[0, o(n^{1/6})]$. (Received June 27, 2014)

1102-60-268 **Yuliy Baryshnikov*** (ymb@uiuc.edu), 1409 W. Green Street, Urbana, IL 61801.
Persistence diagrams of Brownian paths. Preliminary report.

Persistence diagrams became a popular tool of data analysis. In this note I will outline some results one the point process of $\mathbf{PH}_0$ of Brownian paths and bridges on an interval. (Received July 29, 2014)

65 ► Numerical analysis

1102-65-9 **Fritz Keinert*** (keinert@iastate.edu). *Regularity and Construction of Boundary Multiwavelets.*

Boundary functions for wavelets on a finite interval are often constructed as linear combinations of boundary-crossing scaling functions. A more general approach uses boundary recursion relations. We describe a number of results that relate the two approaches, and show how to characterize regularity of boundary functions from their recursion coefficients. These results are applied in a new algorithm for constructing boundary multiwavelets with maximal approximation order for given interior multiwavelets. (Received March 11, 2014)

1102-65-29 **Mihaela Cristina Drignei*** (mdrignei@pitt.edu), University of Pittsburgh at Bradford, Bradford, PA 16701. *A Newton-type method for solving an inverse Sturm-Liouville problem.*

A Newton-type method is proposed for the recovery of the unknown coefficient function in the canonical Sturm-Liouville differential equation from two spectral data. Specifically, the two spectral data will be used to produce two Cauchy data, which in turn will serve as the input in a nonlinear equation whose unknown is the coefficient function in the canonical Sturm-Liouville differential equation. This nonlinear equation is to be solved numerically by the Newton method. Each Newton iterate requires that a Goursat-Cauchy boundary value problem be solved numerically. The numerical implementation of the Newton method that serves this inverse two spectra problem is illustrated with examples for the case of the two spectra being the Dirichlet eigenvalues, and the Dirichlet-Robin eigenvalues. The numerical examples confirm that the Newton method applied to this inverse Sturm-Liouville problem works well in both situations: given and estimated the boundary parameter. (Received June 27, 2014)

93 ► Systems theory; control

1102-93-8 **Palle E T Jorgensen*** (palle-jorgensen@uiowa.edu), P Jorgensen, Math, MLH, University of Iowa, Iowa City, IA 52242. *Analytic, algebraic, and group theoretic, tools in wavelets and filters.*

The talk will begin with multiresolutions, and then turn to matrix valued functions of one or more complex variables, motivated by signal processing, "the lifting schemes," and "lifting algorithms." Multibands suggest higher order matrix functions which offer their own challenges. Sample result: Under suitable restrictions, in the case of polynomial entries, these matrix functions factor into finite products of alternating upper and lower diagonal matrix functions. Pioneering ideas are from engineering (designs for building filters), but they they are of interest in pure mathematics as well. One of our motivations here is the desire to extend and refine existing methods (for the case of two bands) to the case of multiple bands. In the simplest case, by this we mean that signals are viewed as time function (discrete time) and each time-function generating a frequency response function (generating function) of a complex variable. In many applications it is possible to encode time-signals or their generating functions as vectors in a Hilbert space H. And to do this in such a way that a finite selection of frequency bands will then correspond to a system of closed subspaces in H. (Received March 11, 2014)

97 ► Mathematics education

1102-97-11 **Michael D. Steele*** (steelem@uwm.edu), 2400 E Hartford Ave, Enderis Hall 395, Milwaukee, WI 53209. *Developing Specialized Content Knowledge for Teaching: Integrating Content and Pedagogy in Secondary Mathematics Teacher Education.*

To effectively teach secondary mathematics, teachers need to know more than just the mathematical content that they teach. Teachers also need Specialized Content Knowledge (SCK), a key component of Mathematical Knowledge for Teaching that entails understanding multiple approaches to, representations for, and ways in which students might think about the mathematical ideas in question. Mathematics for Elementary Teachers

courses afford elementary teacher candidates opportunities to learn SCK, but few strong analogues exist for secondary teacher candidates. In this talk, I present models for integrating content and pedagogy that can be implemented in mathematics capstone courses and mathematics methods courses for teacher candidates. Data from course implementations focused on functions and reasoning-and-proving will be shared. (Received April 23, 2014)

1102-97-12 **Eric W Kuennen*** (kuennene@uwosh.edu), Mathematics Department, University of Wisconsin Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901. *Secondary Mathematics Teacher Preparation in the US, Germany, and China.*

In this talk we will consider the knowledge, mathematical and pedagogical, that teachers should have to be prepared for effective teaching, and compare the form and quality of the opportunities for pre-service teachers to gain this knowledge in different countries. We will report on data collected from pre-service teachers in Wisconsin, Germany, and China on mathematics knowledge for teaching, mathematical sophistication, and beliefs about mathematics and the teaching and learning of mathematics. We will discuss the results of our survey and implications for mathematics departments and the role they play in the preparation of future secondary mathematics teachers. (Received April 28, 2014)

1102-97-144 **Kevin McLeod*** (kevinm@uwm.edu). *The Education of Future K-12 Mathematics Teachers and the "Compulsion to Compute".*

In a recent study of the mathematics knowledge of community college students enrolled in remedial mathematics classes, Stigler, Givvin and Thompson observed a habit of mind they termed a "compulsion to compute": these students were quite capable of mathematical reasoning, but chose not to reason if a problem was presented in a manner that apparently allowed for computation as a possible solution strategy—even when computation was in fact impossible. The compulsion to compute is presumably not innate: rather, it is instilled in students during their formal mathematics education. This talk will first explore the negative consequences of a compulsion to compute, and will then turn to a discussion of the education of future mathematics teachers with a particular emphasis on strategies that might help them to avoid instilling a compulsion to compute in their own students. Finally, it will be argued that many of the same principles can and should be applied to all undergraduate mathematics courses, not just those taken exclusively, or largely, by future teachers. (Received July 27, 2014)

00 ► General

1103-00-2 **Sourav Chatterjee***, New York University, New York. *Nonlinear large deviations.*

How many graphs on a given number of vertices contain approximately a given number of triangles? This is a combinatorial question that falls under the purview of the probabilistic theory of rare events, also known as the theory of large deviations. Surprisingly, this simple sounding question does not have a straightforward solution using classical large deviation techniques. The reason is that classical large deviations is mainly a .linear. theory, whereas this is a nonlinear problem. In a joint work with S. R. S. Varadhan, we solved this problem a few years ago. The solution, however, involved specialized tools from graph theory such as Szemeredi.s regularity lemma. In this talk, I will present an attempt at building a new abstract theory for computing probabilities of rare events in nonlinear settings. In particular, it yields an elementary solution of the above problem and much more. This is based on joint work with Amir Dembo. (Received April 30, 2013)

1103-00-42 **Vivek Mukundan*** (vivekm85@gmail.com), Department of Mathematics, Purdue University, Office 1037, 150 N. University Street, West Lafayette, IN 47906, and **Jacob Boswell**, Department of Mathematics, Purdue University, Office 1037, 150 N. University Street, West Lafayette, IN 47906. *Rees algebras and almost linearly presented matrices.*

Consider a grade 2 perfect ideal I in $R = k[x_1, \cdots, x_d]$ which is generated by forms of the same degree. Assume that the presentation matrix ϕ is almost linear, that is, all but the last column of ϕ consist of entries which are linear. For such ideals, we find explicit forms of the defining equations of the Rees algebra $\mathcal{R}(I)$. (Received August 14, 2014)

1103-00-53 **Nasser Saad*** (nsaad@upei.ca), University Of Prince Edward Island, 550 University Avenue, Charlottetown, PEI C1A 4P3, Canada. *On W. Gordon's integral (1929) and related applications.*

Analytic evaluation of Gordon's integral (1929)

$$\mathbf{J}_c^{j(\pm p)}(b, b'; \lambda, w, z) = \int_0^\infty x^{c+j-1} e^{-\lambda x} {}_1F_1(b; c; wx) {}_1F_1(b'; c \pm p; zx) dx,$$

is given along with convergence conditions. It shows enormous number of definite integrals, frequently appear in theoretical and mathematical physics applications, easily deduced from this generalized integral. Some of the recent applications, in a number of different areas, discussed. (Received August 07, 2014)

01 ► History and biography

1103-01-198 **Ali Alilooee*** (alilooee@mthstat.dal.ca), Department of Mathematics, Dalhousie University, Halifax, NS B3H2Z9, Canada, and **Arindam Banerjee** (ab4cb@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA. *Powers of Edge Ideals of regularity three bipartite graphs.* Preliminary report.

E. Nevo and I. Peeva asked the following question.

Question 1. *Let $I(G)$ be the edge ideal of a graph G which does not have any induced four cycle in its complement. If $reg(I(G)) \leq 3$, then is it true that for all $s \geq 2$, $I(G)^s$ has linear minimal free resolution?*

One important fact about bipartite graphs is that the complement of a bipartite graph cannot have any induced cycle of length greater than four. In light of Fröberg's theorem and this fact, one can say that for bipartite graphs linear presentation implies linear resolution. Due to these, we ask a question similar to Question 1 for bipartite graphs with a weaker hypothesis and answer it in the affirmative:

Theorem 2. *Let G be a bipartite connected graph with edge ideal $I(G)$. If $reg(I(G)) = 3$ then for all $s \geq 1$, $reg((I(G)^s) = 2s + 1$.*

References

[1] E. Nevo and I. Peeva, C_4-free edge ideals, *J. Algebraic Combin.*, 37(2):243-248, 2013.

(Received August 19, 2014)

03 ► Mathematical logic and foundations

1103-03-164 **Robin Cockett*** (robin@ucalgary.ca), University of Calgary, Calgary, Alberta T2N 1W4.
Kleene's minimization as a construction.

Kleene's normal form theorem in recursion theory states that every recursive function can be obtained by performing one minimization of a primitive recursive function. The purpose of this talk is to describe how one may view Kleene's theorem as a construction using an object in a restriction category which admits bounded minimization. The construction embeds the original category into a larger setting with exactly the same total maps but many more partial maps.

Implicit computational setting, which implement some fiunctional complexity class such as (LOGSPACE, PTIME, PSPACE, ...), when viewed through the exception monad, provide a restriction category in which the "natural numbers" admit bounded minimization. Performing the construction on these settings produces Turing categories whose total maps are precisely the maps of the given functional complexity class. Thus this construction provides a link between the abstract recursion theoretic approaches to complexity – using Turing categories – and the implicit complexity settings. (Received August 18, 2014)

1103-03-179 **Keith O'Neill*** (tonei018@uottawa.ca). *Derivations in Kähler Categories.*

Kähler categories, as defined by Blute-Cockett-Porter-Seely, provide a conceptual framework to study differential structure. It is an abstract setting in which the study of universal derivations in a variety of contexts is made precise and simple. Codifferential categories, i.e. the duals of models of differential linear logic, frequently provide examples of Kähler categories.

Kähler categories are equipped with an algebra modality, i.e. a monad T and a commutative associative algebra structure for each object of the form TA, as well as modules of differential forms for all of these algebras. We show that from this structure one can in fact derive a module of differential forms for all T-algebras.

This is joint work with Richard Blute and Rory Lucyshyn-Wright. (Received August 19, 2014)

1103-03-180 **Vincent L. Rouleau*** (vlrouleau@hotmail.com). *On "propositions by testing" in logic and mathematics.*

There seems to be a concept of "proposition by testing" emerging from Jean-Yves Girard's work, especially in phase semantics and coherence spaces. Briefly, a proposition A can be defined as a set where all elements are in a symmetrical relation with elements of another set, the "negation" of A. Although the concept is mostly relevant to (linear) logic, we will take a look at different related topics in mathematics, e.g. vector spaces, groups, MV-algebras, equivalence classes, etc. (Received August 19, 2014)

05 ► Combinatorics

1103-05-30 **Taylor Ball** (tarball@indiana.edu), **Robert W Bell*** (rbell@math.msu.edu), **Jonathan Guzman** (jonrguz@gmail.com), **Madeleine Hanson-Colvin** (mhansoncol@brynmawr.edu) and **Nikolas Schonsheck** (nischonsheck@vassar.edu). *The cop number of Generalized Petersen graphs.*

Given two positive integers n and k such that $k < n/2$, the Generalized Petersen graph $GP(n,k)$ has vertex set $\{a_1,\ldots,a_n,b_1,\ldots,b_n\}$ and edges of the form $\{a_i,b_i\}$, $\{a_i,a_{i+1}\}$, and $\{b_i,b_{i+k}\}$ for each $i=1,\ldots,n$, where indices are read modulo n. We prove that the cop number of any Generalized Petersen graph is less than or equal to 4. It has been verified with a computer that this bound is realized in some examples, for instance $GP(40,7)$. The idea of the proof is to pass to an infinite cyclic covering space. It is shown that in a modified game of cops and robbers two preimages of cops suffice to push a preimage of a robber an arbitrary distance in the positive direction. The result follows by projecting the modified game back down to $GP(n,k)$. Additionally, we generalize this construction to show that the cop number of any I-graph is less than or equal to 5. (Received July 30, 2014)

1103-05-32 **Christophe Reutenauer*** (reutenauer.christophe@uqam.ca). *Study of finite Sturmian words.* Preliminary report.

It is known that for a given natural number n and for a given Sturmian sequence s, the set of words of length n that appear as factor of this sequence has cardinality $n+1$ (Morse and Hedlund 1941). Consider all possible such sets, for fixed n and any Sturmian sequence s. The number of such sets is $\phi(1)+...+\phi(n)$ (Richomme and Séébold 2011). We give a classification in two classes of these sets, characterized by conjugation and periodicity properties. (Received July 31, 2014)

1103-05-33 **Jeffrey Shallit*** (shallit@cs.uwaterloo.ca), School of Computer Science, University of Waterloo, 200 University Ave. W., Waterloo, Ontario N2L 3G1, Canada. *New Results On Infinite Words Obtained with an Automatic Prover.*

In this talk I'll survey some results results we recently obtained with an automatic prover written by my student Hamoon Mousavi. This software package, written in Java, takes as input an automaton M specifying an infinite word $\mathbf{x}$ and a predicate $P(n)$ (expressed in a logical language) about the factors of $\mathbf{x}$, and returns an automaton accepting the representation of those n for which the predicate holds. Depending on the size of the initial automaton M, the type of representation (base-k for $k \geq 2$; Fibonacci representation; Tribonacci representation), and the complexity of the predicate, many nontrivial assertions can be proven mechanically in a few seconds or minutes.

As an example, we used this prover to show the existence of an aperiodic infinite binary word avoiding the pattern xxx^R and infinitely many distinct primitive words t such that $t^\omega = ttt\cdots$ avoids the same pattern.

This is joint work with Chen Fei Du, Hamoon Mousavi, and Luke Schaeffer. (Received July 31, 2014)

1103-05-34 **Lara Pudwell*** (lara.pudwell@valpo.edu), Department of Mathematics and Statistics, 1900 Chapel Drive, Valparaiso, IN 46383. *Ascent sequences avoiding 0021.*

Ascent sequences were introduced by Bousquet-Mélou et al. in connection with a variety of other combinatorial structures. In 2011, Duncan and Steingrímsson introduced pattern avoidance in ascent sequences. They conjectured that ascent sequences avoiding 0021 and those avoiding 1012 are both counted by the binomial convolution of the Catalan numbers. Later, Mansour and Shattuck proved the conjecture correct for 1012 avoiders. In this talk, we outline the proof that 0021-avoiding ascent sequences have the same enumeration. The proof uses generating trees to elucidate the structure of the sequences in question, but the generating tree structure does not directly lead to the correct enumeration. Rather, we experimentally conjecture an appropriate multivariate generating function that tracks several statistics on the ascent sequences, verify it satisfies the appropriate structure, and specialize to the desired univariate solution. This result completes the Wilf-classification of patterns of length 4 for ascent sequences. (Received August 01, 2014)

1103-05-36 **Dominique Perrin*** (dominique.perrin@esiee.fr). *Natural codings of linear involutions.*

We present results on the properties of the minimal systems obtained by the natural codings of linear involutions. These results generalize those obtained for interval exchange transformations. As for several other minimal systems, a strong connection between maximal bifix codes and subgroups of finite index of free groups is shown. Two proofs are given for the results, one by direct combinatorics on words and the other using geometric methods (joint work with Valérie Berthé, Vincent Delecroix, Francesco Dolce, Giuseppina Rindone and Christophe Reutenauer). (Received August 02, 2014)

1103-05-38 **Salvatore Stella*** (sstella@ncsu.edu) and **Nathan Reading** (nreadin@ncsu.edu). *Coxeter combinatorics on affine root systems.*

Motivated by their study of cluster algebras Fomin and Zelevinsky introduced, for any finite root system, the set of its almost-positive roots and a compatibility relation on it. The resulting combinatorial structure, known as the generalized associahedron, encodes many of the properties of the associated finite-type cluster algebras with a bipartite initial seed.

In this talk, after briefly reviewing some of the finite-type results, we explain how to extend them to the acyclic affine case.

This is joint work with Nathan Reading (Received August 03, 2014)

1103-05-47 **Adriano M. Garsia*** (garsia@math.ucsd.edu), UC San Diego 9500 Gilman Dr. CA 920, La Jolla,, CA 92093, and **Emily Leven** (esergel@ucsd.edu), La Jolla,, CA 92093. *Cyclic Rearrangements of Parking Functions.* Preliminary report.

From the onset of the 1993 discovery of the Macdonald polynomial expansion of the bigraded Frobenius characteristic $\Phi_n[X;q,t]$ of Diagonal Harmonics, a variety of combinatorial and symmetric function puzzles arose over the following two decades . Our findinhgs here add one more puzzle to this unending saga. It was noticed in the early 90's that $\Phi_n[X;q,t]$ is mysteriously related to Lagrange inversion. More precisely it was shown that the specialization $\Phi_n[X;q,1]$ yields an *area* and Gessel Fundamental, Parking function way of expressing the solution of the q-analogue of Lagrange inversion while the generating function of the sequence $\left\{q^{\binom{n}{2}}\Phi_n[X;q,1/q]\right\}_{n\leq 1}$ gives a q-analogue of the formula expressing the solution of Lagrange inversion. Our discovery here is that $q^{\binom{n}{2}}\Phi_n[X;q,1/q]$ can be obtained as a cyclic rearrangement of $\Phi_n[X;q,1]$. Even more importantly, this phenomenon can be demonstrated to hold also in the rational rational Parking function case. (Received August 06, 2014)

1103-05-55 **Stephanie van Willigenburg*** (steph@math.ubc.ca). *Modules of the 0-Hecke algebra and quasisymmetric Schur functions.*

Quasisymmetric Schur functions are a basis for the algebra of quasisymmetric functions, which refine classical Schur functions and many of their combinatorial properties in a natural way. However, an important question is whether a representation theoretic interpretation for quasisymmetric Schur functions exists.

In this talk we will answer this question in the affirmative by defining an action of the 0-Hecke algebra on standard reverse composition tableaux and using it to produce 0-Hecke modules whose quasisymmetric characteristic is a quasisymmetric Schur function. Furthermore we will see how these modules are related to the weak Bruhat order and truncated shifted reverse tableaux. This is joint work with Vasu Tewari. (Received August 07, 2014)

1103-05-67 **Scott Andrews*** (scott.andrews@colorado.edu). *The Hopf monoid on nonnesting supercharacters.*

Indexing the irreducible representations of $UT_n(\mathbb{F}_q)$, the group of unipotent upper-triangular matrices over the field with q elements, is known to be a wild problem. Recently this problem has been studied via supercharacter theories. I will present a supercharacter theory of $UT_n(\mathbb{F}_q)$ with supercharacters and superclasses indexed by nonnesting labeled set partitions. This supercharacter theory generalizes to a large class of subgroups of $UT_n(\mathbb{F}_q)$ that are known as pattern groups. Studied as a collection, the spaces of superclass functions on pattern groups form a Hopf monoid whose product and coproduct have nice combinatorial descriptions. (Received August 11, 2014)

1103-05-69 **Natasha Komarov*** (nkom@cmu.edu), Department of Mathematics, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213, and **John Mackey**. *Containment: A Variation of Cops and Robbers.*

We consider "Containment": a variation of the graph pursuit game of Cops and Robber in which cops move from edge to adjacent edge, the robber moves from vertex to adjacent vertex (but cannot move along an edge occupied by a cop), and the cops win by "containing" the robber—that is, by occupying all $\deg(v)$ of the edges incident with a vertex v while the robber is at v. We develop bounds that relate the minimal number of cops, $\xi(G)$, required to contain a robber to the well-known "cop-number" $c(G)$ in the original game: in particular, $c(G) \leq \xi(G) \leq \gamma(G)\Delta(G)$. We note that $\xi(G) \geq \delta(G)$ for all graphs G, and analyze several families of graphs in which equality holds, as well as several in which the inequality is strict. We also give examples of graphs which require an unbounded number of cops in order to contain a robber, and note that there exist cubic graphs with $\xi(G) \geq \Omega(n^{1/6})$. (Received August 11, 2014)

1103-05-75 **Marcelo Aguiar*** (maguiar@math.cornell.edu) and **T Kyle Petersen**. *The Steinberg torus and the Coxeter complex of a Weyl group.*

Given an irreducible crystallographic root system Φ, consider the torus obtained as the quotient of the ambient space by the coroot lattice of Φ. There is a certain cell complex structure on this torus, introduced by Steinberg and studied by Dilks, Petersen, and Stembridge. In joint work with Petersen, we exhibit a module structure on (the set of faces of) this complex over the (set of faces of the) Coxeter complex of Φ. The latter is a monoid under the Tits product of faces. The module structure is obtained from geometric considerations involving affine hyperplane arrangements. As a consequence, we obtain a module structure on the space spanned by affine descent classes of a Weyl group, over the classical descent algebra of Solomon. We provide combinatorial models when Φ is of type A or C. (Received August 12, 2014)

1103-05-76 **Lara Pudwell** and **Eric Rowland*** (rowland@lacim.ca). *Avoiding fractional powers over the natural numbers.*

Beginning with work of Thue, researchers have been interested in the avoidability of repetitions in long words over a finite alphabet. A recent variant has been to consider an infinite alphabet instead, for example the alphabet $\mathbb{Z}_{\geq 0}$. Since most patterns are avoidable over $\mathbb{Z}_{\geq 0}$, one question of interest is characterizing the lexicographically least infinite word avoiding a given pattern. For natural numbers $a \geq 2$, Guay-Paquet and Shallit established the structure of the lexicographically least words avoiding a-powers and avoiding overlaps. Here we systematically study the lexicographically least word avoiding $\frac{a}{b}$-powers for rational numbers $\frac{a}{b} > 1$. In many cases these words are fixed points of uniform morphisms on $\mathbb{Z}_{\geq 0}^*$. (Received August 12, 2014)

1103-05-78 **Greta Panova*** (panova@math.upenn.edu), UPenn mathematics department, 209 south 33rd street, Philadelphia, PA 19104. *Kronecker coefficients.*

We will consider several aspects and new results related to the Kronecker coefficients of the Symmetric group S_n. The question on their positivity plays a role in the Saxl conjecture on whether the tensor square of a particular irreducible representation of S_n contains all irreps. Another aspect is their new role in the Geometric Complexity Theory aimed at resolving the P vs NP problem. This talk will be based on several papers joint with Igor Pak and Ernesto Vallejo. (Received August 13, 2014)

1103-05-85 **Daniel Birmajer**, **Juan B Gil** and **Michael D Weiner*** (mdw8@psu.edu), Penn State Altoona, 3000 Ivyside Park, Altoona, PA 16601. *On Convolutions of Linear Recurrence Sequences.* Preliminary report.

For arbitrary homogeneous linear recurrence sequences with constant coefficients, we use a representation in terms of partial Bell polynomials to discuss combinatorial formulas for multifold convolutions. We will also discuss how these formulas extend to more general linear recurrence sequences. (Received August 13, 2014)

1103-05-98 **Mikhail Mazin*** (mmazin@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506-2602. *Hyperplane Arrangements and Parking Functions.*

Back in the nineties Pak and Stanley introduced a labeling of the regions of a k-Shi arrangement by k-parking functions and proved its bijectivity. Duval, Klivans, and Martin considered a modification of this construction associated with a graph G. They introduced the G-Shi arrangement and a labeling of its regions by G-parking functions. They conjectured that their labeling is surjective, i.e. every G-parking function appears as a label of a region of the G-Shi arrangement. Later Hopkins and Perkinson proved this conjecture. In particular, this provided a new proof of the bijectivity of Pak-Stanley labeling in the $k = 1$ case. We generalize Hopkins-Perkinson's construction to the case of arrangements associated with oriented multigraphs. In particular, our construction provides a simple straightforward proof of the bijectivity of the original Pak-Stanley labeling for arbitrary k.

In this talk, I will introduce necessary background and definitions and sketch the proof of the surjectivity of the labeling. (Received August 14, 2014)

1103-05-100 **Nursel Erey***, nurselerey@gmail.com, and **Sara Faridi**. *Betti Numbers of Simplicial Forests.* Preliminary report.

Given a simplicial complex one can associate the facet ideal which is generated by the monomials corresponding to the facets of the simplicial complex. The relation between the algebraic invariants of the facet ideal and the combinatorial properties of the corresponding simplicial complex has received considerable amount of interest. In this talk, we will focus on a class of simplicial complexes, namely simplicial forests. We will combinatorially characterize the Betti number for the facet ideal of a simplicial forest. This generalizes the previously known characterization of the Betti number for the edge ideal of a graph forest. (Received August 14, 2014)

1103-05-103 **Daniel Birmajer**, **Juan B. Gil*** (jgil@psu.edu) and **Michael D. Weiner**. *A family of Bell transformations.* Preliminary report.

We introduce a family of sequence transformations defined by means of partial Bell polynomials. With appropriate choices of parameters, our family includes known transformations like INVERT, CONV, and EXP, as well as possibly unexplored sequence transformations that lead to a variety of new (not listed in OEIS) integer sequences. We use properties of the partial Bell polynomials to prove inverse relations and some recurrence formulas. (Received August 14, 2014)

1103-05-113 **Nicholas A. Loehr*** (nloehr@vt.edu), 460 McBryde Hall, Blacksburg, VA 24061-0123, and **Gregory S. Warrington** and **Drew Armstrong**. *Sweep maps and generalized q,t-Catalan numbers.*

We define a family of maps on lattice paths, called *sweep maps*, that assign levels to each step in the path and sort steps according to their level. Surprisingly, although sweep maps act by sorting, they appear to be bijective. We explain how inversion of the sweep map (which is an open problem in general) can be solved in known special cases by finding a *bounce path* for the lattice paths under consideration. The sweep maps lead to concise combinatorial formulas for the q,t-Catalan numbers, the higher q,t-Catalan numbers, the q,t-square numbers, and many more general polynomials connected to the nabla operator and rational Catalan combinatorics. Many algorithms that have appeared in the q,t-Catalan literature are all special cases of the sweep maps or their inverses. The sweep maps provide a simple unifying framework for understanding all of these algorithms. (Received August 15, 2014)

1103-05-117 **James D. Currie*** (j.currie@uwinnipeg.ca), Faculty of Science, University of Winnipeg, 515 Portage Ave, Winnipeg, Manitoba R3B 2E9, Canada. *Perfect sets and words avoiding patterns.*

A non-empty set L of ω-words is **perfect** if whenever $u \in L$, there are other elements of L sharing arbitrarily long prefixes with u. The set of binary overlap-free ω-words is known to be perfect, and for any positive integers k and n, the set of ω-words on an n-letter alphabet avoiding k powers is either empty or perfect. I conjecture that for an arbitrary pattern p, the set of ω-words on an n-letter alphabet avoiding (or avoiding in the Abelian sense) p is either empty or perfect.

I will show that the results mentioned above on overlap-free words and k-power-free words can be shown using a unified set of technical tools, and will discuss the relevance of these tools to typical questions of combinatorics on words: n-avoidability, extendibility of words, and complexity of languages. (Received August 15, 2014)

1103-05-121 **Angela Hicks*** (ashicks@stanford.edu) and **Emily Leven**. *A simpler formula for the number of diagonal inversions of an (m, n)-Parking Function.*

Recent results have placed the classical shuffle conjecture of Haglund et al. in a broader context of an infinite family of conjectures about parking functions in any rectangular lattice. In this context, the combinatorial side of the new conjectures has been defined using a complicated generalization of the dinv statistic which is composed of three parts and which is not obviously non-negative. Here we simplify the definition of dinv, prove that it is always non-negative, and give a spacial description of the statistic in the style of the classical case. Time permitting, we'll discuss a result obtained using the simplified definition. (Received August 15, 2014)

1103-05-124 **Ernesto Vallejo*** (vallejo@matmor.unam.mx). *Some new results on the stability of Kronecker coefficients.*

In this talk we show how the diagrammatic method for computing Kronecker coefficients, developed by the author, can be applied to obtain several stability properties of these coefficients. As a particular case, we obtain the stability observed by Murnaghan a long time ago, and first proved by Littlewood in 1958. If time permits we will give other applications of the diagrammatic method. (Received August 16, 2014)

1103-05-125 **Brendon Rhoades*** (bprhoades@math.ucsd.edu). *Alexander duality and rational associahedra.*

Rational Catalan combinatorics is a program which takes as input a pair of coprime positive integers $(a < b)$ and returns a generalization of a Catalan object (such as noncrossing partitions, Dyck paths, and polygon triangulations). It is a fact of elementary number theory that if $(a < b)$ are coprime positive integers, so are $(b - a < b)$. We show how this observation "categorifies" to an instance of Alexander duality at the level of *rational associahedra*. In doing so, we prove a conjecture of D. Armstrong, B. Rhoades, and N. Williams. Our results exhibit genuinely new features of rational Catalan combinatorics which are invisible at the classical and Fuss levels of generality. (Received August 16, 2014)

1103-05-130 **Nataša Jonoska*** (jonoska@mail.usf.edu), **Florin Manea** (flmanea@gmail.com) and **Shinnosuke Seki** (shinsek@gmail.com). *Counting Squares in Binary Words.*

If u is a word, then uu is said to be a square of u. It has been conjectured by Fraenkel and Simpson in 1998 that a word of length n cannot have more than n distinct squares as subwords. We suggest a stronger conjecture for the number of distinct squares in a word over alphabet $\{a, b\}$. Let k be the least of the number of a's and the number of b's in the word. In this case, we propose that the number of distinct squares in a word of length n is bounded by $\frac{2k-1}{2k+2}n$. We observe that this new bound holds for several classes of binary words and we provide examples of words that achieve the proposed bound, thereby proving that the bound is tight. (Received August 17, 2014)

1103-05-147 **Cristian Lenart*** (clenart@albany.edu), Dept. of Mathematics and Statistics, State Univ. of New York at Albany, 1400 Washington Ave., Albany, NY 12222, and **Arthur Lubovsky** (alubovsky@albany.edu), Dept. of Mathematics and Statistics, State Univ. of New York at Albany, 1400 Washington Ave., Albany, NY 12222. *A uniform realization of the combinatorial R-matrix.*

Kirillov-Reshetikhin (KR) crystals are colored directed graphs encoding the structure of certain finite-dimensional representations of affine Lie algebras. In recent work S. Naito, D. Sagaki, A. Schilling, and M. Shimozono, I gave a uniform realization of a tensor product of (column shape) KR crystals, for all untwisted affine types, in terms of the so-called quantum alcove model. I will present my work with A. Lubovsky on using the mentioned model to realize the combinatorial R-matrix, i.e., the unique affine crystal isomorphism permuting factors in a tensor

product of KR crystals. As in type A the combinatorial R-matrix is realized by Schützenberger's sliding game (jeu de taquin) on Young tableaux, our algorithm generalizes the type A one. (Received August 18, 2014)

1103-05-150 **S. Brlek** and **N. Lafrenière*** (nadia.l@lacim.ca). *Extending the Brlek-Reutenauer Identity.*

Srečko Brlek and Christophe Reutenauer discovered some years ago an intriguing correspondance between palindromic complexity and factor complexity for words having language closed on reversal, periodic words and finite words. The equation has yet been proved for these types of words, but also for uniformly recurrent words and can be generalized to compare the pseudo-palindromic complexity and the factor complexity. The talk will discuss these extensions of the original conjecture. (Received August 18, 2014)

1103-05-156 **Sébastien Labbé*** (labbe@liafa.univ-paris-diderot.fr) and **Christophe Reutenauer**. *A d-dimensional extension of Christoffel words.*

In this article, we extend the definition of Christoffel words to directed subgraphs of the hypercubic lattice in arbitrary dimension that we call Christoffel graphs. Christoffel graphs when $d = 2$ correspond to well-known Christoffel words. Due to periodicity, the d-dimensional Christoffel graph can be embedded in a $(d-1)$-torus (a parallelogram when $d = 3$). We show that Christoffel graphs have similar properties to those of Christoffel words: symmetry of their central part and conjugation with their reversal. Our main result extends Pirillo's theorem (characterization of Christoffel words which asserts that a word amb is a Christoffel word if and only if it is conjugate to bma) in arbitrary dimension. In the generalization, the map $amb \mapsto bma$ is seen as a flip operation on graphs embedded in $\mathbb{Z}^d$ and the conjugation is a translation. We show that a fully periodic subgraph of the hypercubic lattice is a translate of its flip if and only if it is a Christoffel graph. (Received August 18, 2014)

1103-05-163 **Drew Armstrong**, **Nicholas A Loehr** and **Gregory S Warrington*** (gswarrin@uvm.edu). *Rational q-Catalan numbers and q-binomials.*

We present conjectured combinatorial formulas for rational q-Catalan numbers, $\mathrm{Cat}_{a,b}(q)$, and rational q-binomial coefficients, $\begin{bmatrix} a+b \\ a,b \end{bmatrix}_q$. For the latter case, the parameters a and b need not be coprime. However, for the coprime case we show bijectively that the two conjectures are equivalent. (Received August 18, 2014)

1103-05-171 **Neil A. McKay*** (neilmckay@dal.ca). *Recognizing Values from Hackenbush Hotchpotch.* Preliminary report.

Hackenbush Hotchpotch is a combinatorial game played by two players (Left and Right) on a graph where edges are colored blue, red, or green and some vertices are identified as the ground. A move for Left is to remove a bLue or green edge. A move for Right is to remove a Red or green edge. After a move, any edge not connected to the ground is removed. The first player unable to move loses.

For every combinatorial game position, say G, there is a unique simplest position, called the canonical form that is equal to G under the Fundamental Equivalence. The canonical forms of Hackenbush Hotchpotch are well-understood if a position has no green edges or only green edges. Furthermore, there are efficient algorithms to take a Hackenbush tree or forest and find the canonical form.

Given a canonical forms we do not know when there are Hackenbush positions which are equal. In particular, we ask which canonical forms are equal to some Hackenbush tree. We present a solution, based on ordinal sums, for identifying paths and extend those methods to some classes of Hackenbush forests. (Received August 18, 2014)

1103-05-172 **Laura Escobar***, 310 Malott Hall, Math dept, Ithaca, NY 14853. *Toric varieties of associahedra.*

In this talk we will define three objects: Bott-Samelson varieties, subword complexes and brick polytopes. More importantly we will discuss how these objects are connected: the moment polytope of a fiber of the Bott-Samelson map is the Brick polytope. In particular, we give a nice description of the toric variety of the associahedron in terms of flags arranged in a poset. (Received August 18, 2014)

1103-05-177 **Huilan Li*** (huilan@math.drexel.du), Department of Mathematics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104. *Combinatorial Hopf algebras and representation of Towers of algebras.*

Combinatorial Hopf algebra can be realized as the Grothendick group of some tower of algebras. A well-known example is that the space of symmetric functions (in commutative variables) can be understood as the Grothendick group of the symmetric groups. The induction and restriction on modules in the Grothendick group give rise to the algebra and coalgbra structures. We show that the space of symmetric functions in

noncommutative variables could be realized as the Grothendick group of the upper triangular groups over finite fields. This talk is based on the work with N. Bergeron, N. Thiem, M. Aguiar and more. (Received August 19, 2014)

1103-05-181 **Michael Schweitzer** and **Derek Smith*** (smithder@lafayette.edu). *Solving a Duplication Problem on a Square Grid.* Preliminary report.

The following duplication problem was introduced by Rosenfeld in *The American Mathematical Monthly* in 1991, motivated by efforts to find better bounds for the Shannon capacity of odd cycles. Mark as many cells as possible in an $n \times m$ rectangular grid using the following steps. For the initial step, mark a single cell. For all subsequent steps, find a completely unmarked translate of the currently marked cells, and then mark those cells as well. At the end of k steps, 2^k cells will be marked.

Recently, a specific instance of the problem was posed by Rosenfeld as unsolved: Is it possible to mark 128 cells of a 12×12 square grid? We solve this instance and present proofs, some by hand and some by computer, that determine the largest number of cells that can be marked in an $n \times n$ grid for $n \leq 182$. (Received August 19, 2014)

1103-05-183 **Emmanuel Briand*** (ebriand@us.es), Departamento de Matemática Aplicada I, E. T. S. de Ingeniería Informática, Avenida Reina Mercedes S/N, 41012 Sevilla, Spain. *Stability of Kronecker coefficients.*

I will present some recent works on the stability of Kronecker coefficients (some sequences of Kronecker coefficients that are eventually constant) and the interpretations of the corresponding stable values. (Received August 19, 2014)

1103-05-185 **Eugene Gorsky*** (egorsky@math.columbia.edu), Department of Mathematics, Columbia University, 2990 Broadway, New York, NY 10027, and **Mikhail Mazin** and **Monica Vazirani**. *Affine permutations and rational slope parking functions.*

We introduce a new approach to the enumeration of rational slope parking functions with respect to the area and a generalized dinv statistics, and relate the combinatorics of parking functions to that of affine permutations. We relate our construction to two previously known combinatorial constructions: Haglund's bijection exchanging the pairs of statistics (area,dinv) and (bounce,area) on Dyck paths, and Pak-Stanley labeling of the regions of k-Shi hyperplane arrangements by k-parking functions. Essentially, our approach can be viewed as a generalization and a unification of these two constructions. We also relate our combinatorial constructions to representation theory. We derive new formulas for the Poincare polynomials of certain affine Springer fibers and describe a connection to the theory of finite dimensional representations of DAHA and nonsymmetric Macdonald polynomials. (Received August 19, 2014)

1103-05-189 **Drew Armstrong***, Department of Mathematics, University of Miami, Coral Gables, FL 33146. *The story of Catalan numbers.*

I will talk about the history of Catalan numbers. (Received August 19, 2014)

1103-05-193 **Christian Stump*** (christian.stump@fu-berlin.de), **Hugh Thomas** and **Nathan Williams**. *Generalized cluster complexes and a new m-Tamari lattice.*

In this talk, I will discuss how one can use subword complexes for Artin groups to understand generalized cluster complexes as defined and studied by S. Fomin and N. Reading. This new description yields, in particular, a natural way of defining a poset structure on the facets of the generalized cluster complex. As these are well-known to be counted by the Fuß-Catalan numbers, one might hope to obtain the m-Tamari poset studied in the recent past by several authors. Surprisingly, it turns out that these two lattices do not coincide, even though they share many combinatorial properties, such as a way to obtain the h-polynomial of the generalized cluster complex. (Received August 19, 2014)

1103-05-197 **Darij Grinberg***, 70 Pacific Street, Apt 334, Cambridge, MA 02139. *Quasisymmetric functions and dual immaculate creation operators.*

Mike Zabrocki conjectured that the dual immaculate quasisymmetric functions (an analogue of Schur functions in which the semistandard Young tableaux are replaced by "immaculate tableaux" – tableaux of composition shape with every row weakly increasing and the first column strictly increasing) can be constructed inductively in a similar vein to the definition of the immaculate noncommutative symmetric functions, using Bernstein-like creation operators. I will give a proof of this fact and relate it to the dendriform algebra structure on QSym. I will also discuss connections to Malvenuto and Reutenauer's generalization of P-partitions – the so-called Γ-partitions – and how the theory of QSym could be constructed using the latter (forthcoming work).

Most of the talk follows http://web.mit.edu/~darij/www/algebra/dimcreation.pdf . (Received August 19, 2014)

1103-05-200 **Chris Berg**, **Nathan Williams** and **Mike Zabrocki*** (zabrocki@mathstat.yorku.ca), 4700 Keele St, Toronto, ON M3J1P3, Canada. *Symmetries on the lattice of k-bounded partitions.*

Suter proved the sub-poset of partitions contained in some k-rectangle has a (k+1)-rotational symmetry. It turns out that this surprising fact about partitions arises because this poset is isomorphic to a subposet of the weak order on the affine Weyl group mod the finite Weyl group in type A.

Inspired by the combinatorics of k-Schur functions, we generalize Suter's result by considering what the analogous statement is on the weak order on (k+1)-cores or k-bounded partitions. In developing the combinatorics of these struc- tures we show how maximal k-rectangles can be used to give the coordinates for elements of the affine Weyl group quotient. (Received August 19, 2014)

11 ► Number theory

1103-11-4 **Sujatha Ramdorai*** (sujatha@math.ubc.ca), Math Department, 1984, Mathematics Road, UBC, Vancouver, BC V6T1Z2, Canada. *Galois representations and Iwasawa theory.*

Galois representations have been an important area of study as they provide information on Galois extensions of the field of rational numbers. Their study pervades broad areas in arithmetic and are now an important aspect of study in Iwasawa theory. We shall review some results on the noncommutative Iwasawa theory associated to Galois representations. (Received August 20, 2014)

1103-11-19 **Nancy Childress** and **Scott Zinzer***, SoMSS, Arizona State University, Tempe, AZ 85287. *Iwasawa λ-invariants of p-adic measures and their Γ-transforms.*

Let $\preccurlyeq$ be a total order on $\mathbb{N}^d$ extending the product order. For a d-variable power series F with p-adic integral coefficients, we introduce the Iwasawa λ-invariant of F associated to $\preccurlyeq$. We give the relationship between such λ-invariants of two power series which are naturally associated to the Γ-transform of a p-adic measure on $\mathbb{Z}_p^d$. In particular, we show that these new notions of λ-invariants behave as their one-dimensional counterparts with respect to the Γ-transform on p-adic measures. This work generalizes the statement and proof of the analogous result for p-adic measures on $\mathbb{Z}_p$ due to Satoh. We also show how our results can be used to recover similar results for the various λ-invariants of a p-adic measure on $\mathbb{Z}_p^d$ introduced earlier in the literature. (Received July 16, 2014)

1103-11-25 **Marc Chamberland*** (chamberl@math.grinnell.edu), Grinnell, IA 50112. *Averaging Structure in the $3x+1$ Problem.* Preliminary report.

The famous 3x+1 problem has resisted analysis from multiple perspectives for many decades. This talk studies the more general $qx + r$ problem, where q and r are odd, and finds new, averaging structures for the iterates. This structure supports the conjecture that all orbits enter a cycle if $q = 1$ or 3 but most orbits diverge if $q \geq 5$. (Received July 24, 2014)

1103-11-59 **Armin Straub*** (astraub@illinois.edu). *On a q-analog of the Apéry numbers.* Preliminary report.

The Apéry numbers $A(n)$ are the famous sequence which underlies Apéry's proof of the irrationality of $\zeta(3)$. Together with their siblings, known as Apéry-like, they enjoy remarkable properties, including connections with modular forms, and have appeared in various contexts. One of their (still partially conjectural) properties is that these sequences satisfy supercongruences, a term coined by Beukers to indicate that the congruences are modulo exceptionally high powers of primes. For instance,

$$A(p^r m) \equiv A(p^{r-1} m) \pmod{p^{3r}}$$

for primes $p \geq 5$. In this talk, we introduce and discuss a q-analog of the Apéry numbers. In particular, we prove a supercongruence for these polynomials. (Received August 17, 2014)

1103-11-60 **Stefan Catoiu*** (satoiu@condor.depaul.edu), 2320 N. Kenmore Avenue, Chicago, IL 60614. *Diophantine equations arising from generalized hyperbolic and trigonometric Hopf algebras.*

We investigate Diophantine equations arising from generalized trigonometric and hyperbolic Hopf algebras. In particular, we provide an appropriate degree n generalization of the Pythagorean equation that is different from Fermat's equation. (Received August 10, 2014)

1103-11-64 **Eyal Z Goren*** (eyal.goren@mcgill.ca) and **Ehud De Shalit**. *p-adic properties of Picard modular surfaces and forms.* Preliminary report.

We consider geometric questions concerning Picard modular surfaces in positive characteristic p and special relations between their automorphic vector bundles. We apply this to the study of p-adic modular forms and the construction of a theta operator. Along the way we provide an interesting model for the universal abelian threefold in characteristic zero that allows us to perform calculations that are relevant to our p-adic constructions. (Received August 11, 2014)

1103-11-94 **Siddarth Sankaran*** (siddarth.sankaran@utoronto.ca). *Cycles on Rapoport-Zink spaces and modular forms.*

In this talk, I will discuss examples of Rapoport-Zink spaces, which are moduli spaces of p-divisible groups, and structural results regarding certain families of 'special' cycles on them. Understanding these (local) cycles is a crucial step in Kudla's programme, which seeks to relate (global) cycles on Shimura varieties to Fourier coefficients of modular forms. (Received August 14, 2014)

1103-11-96 **Manfred Kolster*** (kolster@mcmaster.ca), 1280 Main Street West, Hamilton, Ontario L8S 4L8, Canada. *The Coates-Sinnott Conjecture.*

The Coates-Sinnott Conjecture states a generalization of the classical Stickelberger Theorem, namely that certain analogues of Stickelberger elements, constructed using special values at $1-n$ for $n \geq 2$ of an equivariant L-function attached to a finite abelian extension E/F of number fields, annihilate the even K-groups $K_{2n-2}(o_E)$ of the ring of integers o_E of E.

In the talk we discuss the relation to p-adic versions of the Conjecture (p any prime) and to the Equivariant Main Conjecture in Iwasawa Theory, emphasizing the situation for the notoriously difficult prime 2.

Part of this is joint work with Reza Taleb. (Received August 14, 2014)

1103-11-122 **Michael J. Mossinghoff***, Dept. of Mathematics and Computer Science, Davidson College, Davidson, NC 28035-6996, and **Timothy S. Trudgian**, College of Physical and Mathematical Sciences, Australian National University, Canberra, Australia. *A zero-free region for the Riemann zeta-function.* Preliminary report.

In his work on the Prime Number Theorem, de la Vallée Poissin proved that the Riemann zeta function $\zeta(\sigma+it)$ has no zeros in the region $\sigma > 1 - 1/(R\log|t|)$ and $|t| \geq 2$, with $R \approx 30.47$. While a zero-free region of this form is superseded asymptotically by results of Vinogradov and Ford, for more limited heights this classical region remains of interest, and finds application in various problems in number theory. As a result, a number of researchers have reduced the value of R in the de la Vallée Poissin zero-free region over the years, including Kadiri, who showed in 2005 that one can take $R = 5.69693$. We report on some experimental and analytic work on reducing this constant further. (Received August 15, 2014)

1103-11-126 **Michael Filaseta*** (filaseta@math.sc.edu). *Integral points on curves and Hilbert's Irreducibility Theorem.* Preliminary report.

The speaker has been interested in finding an elementary argument tying together Siegel's Theorem on the finiteness of integral points on curves of genus > 0 to Hilbert's Irreducibility Theorem, the latter in the form that for a given irreducible $f(x,y) \in \mathbb{Q}[x,y]$ of degree at least one in x, the polynomial $f(x,t)$ is irreducible over $\mathbb{Q}$ for almost all integers t. In this talk, we will present such an argument. (Received August 16, 2014)

1103-11-137 **John B. Cosgrave** and **Karl Dilcher*** (dilcher@mathstat.dal.ca), Department of Math. & Stats., Dalhousie University, Halifax, NS B3H 4R2, Canada. *The multiplicative orders of certain Gauss factorials.*

This talk deals with the multiplicative orders of $\left(\frac{n-1}{M}\right)_n! \pmod n$ for odd prime powers $n = p^\alpha$, $p \equiv 1 \pmod M$, where the Gauss factorial $N_n!$ denotes the product of all integers up to N that are relatively prime to n. Considering the connection between the orders for p^α and for $p^{\alpha+1}$, we obtain new criteria for exceptions to a general pattern, with particular emphasis on the cases $M = 3$, $M = 4$ and $M = 6$. In the process we also obtain some results of independent interest. Most results are based on generalizations of binomial coefficient congruences of Gauss, Jacobi, and Hudson and Williams. (Received August 17, 2014)

1103-11-142 **Joel Bellaiche*** (jbellaic@brandeis.edu). *The eigencurve at classical points of weight 1.*

This is a joint work with Mladen Dimitrov. We determine the geometry of the eigencurve at points corresponding to classical modular forms of weight one. At such a point (under a mild assumption of regularity at p) we prove that the eigencurve is always smooth, and that it is furthermore étale over the weight space if and only if the form has real multiplication by a quadratic real field in which p splits. As a consequence of this result, we can

construct p-adic L-function for forms of weight one which fit in a two-variable family over the eigencurve. (Received August 18, 2014)

1103-11-145 **Kazim Buyukboduk** and **Antonio Lei*** (antonio.lei@mat.ulaval.ca), Département de Mathématiques et de Stat., Pavillion Alexandre-Vachon, 1045 Avenue de la Médecine, Québec, Québec G1V 0A6, Canada. *Integral Iwasawa theory of p-adic representations at non-ordinary primes.*

We study the Iwasawa theory of p-adic representations at non- ordinary primes, over the cyclotomic tower of a number field that is either totally real or CM. In particular, under certain technical assumptions, we construct Sprung-type Coleman maps on the local Iwasawa cohomology groups and use them to define integral p- adic L-functions and cotorsion Selmer groups. This allows us to reformulate Perrin-Riou's main conjecture in terms of these objects, in the same fashion as Kobayashi's ±-Iwasawa theory for supersingular elliptic curves. (Received August 18, 2014)

1103-11-149 **Jennifer Park*** (jmypark@math.mit.edu), McGill University, 845 Rue Sherbrooke Ouest, Montreal, QC H3A 0G4, Canada. *Effective Chabauty for symmetric powers of curves.*

Faltings' theorem states that curves of genus g$>$ 1 have finitely many rational points. Using the ideas of Faltings, Mumford, Parshin and Raynaud, one obtains an upper bound on the number of rational points, but this bound is too large to be used in any reasonable sense. In 1985, Coleman showed that Chabauty's method, which works when the Mordell-Weil rank of the Jacobian of the curve is smaller than g, can be used to give a good effective bound on the number of rational points of curves of genus g $>$ 1. We draw ideas from nonarchimedean geometry to show that we can also give an effective bound on the number of rational points outside of the special set of the d-th symmetric power of X, where X is a curve of genus g $>$ d, when the Mordell-Weil rank of the Jacobian of the curve is at most g-d. (Received August 18, 2014)

1103-11-159 **Shashank Kanade** (skanade@math.rutgers.edu) and **Matthew C. Russell*** (russell2@math.rutgers.edu). *Conjecturing new partition identities with computer algebra.* Preliminary report.

Rogers-Ramanujan identities and their numerous generalizations (Gordon, Andrews-Bressoud, Capparelli, etc.) form a family of very deep identities concerned with the integers partitions. These identities (written in generating function form) are typically of the form "product side" equals "sum side", with the product side enumerating partitions obeying certain congruence conditions and the sum side obeying certain initial conditions and difference conditions (along with possibly other restrictions). We use symbolic computation to generate various such sum sides and then use Euler's algorithm to see which of them actually do produce elegant conjectured product sides. We not only rediscover many of the known identities but also discover some apparently new ones. (Received August 18, 2014)

1103-11-187 **Glenn Stevens*** (ghs@math.bu.edu), Department of Mathematics and Statistics, 111 Cummington Mall, Boston, MA 02215, and **Avner Ash**. *The Eigenvariety Machine and a Conjecture of Eric Urban.*

Eigenvarieties have played an important role in the p-adic theory of automorphic forms and their global arithmetic properties, by providing a natural context for investigating families of galois representations, and p-adic L-functions. In this talk we present an axiomatic construction of cohomological eigenvarieties and discuss a conjecture of Eric Urban that predicts the dimension of these eigenvarieties in automorphic settings. Our starting point is the "eigenvariety machine" of Coleman-Mazur and Buzzard which produces eigenvarieties attached to orthonormalizable Banach modules with an action of the Hecke algebra. We extend this by constructing eigenvarieties associated to the arithmetic cohomology of orthonormalizable Banach modules and by giving a lower bound for their dimensions, consistent with Urban's conjecture. (Received August 19, 2014)

13 ► Commutative rings and algebras

1103-13-14 **Adam Van Tuyl*** (avantuyl@lakeheadu.ca), Department of Mathematical Sciences, Lakehead University, Thunder Bay, Ontario P7B 5E1, Canada. *Edge ideals of circulant graphs.*

Fix a positive integer n and subset $S \subseteq \{1, 2, \ldots, \lfloor \frac{n}{2} \rfloor\}$. The circulant graph $C_n(S)$ is the graph on the n vertices $\{0, 1, \ldots, n-1\}$ with edge set consisting of all $\{i, j\}$ with $|i-j| \pmod n \in S$. Graph theorists have recently been interesed in identifying which circulant graphs are well-covered, that is, all the maximum vertex covers have the same size. If we consider the edge ideal of a graph, a well-covered graph implies that the edge ideal is an unmixed

ideal. In this talk, we use the recent results on well-covered circulant graphs to identify circulant graphs that are either Cohen-Macaulay or Buchsbaum. This talk is based upon the NSERC Undergradue Student Research Awards projects of C. Watt (2012) and J. Earl (2014); these projects were co-supervised by myself and K. Vander Meulen (Redeemer). (Received July 04, 2014)

1103-13-17 **Chris Francisco*** (chris@math.okstate.edu), Department of Mathematics, 401 MSCS, Oklahoma State University, Stillwater, OK 74078, and **Jeffrey Mermin** and **Jay Schweig**. *Some numerical results on decompositions of Betti diagrams.* Preliminary report.

We discuss the effect of multiplying an ideal by a form on the Boij-Söderberg decomposition. We also describe an alternative decomposition of Betti diagrams (with coefficients that are not always positive). (Received July 14, 2014)

1103-13-26 **Laura Ghezzi*** (lghezzi@citytech.cuny.edu). *Hilbert Coefficients and Reduction Numbers.*

Let $(R, \mathfrak{m})$ be a Noetherian local ring and let I be a $\mathfrak{m}$-primary ideal. We discuss relationships between the Hilbert coefficients of I and its reduction number. This is joint work with Goto, Hong, and Vasconcelos. (Received July 25, 2014)

1103-13-37 **Mats Boij** (boij@kth.se), **Juan Migliore*** (migliore.1@nd.edu), **Rosa Miró-Roig** (miro@ub.edu) and **Uwe Nagel** (uwe.nagel@uky.edu). *A geometric approach to the Weak Lefschetz Property for height four complete intersections.* Preliminary report.

The Weak Lefschetz Property (WLP) for an artinian graded algebra says that for a general linear form, the induced multiplication from any component to the next has maximal rank. In characteristic zero, it is known that every complete intersection of height 2 or 3 has the WLP, and it is known that a monomial complete intersection of any height has the WLP. So far the known methods have not extended these results even to arbitrary complete intersections of height 4. We introduce a new approach, which translates the question into one about the general hyperplane section of a certain smooth curve (at least in some interesting cases). It does not prove the desired general result, but it provides some partial results. This is joint work with Mats Boij, Rosa Miró-Roig and Uwe Nagel. (Received August 02, 2014)

1103-13-54 **Selvi Beyarslan**, **Tai Ha*** (tha@tulane.edu) and **Tran Nam Trung**. *Regularity of powers of edge ideals.*

Let $I = I(G)$ be the edge ideal of a simple graph G. When G is a tree or when G is a cycle we explicitly compute the regularity of I^s for any $s \geq 1$. In particular, we exhibit the asymptotic linearity of the regularity of I^s for $s \gg 0$. (Received August 07, 2014)

1103-13-70 **Sandra Spiroff*** (spiroff@olemiss.edu), Department of Mathematics, P.O. Box 1848, Hume Hall 335, University, MS 38677, and **Sean Sather-Wagstaff**. *Torsion Divisor Classes.*

We investigate torsion elements in the kernel of the map between divisor class groups Cl(A) to Cl(A/I), where I is an ideal of finite projective dimension in an excellent local normal domain A. Our work relates back to a 1994 result by P. Griffith and D. Weston in the case that I is principal. (Received August 11, 2014)

1103-13-73 **Bill Robinson*** (robinsonwm@uky.edu) and **Uwe Nagel**. *Liaison Classification of Skew Tableau Ideals.*

Symmetric skew tableau schemes are defined by ideals which arise from the study of edge ideals of bipartite graphs. They are generated by minors in a subregion of a symmetric matrix of indeterminates called a skew tableau. In our talk, we will present some recent results on the liaison classification of skew tableau ideals, discuss a few of the nice properties that they enjoy, and mention some ongoing areas of research. This is joint work with Uwe Nagel. (Received August 11, 2014)

1103-13-74 **Alessio Moscariello** and **Alessio Sammartano*** (asammart@purdue.edu). *A conjecture of Wilf on the Frobenius number.*

The Frobenius number F of given coprime positive integers $a_1 < \cdots < a_d$ is the largest integer which is not representable as a non-negative integer combination of the a_i's. Let n denote the number of integers less than F admitting such a representation: Wilf conjectured in 1978 that $F + 1 \leq nd$. The inequality has an interpretation in terms of one-dimensional local rings. We will discuss some recent progress on the conjecture, as well as some related problems. (Received August 12, 2014)

1103-13-87 **Anthony V. Geramita**, **Andrew H. Hoefel** and **David L. Wehlau*** (wehlau@rmc.ca). *Hilbert Functions of Artinian Gorenstein Ideals Stabilized by the Symmetric Group.*

We consider graded artinian Gorenstein quotients of the polynomial ring which are also representations of the symmetric group and whose socle is invariant. We will determine their graded characters and Hilbert functions by relating these algebras to subrepresentations of the regular representation of the symmetric group. These turn out to be closely related to Kostka-Foulkes polynomials. (Received August 13, 2014)

1103-13-92 **Uli Walther*** (walther@math.purdue.edu), **Gennady Lyubeznik** and **Anurag K. Singh**. *Local cohomology of determinantal ideals over the integers.*

In joint work with Gennady Lyubeznik and Anurag Singh we investigate local cohomology of the ideal of k-minors of an m-by-n matrix of indeterminates over the integers. This is interesting since the behavior over fields of characteristic zero differs wildly from the finite characteristic case, and the integers tie both cases together. (Received August 14, 2014)

1103-13-118 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu), **Bethany Kubik** and **Chelsey Paulsen**. *Path ideals of weighted graphs.* Preliminary report.

Given a (finite simple) graph G, the edge ideal of G is a square-free monomial ideal generated by the edges of G. This is a fairly well-studied invariant of G. Recently, the r-path ideal of G has been introduced and studied when G is a tree. We study this ideal for arbitrary G. Moreover, we introduce versions of these ideals when G is a weighted graph. These ideals are not square-free in general. We give explicit descriptions of their primary decompositions, and we present some criteria for these ideals to be Cohen-Macaulay (Received August 15, 2014)

1103-13-120 **Federico Galetto***, 48 University Avenue, Queen's University, Kingston, ON K7L 3N6, Canada. *Equivariant resolutions of De Concini-Procesi ideals.* Preliminary report.

For modules over polynomial rings with a reasonable group action, the minimal free resolution of the module inherits an action by the same group. Understanding how the group acts on the resolution leads to a refinement of classical invariants of the module, such as the Betti numbers and the Hilbert series. In this talk, I will present examples of resolutions, with the action of a symmetric group, arising from certain ideals introduced by De Concini and Procesi with particular significance in geometry, combinatorics and representation theory. (Received August 15, 2014)

1103-13-128 **Jonathan Montaño*** (jmontano@purdue.edu), Department of Mathematics, Purdue University, 150 North University Street, West Lafayette, IN 47907. *Artin-Nagata properties, minimal multiplicities, and depth of fiber cones.*

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

1103-13-131 **H. E. A. Eddy Campbell*** (eddy@unb.ca), Sir Howard Douglas Hall, 3 Bailey Drive, Fredericton, NB E3B 5A3, Canada, and **David L. Wehlau** and **R J Shank**. *Modular Invariant Rings of Elementary Abelian p-Groups.*

This is work with Jim Shank and David Wehlau that appeared in Transformation Groups, V18, No. 1, 2013, together with a sequel still in progress. We studied rings of invariants of elementary Abelian p-groups in characteristic p. We parameterized all 2 and 3 dimensional representations. We are able to compute the associated invariant rings for all 2 dimensional represent ions and for 3-dimensional representations for such groups of rank at most 3. These rings are complete intersections of embedding dimension of at most 5. We conjecture that all 3-dimensional representations of an elementary Abelian group of rank r are complete intersections of embedding dimension at most [r/2] +3. (Received August 17, 2014)

1103-13-141 **Angelica Benito**, **Greg Muller**, **Jenna Rajchgot*** (rajchgot@umich.edu) and **Karen E. Smith**. *Singularities of locally acyclic cluster algebras.*

Locally acyclic cluster algebras, introduced by Greg Muller, are a class of cluster algebras which are flexible enough to include many of the fundamental examples of cluster algebras, yet restrictive enough to avoid the pathological behavior sometimes found in general cluster algebras. I will show that locally acyclic cluster algebras of positive characteristic are strongly F-regular, a condition with strong consequences for singularities. Time

permitting, I'll provide some examples to show that we cannot expect arbitrary cluster algebras to be strongly F-regular. No knowledge of cluster algebras or strong F-regularity will be assumed.

This is joint work with Angelica Benito, Greg Muller, and Karen E. Smith. (Received August 17, 2014)

14 ► Algebraic geometry

1103-14-13 **Jaydeep Chipalkatti*** (chipalka@cc.umanitoba.ca), Department of Mathematics, University of Manitoba, Winnipeg, Manitoba R3T2N2, Canada. *The coincidences of Pascal lines.*

Pascal's theorem says that given six distinct points $A, B, \ldots, F$ on a conic, the three cross-joins $AE \cap BF, AD \cap CF, BD \cap CE$ are concurrent. The line containing them is called their Pascal. By permuting the names of the points, one gets sixty such lines in general, which are all distinct for a general choice of initial points. We show that if some of the Pascals coincide (i.e., the lines are not all distinct), then the points must either be in involution, or in the 'ricochet configuration'. The proof uses Gröbner basis techniques to solve multivariate polynomial equations. (Received July 02, 2014)

1103-14-63 **Nathan Grieve*** (nathan.m.grieve@gmail.com). *Analogies amongst vector bundles on G/B and Abelian varieties.*

Let Y be an abelian variety, G a semi-simple algebraic group, $B \subseteq G$ a Borel subgroup, and $X = G/B$. The goal of this talk is to explain several analogies between vector bundles on Y and X. While some of these analogies are classical, others are more recent and become apparent when considering work of Dimitrov-Roth, concerning cup-product problems determined by line bundles on X, and work of myself, related to cup-product problems determined by line bundles on Y. I will then, time permitting, motivate and discuss the problem of extending these analogies further, for instance in the setting of polarized towers of abelian varieties and flag manifolds associated to Kac-Moody groups. (Received August 11, 2014)

1103-14-81 **Brian Harbourne*** (bharbourne1@unl.edu), Math Department, University of Nebraska-Lincoln, Lincoln, NE 68588. *Open problems on negativity in algebraic geometry and connections to combinatorics and commutative algebra.* Preliminary report.

An open question involving projective plane curves is how negative reduced curves can be. This question is interesting only for singular curves. So let C be a singular plane curve defined by a square free homogeneous polynomial F_C of degree d. Let s be the number of singular points of C and let the multiplicities of the singularities of C be $m_1, \ldots, m_s$. Define the negativity N_C of C to be $N_C = (d^2 - m_1^2 - \cdots - m_s^2)/s$. It is an open problem to determine a lower bound on the possible values of N_C over all reduced curves C, or even to show a bound exists. Examples of curves C with $N_C \leq -3$ are rare and none are known with $N_C \leq -4$. This problem is closely related to seemingly unrelated problems in combinatorics (such as finding finite sets of lines such that there are no points where exactly two of the lines cross) and commutative algebra (such as finding examples of ideals I of finite sets of points in the plane such that $I^{(3)} \not\subseteq I^2$). I will discuss connections between these problems, and some recent results. (Received August 13, 2014)

1103-14-114 **Ragnar-Olaf Buchweitz**, **Graham J Leuschke*** (gjleusch@syr.edu) and **Michel Van den Bergh**. *The derived category of Grassmannians.*

We consider Grassmannian varieties in arbitrary characteristic. Generalizing Kapranov's well-known characteristic-zero results we construct dual exceptional collections on them as well as a tilting bundle. (Received August 15, 2014)

1103-14-116 **Karen A Chandler*** (chandler@math.harvard.edu), Halifax, NS , Canada. *The Fröberg-Iarrobino Conjecture on fat points and its extensions to fat higher-dimensional subspaces.*

Given maximal ideals $\mathfrak{m}_1, \ldots, \mathfrak{m}_d$ of the graded ring $S = \mathcal{K}[X_0, \ldots, X_n]$ and an ideal $I = \mathfrak{m}_1^{k_1} \cap \ldots \cap \mathfrak{m}_d^{k_d}$ we consider $\dim(S/I)_m$ for each m: the Hilbert function of a collection of "fat points". R. Fröberg and A. Iarrobino examine such dimensions and give an explicit conjectural function G (according to n, $k_1, \ldots, k_d$, and d) along with conjectures on whether this is an upper bound for the Hilbert function and consider when equality occurs.

Previously we have observed — at least qualitatively — a geometric interpretation of these conjectures. Here, we explicitly calculate this geometric intersection value to show equality with the conjectured value G. Further it is natural to extend the Fröberg-Iarrobino hypotheses, conjectures, and formula toward any collection of fat projective subspaces of $\mathbb{P}^n$; indeed this is required in the evaluation on points. We shall illustrate an approach toward verifying the extended hypotheses and conjecture. (Received August 17, 2014)

1103-14-136 **Anthony Geramita*** (anthony.geramita@gmail.com), Dept. of Mathematics and Statistics, Queen's University, KINGSTON, Ontario K7L3N6, Canada. *The Secant Line Variety to the Varieties of Reducible Plane Curves.*

Let $S = K[x_0, x_1, x_2] = \oplus_{i=0}^{\infty} S_i$ be the standard graded polynomial ring over an algebraically closed field K. Let $\lambda = [d_1, \ldots, d_r]$ be a partition of d into exactly r parts. The subvariety of $P(S_d)$ consisting of all forms which split as a product $F = F_1 \cdots F_r$, where $\deg F_i = d_1$ is called the variety of *reducible curves of type* λ.

The results described in this talk, which is joint work with M.V. Catalisano, A. Gimigliano and Y.S. Shin, will give the dimensions of the secant line varieties of the varieties described above, for every partition λ. (Received August 17, 2014)

1103-14-140 **Amy Ksir*** (ksir@usna.edu) and **Caroline Grant Melles** (cgg@usna.edu). *Automorphisms of genus* 2 *curves and their skeletons.*

Let K be an algebraically closed non-Archimedean field which is complete with respect to a non-trivial Archimedean valuation. For each smooth projective algebraic curve X over K, there is a Berkovich analytification X^*. When X has genus at least 1, there is a unique minimal skeleton Σ in X^* with the structure of a finite metric graph. An automorphism of X induces an automorphism of X^* which restricts to a metric graph automorphism of Σ. In some cases, however, the group of automorphisms of the metric graph is larger than the automorphism group of the original curve. I will describe the situation in some detail in the genus 2 case. (Received August 17, 2014)

16 ► Associative rings and algebras

1103-16-58 **Leonid Krop*** (leonard.krop@gmail.com), Department of Mathematics, DePaul University, Chicago, IL 60614. *Counting number of isomorphism classes of extensions.*

For brevity, let us call a Hopf algebra nontrivial if it is neither commutative, nor cocommutative. We determine the number of nonisomorphic Hopf algebras H which exhibit an extension
$\Bbbk^G \to H \to \Bbbk C_p$ with $G = C_{p^e} \times C_p, e \geq 1$ and p odd. The even order case has been done by
Y. Kashina (2003).

Applying general theory for counting isomorphism classes of extensions with an arbitrary finite p-group G we prove the following

Theorem: For any $e \geq 2$ there are $2p + 8$ nontrivial Hopf algebras in the class of Hopf algebras which are extensions of $\Bbbk^G$ by $\Bbbk C_p$.

Combining with some of our previous results the Theorem allows us to complete calculation of the number of nonisomorphic nontrivial semisimple Hopf algebras of dimension p^4 containing an abelian group of group-likes of order p^3. That number equals to $5p + 24$ if $p > 3$, and 33, otherwise. (Received August 09, 2014)

1103-16-68 **Hamid Usefi*** (usefi@mun.ca), Department of Mathematics and Statistics, Memorial University of Newfoundland, St John's, NL A1C5S7, Canada, and **Salvatore Siciliano** (salvatore.siciliano@unisalento.it), Dipartimento di Matematica e Fisica, "Ennio De Giorgi", Universita' del Salento, 73100 Lecce, Lecce, Italy. *Lie properties of smash products.*

Let L be a (restricted) Lie algebra over a field $\mathbb{F}$ and G a group. It is known when the group algebra $\mathbb{F}G$ of G or the enveloping algebra $U(L)$ of L are Lie solvable or Lie nilpotent. Suppose now that G acts on L by automorphisms. Then one can form the smash product $U(L)\#\mathbb{F}G$. Smash products appear in the context of Hopf algebras as it is known that every cocommutative Hopf algebra over an algebraically closed field of characteristic zero can be presented as a smash product. We give necessary and sufficient conditions under which $U(L)\#\mathbb{F}G$ is Lie solvable or Lie nilpotent. (Received August 11, 2014)

1103-16-79 **Tom Halverson*** (halverson@macalester.edu), Macalester College, 1600 Grand Ave, Saint Paul, MN 55105, and **Nathaniel Thiem**. *Restriction-Induction Centralizer Algebras.* Preliminary report.

The partition algebra is the centralizer algebra of the k-fold tensor product of the permutation module of the symmetric group S_n. This tensor product module is isomorphic to k-fold iterations of restriction from S_n to S_{n-1} and induction back to S_n. We explore the general phenomenon of restriction-induction centralizer algebras. As an application we will consider two different ways to construct a q-analog of the partition algebra, one coming from restriction and induction on Iwahori-Hecke algebras and one coming from Harish-Chandra restriction and induction on finite general linear groups. (Received August 13, 2014)

1103-16-84 **David E Radford*** (radford@uic.edu). *Biproducts and Kashina's Examples.* Preliminary report.

We revisit a class of examples described in the original paper on biproducts, expand the class, and provide a detailed analysis of the coalgebra and algebra structures of many of these examples. Connections with the semisimple Hopf algebras whose dimension is a power of two determined by Kashina are examined.

The finite-dimensional non-trivial semisimple cosemisimple Hopf algebras we construct are shown to be lower cosolvable. Some of these have one proper normal Hopf subalgebra and are not lower solvable. (Received August 13, 2014)

1103-16-90 **Alessandro Ardizzoni*** (alessandro.ardizzoni@unito.it), University of Turin, Department of Mathematics "Giuseppe Peano", via Carlo Alberto 10, I-10123 Torino, Italy. *A functorial approach to Lie Theory.*

Hom-Lie algebras, Lie color algebras, Lie superalgebras and other type of generalized Lie algebras are recovered by means of an iterated construction, known as monadic decomposition of functors, which is based on Eilenberg-Moore categories.

This talk is mainly based on the work [A. Ardizzoni and C. Menini, "Milnor-Moore Categories and Monadic Decomposition", submitted. (arXiv:1401.2037)] (Received August 14, 2014)

1103-16-108 **Gaston Andres Garcia*** (ggarcia@mate.unlp.edu.ar). *Multiparameter quantum groups, bosonizations and cocycle deformations.*

In this talk we will discuss cocycle deformations on bosonizations of braided Hopf algebras R over Hopf algebras with bijective antipode H in order to study multiparameter quantum groups. With this in mind, we first describe quantum groups given by multiparametric deformations of enveloping algebras of Kac-Moody algebras as a family of pointed Hopf algebras, which are quotients of bosonizations of pre-Nichols algebras, and show that under some hypothesis, these quantum groups depend only on one parameter on each connected component of the Dynkin diagram; in particular, we obtain in this way a known result of Hu, Pei and Rosso. (Received August 14, 2014)

1103-16-112 **Peter Schauenburg*** (peter.schauenburg@u-bourgogne.fr), Institut de Mathématiques de Bourgogne, Faculté des Sciences Mirande, 9 avenue Alain Savary, BP 47870, 21078 Dijon, France. *Autoequivalences of Yetter-Drinfeld module categories.*

We report on two classes of autoequivalences of the category of Yetter-Drinfeld modules over a finite group, or, equivalently, the category of modules over the Drinfeld double of that group. Both autoequivalences are associated to taking r-th powers with r relatively prime to the exponent of the group. They preserve tensor products, and preserve Frobenius-Schur indicators up to Galois conjugation. (Received August 15, 2014)

1103-16-127 **Serban Raianu*** (sraianu@csudh.edu), Mathematics Department, California State University, Dominguez Hills, 1000 E Victoria St, Carson, CA 90747. *Corings and External Homogenization.*

We give a coring version for the external homogenization for Hopf algebras, which is a generalization of a construction from graded rings, called the group ring of a graded ting. We also provide a coring version of a Maschke-type theorem. (Received August 17, 2014)

1103-16-133 **Yuri Bahturin*** (bahturin@mun.ca). *Group gradings on infinite-dimensional algebras.*

I will talk about some classification results concerning gradings by groups on certain simple infinite-dimensional associative and Lie algebras and problems which arise in the general case. (Received August 17, 2014)

1103-16-134 **William Chin*** (chin.bill@gmail.com), Dept. of Mathematical Sciences, DePaul University, Chicago, IL 60614. *Coverings of graded pointed Hopf algebras.*

We introduce coverings of graded pointed Hopf algebras. The theory developed shows that covering Hopf algebras of a bosonized Nichols algebra can be concretely expressed by biproducts using a quotient of the universal coalgebra covering group of the Nichols algebra. If there are enough quadratic relations, the universal coalgebra covering is given by the bosonization by the enveloping group of the underlying rack. Coverings provide infinite families of link-indecomposable finite-dimensional Hopf algebras over a range of examples with nonabelian groups of group-like elements. (Received August 17, 2014)

1103-16-144 **Joost Vercruysse***, ULB - Departement de Mathématiques - CP216, Campus de la Plaine, Boulevard du Triomphe, B-1050 Brussels, Belgium. *The Hopf algebroid associated to the partial representations of a Hopf algebra.*

When studying the symmetries of an object X, one sometimes prefers to permit some of these symmetries to act not "globally" (i.e. as a bijection on X), but just "partially" (i.e. as a bijection from a part of X to another part

of X). This has lead to the notions of partial actions and representations of groups. These in turn motivated the study of partial actions ("module algebras") and coactions ("comodule algebras") of Hopf algebras. There are remarkable similarities with the theory of weak Hopf algebras.

We will introduce partial representations, or "partial modules", for a Hopf algebra H. It turns out that the category of partial modules is a monoidal category that coincides with the category of modules over a newly constructed Hopf algebroid H_{par}, which indicates another similarity with weak Hopf algebra theory. An algebra in this monoidal category is precisely a partial action over the Hopf algebra H. Different to the weak case and the case of partial representations of groups, the constructed Hopf algebroid H_{par} can however be infinite dimensional if the initial Hopf algebra H is finite dimensional.

This is a joint work with Marcelo Muniz Alves and Eliezer Batista (Received August 18, 2014)

1103-16-154 **Jolie Roat*** (jdroat@iastate.edu) and **Siu-Hung Ng** (rng@math.lsu.edu). *On $8p$ dimensional Hopf algebras with the Chevalley property.*

The classification of 24-dimensional Hopf algebras remains predominantly open. In particular, little is known about those Hopf algebras with the Chevalley property. In this talk, we will classify the non-semisimple Hopf algebras of dimension 24 with the Chevalley property. In particular, we find such a Hopf algebra must either be pointed, or have a coradical of dimension 12. Further, the 12-dimensional coradical can only be isomorphic to the dual of the dihedral group algebra, the dual of the dicyclic group algebra, or the self-dual, non-commutative semisimple Hopf algebra A_+ of dimension 12 determined by $G(A_+) \cong \mathbb{Z}_2 \times \mathbb{Z}_2$. These results can be extended to Hopf algebras of dimension $8p$ with the Chevalley property. (Received August 18, 2014)

1103-16-155 **Stefaan Caenepeel*** (scaenepe@vub.ac.be), Pleinlaan 2, B-1050 Brussels, Belgium, **Eliezer Batista** (ebatista@mtm.ufsc.br), Departamento de Matemática, Universidade Federal de Santa Catarina, Santa Catarina, Brazil, and **Joost Vercruysse** (jvercruy@ulb.ac.be), Boulevard du Triomphe, Brussels, Belgium. *Hopf categories.* Preliminary report.

We introduce Hopf categories enriched over braided monoidal categories. The notion is linked to several recently developed notions in Hopf algebra theory, such as Hopf group (co)algebras, weak Hopf algebras and duoidal categories. Several classical properties from Hopf algebra theory generalize to Hopf categories, such as for example the fundamental theorem for Hopf modules. (Received August 18, 2014)

1103-16-160 **Siu-Hung Ng*** (rng@math.lsu.edu). *Cleft Extensions and Quotients of Twisted Doubles.*

The construction of twisted quantum doubles $D^\omega(G)$ of finite groups G was motivated by holomorphic orbifold in conformal field theory. In particular, their representation categories are modular. On the other hand, $D^\omega(G)$ can also be viewed as a cleft extension of certain quasi-Hopf algebras in the sense of Masuoka. In this talk, we will discuss a generalized construction of braided quasi-Hopf algebras $D^\omega(G, A)$ from a central subgroup A of a finite group G as a quotient of the cleft extension of some twisted quantum double of G. The modularity of $D^\omega(G, A)$ is determined by the non-degeneracy of the associated bicharacter defined on A.

This is joint work with Geoffrey Mason. (Received August 18, 2014)

1103-16-167 **Yvan Saint-Aubin*** (yvan.saint-aubin@umontreal.ca), Département de mathématiques et de stat., Université de Montréal, Case Postale 6128, centre-ville, Montréal, QC H4A 2J2, Canada, and **Alexi Morin-Duchesne**, **Jørgen Rasmussen** and **Philippe Ruelle**. *The XXZ Hamiltonian and a distinguished bilinear form on modules over the Temperley-Lieb algebra.*

Many two-dimensional lattice models of statistical physics are formulated using a special element of the Temperley-Lieb algebra $TL_n(\beta)$. Then the integer n labels the number of sites on lines of the lattice and β parametrizes the model itself. Physically the spectrum of this element, the Hamiltonian, should be real. Mathematically, this requirement states that, in all physically relevant representations, the element should be self-adjoint with respect to some positive-definite bilinear form. I shall display such a bilinear form for the $U_q(sl_2)$-invariant XXZ Hamiltonian that is central to many physical investigations. (Received August 18, 2014)

1103-16-174 **Yorck Sommerhäuser*** (yorcksom@buffalo.edu), University at Buffalo (SUNY), Department of Mathematics, 244 Mathematics Building, Buffalo, NY 14260. *A Triviality Theorem for Yetter-Drinfel'd Hopf Algebras.*

Usually, a Yetter-Drinfel'd Hopf algebra is not a Hopf algebra. Yetter-Drinfel'd Hopf algebras that are ordinary Hopf algebras are called trivial; by a result of P. Schauenburg, this happens if and only if the quasisymmetry in the category of Yetter-Drinfel'd modules accidentally coincides with the ordinary flip of tensor factors on the

second tensor power of the Yetter-Drinfel'd Hopf algebra. In the case of Yetter-Drinfel'd Hopf algebras over group rings of finite groups, this happens if the degrees of homogeneous elements act trivially.

In certain situations, every Yetter-Drinfel'd Hopf algebra is trivial. One such situation will be discussed in the talk, where we will prove the following triviality theorem:

Suppose that A is a Yetter-Drinfel'd Hopf algebra over the group ring of a finite abelian group G, for a base field of characteristic zero. Suppose that A is commutative and semisimple. If the dimension of A is relatively prime to the order of G, then A is trivial.

The result was known in the case where the order of G is prime. (Received August 18, 2014)

1103-16-184 **Virgínia Silva Rodrigues*** (v.rodrigues@ufsc.br), Federal University of Santa Catarina, Department of Mathematics, Campus Trindade, Florianopolis-SC, Brazil, Florianopolis, SC 88.040-900, Brazil, and **Sara Regina da Rosa Pinter**. *On dual objects in braided categories.*

Given a monoidal category $(\mathcal{C}, \otimes, \mathbb{I}, a, l, r)$ dual objects of an object are fundamental to define a rigid category. A monoidal category $\mathcal{C}$ is said to be rigid if any object has a left and a right dual object. In case of any monoidal category if the left dual of an object exists it does not imply the existence of the right one. So, we consider a braided category, which is a monoidal category equipped with a natural isomorfism *braid* between the functors $\otimes$ and $\otimes\tau$, and we show that in this case if an object has right dual it also has left dual and conversely. If time permits we finalize with examples that show the non-reciprocity of the concepts of monoidal, braided and symmetric categories. (Received August 19, 2014)

1103-16-188 **Aaron Lauve*** (lauve@math.luc.edu), Loyola University, Dept. of Math. and Stats., 1032 W. Sheridan Road, Chicago, IL 60660, and **Mitja Mastnak** (mmastnak@cs.smu.ca). *Measurings in graded connected Hopf algebras.* Preliminary report.

This is a talk about formulas. In the combinatorics literature, graded connected Hopf algebras are used to organize statistics on combinatorial gadgets and to uncover new formulas they satisfy. The category of "combinatorial Hopf algebras" was developed by Aguiar-Bergeron-Sottile to organize this zoo, and a terminal object was found (the Hopf algebra $QSYM$ of quasisymmetric functions), enunciating precisely what types of formulas are constructible.

In this talk, we approach graded connected Hopf algebras from another direction, asking for structural formulas (e.g., for the action of the antipode, or for primitive elements) for the creatures in this zoo. We develop the bicategory of "bialgebras with coverings" and find its initial object. (It happens to be the graded dual of $QSYM$.) Time permitting, we illustrate our machinery with several examples. (Received August 19, 2014)

1103-16-195 **Osamu Iyama**, **Nathan Reading**, **Idun Reiten** and **Hugh Thomas*** (hthomas@unb.ca). *Lattice quotients of weak order and algebra quotients of preprojective algebras.* Preliminary report.

Certain lattice quotients of weak order on a finite simply-laced Coxeter group arise as the lattice of torsion classes of quotients of preprojective algebras. This includes the Cambrian quotients and many more. I will explain the general setting, and then focus on type A, in which we can characterize explicitly which lattice quotients appear, and also show that these are exactly the simplicial quotients (i.e., those such that the corresponding coarsening of the Coxeter fan is simplicial). This gives a combinatorial criterion for when a lattice quotient of weak order in the symmetric group is simplicial; no combinatorial criterion was known previously. (Received August 19, 2014)

17 ► Nonassociative rings and algebras

1103-17-153 **Alberto Elduque** (elduque@unizar.es), Departamento de Matemáticas, Universidad de Zaragoza, 50009 Zaragoza, Spain, and **Mikhail Kochetov*** (mikhail@mun.ca), Department of Mathematics and Statistics, Memorial University, St. John's, NL A1C5S7, Canada. *Gradings on trialitarian algebras and simple Lie algebras of type D_4.*

It is well known that the simple Lie algebra L of type D_4 is in many ways different from the other members of the D series. This exceptional behavior is due to the phenomenon of *triality*, that is, the existence of outer automorphisms of order 3 that cyclically permute the natural module and the two half-spin modules.

In this talk, we will study gradings on L by an arbitrary group G, assuming the ground field F to be algebraically closed, char $F \neq 2$. Gradings on matrix algebras and the corresponding classical simple Lie algebras

were studied earlier by several authors. In particular, L can be realized as skew-symmetric elements in the matrix algebra $M_8(F)$, and some of the G-gradings on L are constructed in the same way as for other Lie algebras of skew-symmetric elements.

To obtain the remaining gradings on L, we use affine group schemes (equivalently, commutative Hopf algebras) to transfer gradings between L and the so-called trialitarian algebra E: the product of three copies of $M_8(F)$ equipped with some additional structure. (Received August 18, 2014)

18 ► Category theory; homological algebra

1103-18-22 **Marta C. Bunge*** (marta.bunge@mcgill.ca), McGill University, Department of Mathematics and Statistics, Montreal, Quebec H3A 2K6, Canada. *Pitts Monads and a Lax Descent Theorem.*

For M the symmetric monad (M.Bunge and A.Carboni 1995) on the 2-category B of toposes bounded over a base topos S with a natural numbers object, the M-maps (M.Bunge and J.Funk 2006) are the S-essential geometric morphisms. By a "KZ monad" we mean here a Kock-Zoeberlein monad (A. Kock 1975). A "Pitts KZ monad" on a 2-category B is introduced as a KZ monad M on B that satisfies the analogue of Pitts' theorem (A.M.Pitts 1996) on comma squares along S-essential geometric morphisms. There is a dual notion of Pitts co-KZ monad N on any 2-category B. The purpose of this talk is to state and prove the following general lax descent theorem: If M is a Pitts KZ monad on a 2-category B of categories with pullbacks and stable finite colimits, such that B has an objects classifier which is an M-algebra, then every surjective M-map is of effective lax descent. There is a dual version for Pitts co-KZ monads. These theorems have several applications for morphisms of toposes and of locales. The Pitts monads involved are the symmetric monad, the lower and upper power locale monads, and a "coherent monad" introduced for the intended application (M.Zawadowski 1995, I.Moerdijk and J.J.C. Vermeulen 2000). (Received July 29, 2014)

1103-18-27 **Robert Pare*** (pare@mathstat.dal.ca), Department of Mathematics and Statistics, Dalhousie University, Halifax, NS B3H 4R2, Canada. *Examples of Intercategories.*

An intercategory is a kind of triple category in which one composition is strict and the other two bicategorical in nature. The essential feature is that interchange does not hold between the second and third compositions. There is instead a comparison morphism satisfying coherence conditions. We will present some examples illustrating this concept and how it might be useful.

This is joint work with Marco Grandis. (Received July 28, 2014)

1103-18-29 **Philip J. Scott*** (phil@site.uottawa.ca), Dept. of Mathematics and Statistics, University of Ottawa, 585 King Edward, Ottawa, ON K1N 6N5, Canada. *AF Inverse Monoids and the Structure of Countable MV-Algebras.* Preliminary report.

In the 1980's, D. Mundici connected up MV-algebras (arising from many-valued logics) with G. Elliott's program for the classification of AF C*-algebras via countable dimension groups. Independently, in the 1990's the algebraic theory of quantum effects led to development of Effect Algebras by mathematical physicists and to their connections with dimension groups. Recently, both theories have come under increasing scrutiny by category theorists.

We find a general setting, the theory of AF Inverse Monoids, in analogy to AF C*-algebras. Both MV- and Effect algebras naturally arise. Our methods are related to recent work in non-commutative Stone duality, étale topological groupoids, and pseudogroups (cf. work of Kudryavtseva, Lawson, Lenz, and Resende) as well as to classical work of Renault (groupoid approach to C*-algebras) and Bratteli.

We prove that every countable MV-algebra can be co-ordinatized, i.e. every MV-algebra is isomorphic to the lattice of principal ideals of some Boolean AF Inverse Monoid. As a concrete example, we give an explicit description of the AF inverse monoid that co-ordinatizes the MV-algebra of dyadic rationals in $[0, 1]$. It turns out to be a discrete version of the CAR algebra of a Fermi gas. (Joint work with Mark Lawson, Heriot-Watt) (Received July 30, 2014)

1103-18-72 **Michael Makkai*** (makkai@math.mcgill.ca), 805 Sherbrooke Street West, Montreal, Quebec H3A 0B9, Canada. *Pseudo-algebraic 2-categories of structured categories.* Preliminary report.

The 2-category of small pretoposes, functors preserving the pretopos operations up to isomorphism, and arbitrary natural transformations is a central example of what I call a pseudo-algebraic 2-category. The latter is defined as the 2-category of models in the 2-category of small categories, of a small finite-pseudo-limit sketch – subject to

an important restriction given below –, with 1-cells pseudo-natural transformations, and arbitrary modifications as 2-cells. The restriction, roughly speaking, is the exclusion of specifying two different pairs of 1-cells in the sketch resulting in the same composite. The main result reported on is that a pseudo-algebraic 2-category has an underlying category that is dual-regular, that is, equivalent to the category of regular functors from a small regular category to the category of sets; in particular, the underlying category is accessible and has filtered colimits. The present work uses the author's earlier work on anafunctors and that on generalized sketches. The author wishes to thank John Bourke for his interest in this work, and for alerting the author to the fact that without the restriction mentioned above, the main result mentioned above would be false. (Received August 11, 2014)

1103-18-80 **Peter Bubenik*** (peter.bubenik@gmail.com). *Category Theory in Topological Data Analysis.*

Topological Data Analysis (TDA) uses ideas from algebraic topology to study the 'shape' of data. I will give a brief introduction to TDA and then show it can be reinterpreted using category theory. This sheds light on some of the main results of TDA and also suggests how it may be extended. (Received August 13, 2014)

1103-18-89 **Simona Paoli*** (sp424@le.ac.uk), Department of Mathematics, University Road, Leicester, LE17RH, United Kingdom. *Weak globularity: a new paradigm for weakening higher categorical structures.*

Category theory has seen the development of several models of higher structures. Although quite different in flavour, they have in common the fact that the cells in each dimension form a set. This is also called globularity condition. I will discuss a new method for weakening higher categorical structures in which the set of cells in each dimension is replaced by a more complex structure. This gives rise to so called weakly globular structures. I will discuss these as they first arose in the context of homotopy theory, and I will then indicate some of the progress being made towards the general categorical case. (Received August 14, 2014)

1103-18-104 **Jon Funk*** (jonathon.funk@cavehill.uwi.edu), , Barbados, and **Pieter Hofstra**. *Isotropy, crossed sheaves, and braidings.* Preliminary report.

Joint work with Pieter Hofstra. Our further investigation of isotropy and crossed toposes [3] uses the tools of braided involutive closed categories [1]. In fact, if Z denotes the isotropy group internal to a topos EE, then the category EE/Z of crossed sheaves is a closed category with an involution. It is also braided by virtue of the canonical crossed topos structure that Z carries, which is known in the special case of crossed G-sets as the Freyd-Yetter braiding [2,4]. The observation (by Street and probably others) that a crossed module may be regarded as an involutive commutative monoid in crossed G-sets also generalizes to isotropy theory: a crossed topos may be regarded as an involutive commutative monoid in the category of crossed sheaves. These ideas apply to the topos of unital crossed sheaves t:X–>Z (satisfying xt(x)=x); unital crossed sheaves are important because for one thing a crossed topos is unital.

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[2] P. J. Freyd, D. N.Yetter, Braided compact closed categories with ..., Adv in Math 77 (1989).
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[4] T. Yoshida, Crossed G-sets and crossed Burnside rings, (1997). (Received August 14, 2014)

1103-18-110 **Geoff Cruttwell*** (gcruttwell@mta.ca), Department of Mathematics and Computer Scienc, Mount Allison University, Sackville, NB E4L3B5, Canada. *Counting finite categories.* Preliminary report.

In this talk, I'll be interested in a combinatorial question: how many categories are there with n arrows (up to isomorphism)? The online encyclopedia of integer sequences only lists values for n up to 6, and attempting to count such categories with simple programs stops at about that number.

In the talk, I'll describe computational techniques to allow us to extend this count up to categories with 10 arrows, and how this data leads to a conjecture for a general asymptotic formula for the number of categories with n arrows. I'll also discuss the question of looking at categories up to equivalence, and counts for the number of Cauchy-complete categories.

This is joint work with Rejean LeBlanc. (Received August 15, 2014)

1103-18-111 **Nick Gurski*** (nick.gurski@sheffield.ac.uk), **Niles Johnson** and **Angelica M. Osorno**. *Three notions of symmetric monoidal 2-category.*

The definition of a symmetric monoidal bicategory is long and involved, due to its completely general nature. I will discuss three stricter definitions. The first is that of a quasi-strict symmetric monoidal 2-category due to Chris Schommer-Pries. The second is the logically equivalent, but conceptually different notion of a permutative

Gray-monoid. The third notion is that of a permutative 2-category which, while not equivalent to the first two notions, arises naturally in topological applications. (Received August 15, 2014)

1103-18-148 **Donald Yau** (dyau@math.osu.edu), 1179 University Drive, Newark, OH 43055, and **Mark W. Johnson*** (mwj3@psu.edu), 3000 Ivyside Dr., Altoona, PA 16601. *Modules over generalized PROPs.*

The authors have defined generalized PROPs by detailing Markl's vague notion of a pasting scheme, consisting of the graphs one would like to use to index operational structures like operads, properads, (wheeled) PROPs, etc. After discussing the appropriate notions of graphs and pasting schemes, a natural question is how to define modules over such a structure. On one hand, one can verify that such structures are algebras over a colored operad, although with a larger set of colors, and define modules following May. On the other hand, one can produce a new monad, related to the graph substitution monad used to define the relevant operational structures, where the new monad's algebras are also reasonable candidates for the name of a module. The theorem under discussion is that these two notions coincide, and along the way a structure the authors call a 'pointed extension of a monad' plays an important role. (Received August 18, 2014)

1103-18-158 **Adnan Abdulwahid** and **Miodrag C Iovanov*** (miodrag-iovanov@uiowa.edu). *Cofree coalgebras in "usual" monoidal categories.*

The tensor algebra is a well known construction which carries over to abelian monoidal categories, and produces the free algebra on an object V in the category. The existence of a free algebra in the opposite category of an abelian monoidal category C, or the co-free coalgebra on an object V in C is less obvious; the existence of a cofree coring (cofree coalgebra in the category of bimodules over a ring) was left open in [A.Agore, Proc.AMS 139 (2011), 855-863]. Using the special adjoint functor theorem, we show that for many abelian monoidal categories of interest (bimodules, (co)modules over bialgebras, Yetter-Drinfeld modules, etc.), the answer to this question is positive. In particular, the cofree (co)module coalgebra on a (co)module exists. We also determine generators of the category of coalgebras in each of these monoidal categories and give an explicit construction of the cofree coalgebra in each case. (Received August 18, 2014)

1103-18-175 **Gábor Lukács*** (lukacs@topgroups.ca), Halifax, NS , Canada. *On bornologies and monoidal closed structures.*

A *bornology* on a set X is an ideal of subsets of X that cover X. Examples of bornologies include bounded sets in metric spaces, relatively compact sets in topological spaces, precompact sets in uniform spaces, and equicontinuous sets in function spaces.

In this talk, we present classic and new results that use bornologies for constructing monoidal closed structures in categories of topological structures and topological algebras. (Received August 18, 2014)

1103-18-186 **Richard Blute*** (rblute@uottawa.ca). *Derivations in codifferential categories.*

It is a folklore result of algebra that there is a natural correspondence between derivations from an algebra A to an A-module M and algebra homomorphisms from A to $A \oplus M$, equipped with an appropriate algebra structure. This result was lifted to more general categorical settings by Jon Beck.

We show that codifferential categories, i.e. duals of models of differential linear logic, provide an ideal framework for considering this correspondence. We introduce the notion of Beck T-derivation and show that it correctly generalizes previous results in the theory of Kahler categories.

This is joint work with Rory Lucyshyn-Wright and Keith O'Neill. (Received August 19, 2014)

1103-18-196 **Michael Shulman*** (shulman@sandiego.edu). *Univalent FOLDS.* Preliminary report.

The "equivalence principle" of higher category theory says that "meaningful" statements should be invariant under equivalence. First-Order Logic with Dependent Sorts (FOLDS) was introduced by Makkai as a language for describing higher-categorical structures in which this principle would always be true, because there is no "equality" that can distinguish equivalent structures. More recently, Homotopy Type Theory (HoTT) is a foundation for mathematics based on ∞-groupoids, in which Voevodsky's Univalence Axiom (UA) enforces the equivalence principle for ∞-groupoids by essentially *defining* "equal" to mean "equivalent".

In previous work, by "relativizing" UA, we defined a notion of "univalent" or "saturated" 1-category in HoTT that satisfies the equivalence principle. We now extend this to other higher-categorical structures by defining them a la FOLDS inside HoTT. Any FOLDS-signature comes with a canonical notion of "univalence" for its structures in HoTT, and such "univalent structures" satisfy the equivalence principle. Interesting examples include n-categories, †-categories, and double categories.

This is joint work with Benedikt Ahrens and Paige North. (Received August 19, 2014)

20 ► Group theory and generalizations

1103-20-1 **Francois Bergeron*** (bergeron.francois@uqam.ca). *Algebraic combinatorics and finite reflection groups.*

The last years have seen an explosion of research activity at the frontier between Algebraic Combinatorics, Representation Theory, and Algebraic Geometry, with interesting ties with Knot Theory and Theoretical Physics. For a broad audience, we are going to explain why this interaction has been very fruitful, and has raises new intriguing questions in the areas concerned. We will try to give a flavor of results obtained, techniques used, and of the large number of open questions that are still open, and why we should care about all this.

Among the main combinatorial objects at play in this story are generalizations to arbitrary rectangles, of the classical Dyck paths. It is well known (since Euler) that these are counted by the Catalan numbers. Closely linked objects are the so-called Parking Functions. On the algebraic side of the story, one of the important player is the bigraded $\mathbb{S}_n$-module of diagonal harmonic polynomials for the symmetric group $\mathbb{S}_n$. It is conjectured that an adequate enumeration of Parking Functions associated to classical Dyck paths, furnishes an explicit combinatorial formula for the bigraded character of these modules. This is know as the Shuffle Conjecture, which has now been greatly extended to deal with the rectangular context. (Received August 20, 2014)

1103-20-201 **Christophe Hohlweg*** (hohlweg.christophe@uqam.ca), CP8888 succ. Centre Ville, Montréal, Québec H3C3P0, Canada. *Small roots and inversion sets in Coxeter groups.*

Small roots are the main ingredient introduced by Brink and Howlett in order to prove that the language of reduced words in a Coxeter group W is regular. From small roots we obtain via inversion sets a finite set of words called the "elementary elements" in W. In this talk I will discuss the (sometimes conjectural) links of these elements with the canonical automaton for W and the braid group associated to W. This talk is based on a work in progress with P. Dehornoy and M. Dyer. (Received August 20, 2014)

33 ► Special functions

1103-33-6 **Alexey Kuznetsov*** (kuznetsov@mathstat.yorku.ca), Department of Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *On special functions arising in the theory of stochastic processes.*

There exist plenty of examples of applications of analytical techniques and special functions in the theory of stochastic processes. However, it is often overlooked that this connection can also be used in the other direction, that one can use probabilistic techniques and ideas to derive deep and interesting results in the theory of special functions. In this talk I will present several examples of how well-known probabilistic results in the theory of Levy processes and self-similar Markov processes can be creatively applied to obtain new identities and properties related to certain special functions. For example, I will give a simple derivation of the explicit Laplace transform of $f_1(x) = x^{x+c-1}/\Gamma(x+c+1)$ and will show that the functions $f_2(x) = x^{cx}e^{-x}/\Gamma(1+cx)$ and $f_3(x) = e^{-x}I_{cx}(x)$ (here $I_\nu(x)$ denotes the modified Bessel function of the first kind) are completely monotone for all positive values of parameter c. (Received January 22, 2014)

1103-33-15 **Willard Miller, Jr.*** (miller@ima.umn.edu). *Quadratic algebra contractions, 2nd order superintegrable systems and the Askey scheme.*

Quadratic algebras are generalizations of Lie algebras; they include the symmetry algebras of 2nd ordersuperintegrable systems in 2 dimensions as special cases. The superintegrable systems are exactly solvable physical systems in classical and quantum mechanics. We describe a contraction theory for quadratic algebras and show that for constant curvature superintegrable systems, ordinary Lie algebra contractions induce contractions of the quadratic algebras of the superintegrable systems that correspond to geometrical pointwise limits of the physical systems. One consequence is that by contracting function space realizations of representations of the generic superintegrable quantum system on the 2-sphere (which give the structure equations for Racah/Wilson polynomials) to the other superintegrable systems one obtains the full Askey scheme of orthogonal hypergeometric polynomials. This approach generalizes to multivariable Wilson polynomials. (Received July 11, 2014)

1103-33-18 **Robert Milson***, rmilson@dal.ca, and **David Gomez Ullate** and **Yves Grandati**. *Exceptional Hermite Polynomials.*

Exceptional orthogonal polynomials (so named because they span a non-standard polynomial flag) are defined as polynomial eigenfunctions of Sturm-Liouville problems. By allowing for the possibility that the resulting sequence of polynomial degrees admits a number of gaps, we extend the classical families of Hermite, Laguerre

and Jacobi. In recent years the role of the Darboux (or the factorization) transformation has been recognized as essential in the theory of orthogonal polynomials spanning a non-standard flag. In this talk we will focus on exceptional Hermite polynomials: their regularity properties, asymptotics of zeros and their relation to the recent conjecture that ALL exceptional orthogonal polynomials are related via factorization transformations to classical orthogonal polynomials. (Received July 15, 2014)

1103-33-20 **Diego Dominici*** (dominicd@newpaltz.edu), 1 Hawk Dr., New Paltz, NY 12561.
Mehler-Heine type formulas for Charlier and Meixner polynomials.

We derive Mehler–Heine type asymptotic formulas for Charlier and Meixner polynomials, and also for their associated families. These formulas provide good approximations for the polynomials in the neighborhood of x=0, and determine the asymptotic limit of their zeros as the degree n goes to infinity. (Received July 17, 2014)

1103-33-21 **Vincent X Genest*** (vincent.genest@umontreal.ca), Centre de recherches mathématiques, Université de Montréal, P.O. Box 6128, Centre-ville Station, Montréal, Québec H3C 3J7, Canada, and **Luc Vinet**. *The multivariate Hahn polynomials as interbasis expansion coefficients for a superintegrable system.*

In this talk, I will explain how Karlin and McGregor's multivariate Hahn polynomials arise as the interbasis expansion coefficients in the $d+1$-dimensional singular oscillator model. I shall moreover illustrate how this identification can be exploited to derive the properties of these polynomials. (Received July 20, 2014)

1103-33-28 **Armin Straub*** (astraub@illinois.edu) and **Wadim Zudilin**. *Positivity of rational functions and their diagonals.*

The problem to decide whether a given rational function in several variables is positive, in the sense that all its Taylor coefficients are positive, goes back to Szegő as well as Askey and Gasper, who inspired more recent work. It is well known that the diagonal coefficients of rational functions are D-finite. Remarkably, for several of the rational functions whose positivity has received special attention, the diagonal terms in fact have arithmetic significance and arise from differential equations that have modular parametrization. In each of these cases, this allows us to conclude that the diagonal is positive. Further inspired by a result of Gillis, Reznick and Zeilberger, we investigate the relation between positivity of a rational function and the positivity of its diagonal. (Received July 28, 2014)

1103-33-43 **Syed Twareque Ali*** (twareque.ali@concordia.ca), Department of Mathematics and Statistics, Concordia University, 1455 de Maisonneuve Blvd. West, Montreal, Quebec H3G 1M8, Canada. *Some families of quaternionic Hermite polynomials.*

We look at a quaternionic generalization of two classes of complex Hermite polynomials and discuss possible generalizations to other types of polynomials. We also look at the slice-regularity properties of these polynomials. (Received August 04, 2014)

1103-33-45 **Vincent Genest**, **Sarah Post** and **Luc Vinet*** (luc.vinet@umontreal.ca), Centre de recherches mathématiques, Université de Montréal, P.O. Box 6128, Centre-ville Station, Montréal, Québec H3C 3J7, Canada. *q-Rotations and Krawtchouk polynomials.*

An algebraic interpretation of the one-variable affine q-Krawtchouk polynomials is provided in the framework of the Schwinger realization of $\mathcal{U}_q(sl_2)$ involving two independent q-oscillators. The polynomials are shown to arise as matrix elements of unitary "q-rotation" operators expressed as q-exponentials in the $\mathcal{U}_q(sl_2)$ generators. The properties of the polynomials (orthogonality relation, generating function, recurrence relation, difference equation, raising/lowering relations) are derived by exploiting the algebraic setting. The results are extended to another family of polynomials, the quantum q-Krawtchouk polynomials, through a duality relation. (Received August 05, 2014)

1103-33-48 **Karl Dilcher*** (dilcher@mathstat.dal.ca), Department of Mathematics and Statistics, Dalhousie University, Halifax, NS B3H 4R2, Canada, and **Kenneth B. Stolarsky** (stolarsk@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *Zeros and irreducibility of Chebyshev-like polynomials.*

By way of a nonlinear recurrence relations we define a sequence of polynomials resembling the Chebyshev polynomials of the first kind. Among other properties we obtain results on their irreducibility and zero distribution. We then study the 2×2 Hankel determinants of these polynomials, which have interesting zero distributions. Furthermore, if these polynomials are split into two halves, then the zeros of one half lie in the interval $(-1, 1)$, while those of the other half lie on the unit circle. Some further extensions and generalizations of these results are indicated. (Received August 06, 2014)

1103-33-62 **Ash Arsenault*** (asharsenaul0@upei.ca), 487 Corrigan Rd., Mt. Stewart RR#1, PE C0A1T0, Canada. *Using supersymmetric quantum mechanics to generate families of solvable potentials.*

Supersymmetry is a mathematical concept which arose from Quantum Field Theory. However, its development led to investigations of its applications in other areas of physics. Notably, its utility in traditional quantum mechanics was so fruitful that it led to the birth of an entire new field, which we call supersymmetric quantum mechanics, or SUSY QM.

Supersymmetric quantum mechanics is an effective tool that exploits the relationship shared by a pair of supersymmetric partner potentials in order to construct exact solutions of these potentials. In the present work, which introduces solvable classes of the generalized Riccati equation into the realm of SUSY QM, a general method for constructing infinite classes of exactly solvable potentials and their solutions is presented. The isotonic nonlinear oscillator potential, the spiked harmonic oscillator potential and the Kratzer potential are constructed in this work using this general method, although the extension of its application to other classes is also feasible, making this method a powerful technique which can be used to find exact solutions for a wide variety of quantum systems. The construction of the associated exceptional and classical orthogonal polynomials for these families of solvable potentials is also presented. (Received August 11, 2014)

1103-33-176 **christophe vignat*** (cvignat@tulane.edu), Mathematics Department, 424 Gibson Hall, New Orleans, LA 70115. *The generalized Zagier-Bernoulli polynomials and their properties.*

Zagier defined modified Bernoulli numbers in 1998 that exhibit some interesting arithmetic properties. The corresponding polynomials were studied recently by Moll et al. In this talk, a generalized version a la Norlund of these polynomials will be presented, and some of their properties will be deduced from their generating function. (Received August 19, 2014)

35 ► Partial differential equations

1103-35-23 **Shaohua Chen*** (george_chen@cbu.ca), 1250 Grand Lake Road, Cape Breton University, Sydney, Nova Scoti B1P6L2, Canada. *A Singular Gierer-Meinhardt System with General Source Terms.*

In this talk I will present theoretical results on the existence of the steady state solutions to the generalized Gierer-Meinhardt system with zero Dirichlet boundary conditions. I introduce a new functional method to obtain an a priori estimates for the linearized system and then use Schauder's fixed point theorem to prove the existence theorem. (Received July 23, 2014)

1103-35-44 **Dario D. Monticelli*** (dario.monticelli@unimi.it), Via Saldini 50, 20133, Milano, Italy, and **Scott W. Rodney** and **Richard L. Wheeden**. *Regularity results for weak solutions of degenerate quasilinear equations with rough coefficients.*

I will present some recent developments concerning local boundedness estimates, regularity results and the validity of a Harnack inequality for weak solutions of a large class of second order degenerate elliptic quasilinear equations with rough coefficients in divergence form. The possible degeneracy of an equation in the class is expressed in terms of a nonnegative definite quadratic form Q associated with its principal part, and weak solutions are assumed to belong to degenerate Sobolev-type spaces, related to the quadratic form Q. No smoothness is required of the quadratic form or the coefficients of the equation.

We operate in an abstract axiomatic setting which assumes the validity of certain local Sobolev and Poincaré inequalities related to Q, as well as the existence of suitable families of Lipschitz cutoff functions. We also assume that the underlying measure is locally doubling.

Our results extend ones obtained on second order elliptic equations by Serrin (1964) and Trudinger (1967), as well as ones for subelliptic linear equations with rough coefficients obtained by Sawyer–Wheeden (2008–2012).

These results are joint work with S. Rodney (Cape Breton University, Sydney, Canada) and R. L. Wheeden (Rutgers University, New Brunswick, NJ, USA). (Received August 05, 2014)

1103-35-61 **Alessia E. Kogoj*** (alessia.kogoj@unibo.it), Mathematics Department, University of Bologna, IT-40126 Bologna - Italy, BO, Italy, and **Ermanno Lanconelli** (ermanno.lanconelli@unibo.it), Mathematics Department, University of Bologna, IT-40126 Bologna, BO, Italy. *L^p -Liouville Theorems for Invariant Partial Differential Equations.*

Some L^p-Liouville theorems for several classes of Partial Differential Equations will be presented. The involved operators are left invariant with respect to Lie group composition laws in $\mathbb{R}^{n+1}$. Results for both solutions and sub-solutions will be given. (Received August 11, 2014)

1103-35-102 **Lyudmila Korobenko** and **Cristian Rios*** (crios@ucalgary.ca), Department of Mathematics and Statistics, 2500 University Dr. NW, Calgary, AB T2N 1N4, Canada. *Regularity of solutions to degenerate elliptic equations under non-doubling conditions.* Preliminary report.

We prove that every weak solution to a certain class of infinitely degenerate quasilinear equations is continuous. A special feature of the operators we consider is that Lebesgue's measure in not required to be doubling in the associated Fefferman-Phong metric. (Received August 14, 2014)

1103-35-123 **Marius Mitrea*** (mitream@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Characterizing geometric regularity of sets via the behavior of the Riesz transforms.* Preliminary report.

Under mild geometric measure theoretic assumptions on an open set we show that the Riesz transforms on its boundary are continuous mappings on the Hölder space if and only if the set in question is a Lyapunov domain. As a limiting case, we also characterize Reifenberg flatness in terms of the behavior of the Riesz transforms. This is joint work with Dorina Mitrea and Joan Verdera. (Received August 15, 2014)

1103-35-170 **Svetlana Roudenko***, 2115 G St NW, Washington, DC 20052, and **Thomas Duyckaerts**, Paris, France. *Going beyond the threshold: scattering vs. blow-up dichotomy in the focusing NLS equation.*

We consider the focusing nonlinear Schrödinger equation in N-dimensions: $iu_t + \Delta u + |u|^{p-1}u = 0$ in the L^2-supercritical regime, i.e. when $p > 1+\frac{4}{N}$, with finite energy and finite variance initial data. We study solutions in the energy-critical case above the energy threshold $E[u_0] > E[W]$, where W is the stationary solution, or above the mass-energy threshold in the energy-subcritical cases. We obtain the scattering versus blow-up dichotomy above the threshold, which also includes solutions with arbitrarily large mass and energy. This is a joint work with T. Duyckaerts. (Received August 18, 2014)

1103-35-192 **David Cruz-Uribe** and **Kabe Moen***, kabe.moen@ua.edu, and **Scott Rodney**. *Regularity results for weak solutions of elliptic PDEs below the natural exponent.*

We will discuss regularity results for weak solutions to the Dirichlet problem for a divergence form elliptic operator. We give L^p estimates for the second derivative when $p < 2$. Our work generalizes results due to Miranda. (Received August 19, 2014)

37 ► Dynamical systems and ergodic theory

1103-37-83 **Joanna M Furno*** (jfurno@wesleyan.edu). *Approximations and digraph representations of p-adic transformations.*

A transformation on the p-adic integers is a p-adic transitive isometry if it is an isometry that permutes the balls of radius p^{-n} in a cycle, for all $n \in \mathbb{N}$. We use cyclic approximations of p-adic transitive isometries to prove results on spectrum and entropy of the transformations with respect to Haar measure. A p-adic transitive isometry and its nth cyclic approximation induce the same digraph representation on balls of radius p^{-n}. We give an algorithm to label the digraph for translation by rational numbers in $\mathbb{Z}_p$, and we discuss a link between the algorithm and number theory. (Received August 13, 2014)

1103-37-173 **Van Cyr*** (van.cyr@bucknell.edu), 361 Olin Science Building, Department of Mathematics, Bucknell University, Lewisburg, PA 17837, and **Bryna Kra** (kra@math.northwestern.edu), Lunt 224, Department of Mathematics, Northwestern Univeristy, Evanston, IL 60208. *Automorphisms of subshifts with low factor complexity.*

The automorphism group of a symbolic dynamical system (X, σ) is the group of homeomorphisms of X that commute with σ. For many natural systems, this group is extremely complicated (e.g. a theorem of Boyle, Lind, and Rudloph shows that if X is a topologically mixing SFT, then $\mathrm{Aut}(X)$ contains isomorphic copies of

all finite groups, the free group on two generators, and the direct sum of countably many copies of $\mathbb{Z}$). This can be interpreted as a manifestation of the "high complexity" of these shifts.

Many interesting shifts arising in combinatorics on words have "low complexity." In this talk I will discuss recent joint work with B. Kra which places restrictions on the automorphism group of any topologically transitive subshift (not necessarily an SFT) whose factor complexity function grows sub-quadratically. This class contains the Sturmian shifts, the Rauzy-Arnoux shifts, many of the morphic shifts, and others. One of our main results is that, for these shifts, if H is the subgroup of $\mathrm{Aut}(X)$ generated by σ then $\mathrm{Aut}(X)/H$ is a periodic group. (Received August 18, 2014)

1103-37-182 **Reem Yassawi*** (ryassawi@trentu.ca), 1600 West Bank Drive, Peterborough, Ontario K9J7B8, Canada, and **Eric Rowland**. *Some constant length substitutions on closed subsets of the p-adic integers.*

Let $(a_k)_{k\in\mathbb{N}}$ be a sequence of natural numbers such that for some p and any m, $(a_k \mod p^m)_{k\in\mathbb{N}}$ is p-automatic. Examples include *algebraic* sequences: those whose generating function $y = \sum_k a_k x^k$ is the root of a polynomial $P(x, y)$ with integer coefficients; these sequences' projection modulo p^m is p-automatic for any p. Other examples include *cocycle maps* between fixed points $(u_n)_{n\geq 0}$ and $(v_n)_{n\geq 0}$ of two constant length p substitutions on a finite alphabet with the same incidence matrix. We discuss how these sequences naturally lead to a definition of a constant length substitution and corresponding dynamical system, on a closed subset of $\mathbb{Z}_p$, the p-adic integers. This research is joint work with Eric Rowland. (Received August 19, 2014)

41 ► Approximations and expansions

1103-41-50 **Jens Gerlach Christensen*** (jchristensen@colgate.edu), **Karlheinz Gröchenig** and **Gestur Ólafsson**. *Bergman spaces in several complex variables and coorbit theory.* Preliminary report.

We show that the Bergman spaces on the unit ball in several complex variables can be described via a wavelet theory for an appropriate covering group of $SU(n, 1)$. We also provides atomic decompositions and frames for the Bergman spaces via sampling on the group. A remarkable result is that translates of any polynomial (or more generally, any smooth vector for the representation) provides atomic decompositions and frames. This is joint work with Karlheinz Gröchenig and Gestur Ólafsson. (Received August 06, 2014)

1103-41-51 **David Gross** and **Felix Krahmer*** (f.krahmer@math.uni-goettingen.de), University of Goettingen, Institute for Numerical & Applied Mathematics, Lotzestr. 16-18, 37083 Goettingen, Germany, and **Richard Kueng**. *Recovery Guarantees for PhaseLift from Non-Gaussian Measurements.*

The problem of retrieving phase information from amplitude measurements alone has appeared in many scientific disciplines over the last century. PhaseLift is a recently introduced algorithm for phase recovery that is computationally tractable, numerically stable, and comes with rigorous performance guarantees. PhaseLift is optimal in the sense that the number of amplitude measurements required for phase reconstruction scales linearly with the dimension of the signal. However, it specifically demands Gaussian random measurement vectors - a limitation that restricts practical utility and obscures the specific properties of measurement ensembles that enable phase retrieval. In this talk, we extend these results to various non-Gaussian random measurement setups. Firstly, we study a partial derandomization of PhaseLift that only requires sampling from t-designs, polynomial size vector configurations, which have been studied in algebraic combinatorics, coding theory, and quantum information. Beyond the specific case of PhaseLift, this work highlights the utility of t-designs for the derandomization of data recovery schemes. Furthermore, we discuss the case coded diffraction patterns, that is, Fourier measurements with random mask, a setup inspired by practical scenarios. (Received August 06, 2014)

1103-41-52 **Mark Iwen**, **Rayan Saab*** (rsaab@ucsd.edu), **Rongrong Wang** and **Ozgur Yilmaz**. *Random encoding of quantized frame coefficients and quantized compressed sensing measurements.*

Frames generalize the notion of bases and provide a useful tool for modeling the measurement (or sampling) process in several modern signal processing applications. In the digital era, such a measurement process is typically followed by quantization, or digitization.

In the case of Sigma-Delta quantization of frame coefficients, we show that a simple post-processing step consisting of a discrete random Johnson-Lindenstrauss embedding of the integrated bit-stream yields near-optimal approximation accuracy as a function of the number of bits used. The result holds with high probability

on the draw of the embedding, allows efficient reconstruction, and holds for a wide class of frames including smooth frames and random frames. (Joint work with Mark Iwen.)

We also show that if the same encoding scheme is applied to quantized compressed sensing measurements (with a different reconstruction scheme), it also yields near-optimal approximation accuracy as a function of the bit-rate. (Joint work with Rongrong Wang and Ozgur Yilmaz.) (Received August 07, 2014)

1103-41-138 **Azita Mayeli***, The Graduate Center, CUNY, Department of Mathematics, 365 5th Ave, New York, NY 10016. *Exponential bases, Paley-Wiener spaces and applications.* Preliminary report.

We investigate the connection between translation bases for Paley-Wiener spaces and exponential Fourier bases for a domain. We apply these results to the problem of characterization of vector-valued time-frequency translates of a Paley-Wiener "window" signal. (Received August 17, 2014)

1103-41-152 **Alexander M Powell*** (alexander.m.powell@vanderbilt.edu) and **Xuemei Chen**. *Fusion frames and randomized subspace actions.*

We investigate a version of the randomized Kaczmarz algorithm for recovering a signal from a collection of projection-valued fusion-frame measurements. We prove error bounds on the rates of almost sure convergence for this algorithm, and we address the question of which probability distributions on a randomized fusion frame lead to fast convergence. If time permits, we shall also discuss a variant of the Kaczmarz algorithm for consistent reconstruction from measurements that have been perturbed by uniform noise. (Received August 18, 2014)

42 ► Fourier analysis

1103-42-10 **Christopher Heil*** (heil@math.gatech.edu), School of Mathematics, Georgia Tech, Atlanta, GA 30332-0160. *Linear Independence of Time-Frequency Translates.*

The Linear Independence of Time-Frequency Translates Conjecture, also known as the HRT conjecture, states that any finite set of time-frequency translates of a given L^2 function must be linearly independent. This conjecture, which was first stated in print in 1996, remains open today. We will discuss this conjecture, its context, and the (frustratingly few) partial results that are currently available. (Received June 09, 2014)

1103-42-40 **Ahmed I Zayed*** (azayed@depaul.edu). *On Fractional Transforms and Sampling.* Preliminary report.

Sampling of integral transforms, such as the Fourier, Hankel, and Legendre integral transforms, has been studied extensively either directly or indirectly through the initial-value problems which the kernels of the transforms satisfy. Some of these transforms have recently been extended to fractional orders. The kernels of some of these fractional transforms satisfy initial-value problems involving fractional order differential equations. In this talk, we discuss some of these fractional transforms and their sampling theorems. (Received August 03, 2014)

1103-42-49 **James Michael Wilson*** (jmwilson@uvm.edu), Dept of Mathematics, University of Vermont, Burlington, VT 05461. *Almost-orthogonality without discreteness or smoothness.*

Let $N \geq 2$ be fixed. Suppose that, for every dyadic cube Q in $\mathbf{R}^d$, we have: N convex regions $\{R_i(Q)\}_1^N$, subsets of Q; and N complex numbers $\{c_i(Q)\}_1^N$ such that $|c_i(Q)| \leq 1$ and $\sum_1^N c_i(Q)|R_i(Q)| = 0$. Define $\tilde{h}_{(Q)}(x) \equiv |Q|^{-1/2}(\sum_1^N c_i(Q)\chi_{R_i(Q)}(x))$. We prove that there is an absolute constant C, independent of N or d, so that, for all such collections $\{\tilde{h}_{(Q)}\}_Q$ and all finite linear combinations $\sum \lambda_Q \tilde{h}_{(Q)}(x)$,

$$\int \left|\sum \lambda_Q \tilde{h}_{(Q)}\right|^2 dx \leq C(Nd)^2 \sum |\lambda_Q|^2.$$

Our result is a special case of a technical theorem, which we prove. (Received August 19, 2014)

1103-42-77 **Enrico Au-Yeung***, DePaul University, 5th Floor Schmitt Academic Center, 2320 N. Kenmore Ave., Chicago, IL 60614. *A new class of random matrices and second-order stochastic chaos.*

Part of this talk is joint work with Ozgur Yilmaz at the University of British Columbia

We propose a new class of random matrices that enables the recovery of signals with sparse representation in a known basis with overwhelmingly high probability. These random matrices are not made using independently and identically distributed random variables, as in the case of Gaussian or Bernoulli matrices. Therefore, as a benefit, far fewer number of random variables are needed to generate these new types of random matrices. Our techniques draw on the recent development in second-order random chaotic processes.

If time permits, the speaker will discuss application of probability in Banach space to non-asymptotic aspects of vector quantization. It is commonly believed that a machine can learn the pattern from a data set if the number of samples is sufficiently large. But the usual justification is based on large-sample asymptotic theory and does not necessarily apply when the dimension of the underlying model is possibly unknown. (Received August 12, 2014)

1103-42-99 **Gotz Pfander** and **David Walnut*** (dwalnut@gmu.edu), Department of Mathematical Sciences, George Mason University, MSN 3F2, Fairfax, VA 22030. *Recent Developments in Operator Sampling.*

Operator Sampling is a generalization of classical sampling in which the objects being reconstructed from limited data are operators rather than functions. This theory is an outgrowth of the pioneering work of T. Kailath and P. A. Bello in the 1950s and 1960s in which theoretical constraints are found limiting the ability to identify a mobile communication channel by sounding it with a single testing signal. The motivation for investigating these questions arose in part from work in the 1950s on spread-spectrum communications.

In this talk we will briefly describe the problems being investigated, and the tools from time-frequency analysis that are brought to bear on their solution. In particular, we will show that operator sampling contains as a special case classical sampling. Finally we will draw connections to recent results in the theory of finite Gabor frames, to the capacity of time-varying communication channels, and to the measurement of stochastic channels. (Received August 14, 2014)

1103-42-105 **Lucas Chaffee** and **Rodolfo H Torres*** (torres@ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Compactness properties of commutators of bilinear fractional integral operators.* Preliminary report.

This work is continuation of research in the area recently initiated by several authors. We will present the latest progress on the study of compactness properties of commutators of bilinear fractional integral operators, including weighted results and symbol characterizations. (Received August 14, 2014)

1103-42-119 **Li-An Daniel Wang*** (daniel.wang@trincoll.edu), 300 Summit Street, Trinity College, Hartford, CT 06106, and **David Cruz-Uribe**, 300 Summit Street, Trinity College, Hartford, CT 06106. *Extrapolation in weighted variable Lebesgue spaces.* Preliminary report.

We extend the theory of extrapolation to weighted variable Lebesgue spaces. We emphasize a general approach that produces a list of constraints such that, when solved, results in the classical extrapolation theorems as well as their variable weighted extensions. (Received August 15, 2014)

1103-42-143 **Chun Kit Lai*** (cklaimath@gmail.com), san francisco, CA 94132, and **Jean-Pierre Gabardo** and **Yang Wang**. *Gabor orthonormal bases generated by the unit cubes.*

We consider the problem in determining the countable set Λ in the time-frequency space so that the Gabor system, $\mathcal{G}(\chi_{[0,1]^d}, \Lambda)$, generated by the characteristic function of the unit cube on $\mathbb{R}^d$ form a Gabor orthonormal basis (GONB). We show that all such Λ must be a tiling set of the 2d dimensional unit cube. Moreover, all admissible Λ on $d = 1, 2$ are classified. An interesting and surprising result is that for $d \geq 2$, apart from the standard structure of Λ, there exists Λ so that $\mathcal{G}(\chi_{[0,1]^d}, \Lambda)$ forms a GONB but the unit cube in the time side has a significant amount of overlaps when translated by the time component of Λ. (Received August 18, 2014)

1103-42-157 **Galia Dafni*** (galia.dafni@concordia.ca), 1455 de Maisonneuve Blvd West, Montreal, Quebec H3G1M8, Canada, and **Ethan Mombourquette** and **Hong Yue**. *Some characterizations of local bmo and Hardy spaces on spaces of homogeneous type.* Preliminary report.

We extend some previous results to this setting. (Received August 18, 2014)

1103-42-199 **Eric T. Sawyer** (sawyer@mcmaster.ca), Department of Mathematics and Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, **Chun-Yen Shen** (cyshen@math.ncu.edu.tw), National Central University Dept. of Math, No.300, Jhongda Rd., Jhongli City, Taoyuan County, Jhongli City, 32001, Taiwan, and **Ignacio Uriarte-Tuero*** (ignacio@math.msu.edu), 619 Red Cedar Road, Wells Hall, Dept. of Math, Michigan State University, East Lansing, MI 48824. *Two weight norm inequalities for singular and fractional integral operators in R^n.*

I will report on recent advances on the topic, related to proofs of T1 type theorems in the two weight setting for Calderón-Zygmund singular and fractional integral operators, with side conditions, and related counterexamples. Joint work with Eric Sawyer and Chun-Yen Shen. (Received August 19, 2014)

43 ► Abstract harmonic analysis

1103-43-71 **Stephen D. Casey*** (scasey@american.edu), Math/Stat Department, American University, 4400 Massachusetts Avenue, N. W., Washington, DC 20016-8050. *Sampling and Geometry.* Preliminary report.

Sampling theory is a fundamental area of study in harmonic analysis and signal and image processing. Our talk will connect sampling theory with the geometry of the signal and its domain.

There are numerous motivations for extending sampling to non-Euclidean geometries. Applications of sampling in spherical and hyperbolic geometries are showing up areas from EIT to cosmology. Sampling in spherical geometry has been analyzed by many authors and brings up questions about tiling the sphere. Irregular sampling of band-limited functions by iteration in hyperbolic space has been developed. In Euclidean space, the minimal sampling rate for Paley-Wiener functions on $\mathbb{R}^d$, the Nyquist rate, is a function of the band-width. No such rate has yet been determined for hyperbolic or spherical spaces. We look to develop a structure for the tiling of frequency spaces in both Euclidean and non-Euclidean domains. In particular, we develop an approach to determine *Nyquist tiles* and *sampling groups* for spherical and hyperbolic space. We then connect this to arbitrary orientable analytic surfaces using Uniformization. (Received August 11, 2014)

1103-43-93 **Chunping Xie*** (xie@msoe.edu), Dept of Math, Milwaukee School of Engineering, 1025 N. Broadway, Milwaukee, WI 53051. *Littlewood-Paley Functions and Bergman Spaces.* Preliminary report.

The intend of this note is to show that for a analytic function f, f is in the Bergman space $\mathcal{A}^p(D)$, $0 < p < \infty$ if and only if either $g_*(f)$ or $g_d(f)$, Littlewood-Paley functions, belongs to $L^p(D)$. Also a similar results are obtained for the Luzin area function, $A(f)(z)$. (Received August 14, 2014)

44 ► Integral transforms, operational calculus

1103-44-95 **Jarod Hart*** (jarod.hart@wayne.edu) and **Alessandro Monguzzi** (alessandro.monguzzi@unimi.it). *A Biparameter Tb Theorem with an Application to Holomorphic Extension in $\mathbb{C}^2$.*

In this joint work with Alessandro Monguzzi, we prove a new Tb type boundedness criterion for biparameter Calderón-Zygmund operators. We use this Tb theorem to prove L^p bounds for a biparameter Cauchy integral transform defined on certain Lipschitz surfaces in $\mathbb{C}^2$ when $1 < p < \infty$. In this setting, the biparameter Cauchy integral transform plays the role that the biparameter Hilbert transform on the product upper half plane in $\mathbb{C}^2$. Consequently, we prove the following Hilbert-Riemann holomorphic extension result for appropriate Lipschitz surfaces $\Gamma \subset \mathbb{C}^2$: given $1 < p < \infty$ and an $L^p(\Gamma)$ function g defined on $\Gamma \subset \mathbb{C}^2$, we define a function G on $\mathbb{C}^2$ that is holomorphic away from Γ and agrees with g on Γ, in an appropriate limiting sense. Furthermore, $G(w) \to g(z)$ almost everywhere on Γ and in $L^p(\Gamma)$ as $w \in \mathbb{C}^2$ approaches $z \in \Gamma$. (Received August 14, 2014)

46 ► Functional analysis

1103-46-56 **Akram Aldroubi** (akram.aldroubi@vanderbilt.edu) and **Sui Tang*** (sui.tang@vanderbilt.edu), Dept. of Mathematics, Nashville, TN 37240. *Dynamical Sampling, and time-space trade-off in Hilbert spaces.*

Dynamical sampling is a newly proposed framework studying the recovery of the initial state f of an evolution process from a combined set of coarse samples from varying time levels. It has been shown that it is possible to recover the initial state using a reduced number of measuring devices activated more frequently for some special evolution systems. In this paper, dynamical sampling of general evolution processes in the separable Hilbert space case is considered. We give a complete characterization specifying when lossless trade off between spatial and temporal samples happens for the finite dimensional case. For the infinite dimensional case, we give a similar characterization for a special class of evolution system. This work is in collaboration with Carlos Cabrelli and Ursula Molter. (Received August 08, 2014)

47 ► Operator theory

1103-47-7 **Steven H. Weintraub*** (shw2@lehigh.edu), Lehigh University, Bethlehem, PA 18015. *The adjoint of differentiation.*

Let n be any nonnegative integer. Let $V = P_n$ be the vector space of polynomials of degree at most n, equipped with the inner product $\langle f, g\rangle = \int_0^1 f(x)g(x)dx$. Let $D : V \longrightarrow V$ be the differentiation operator, $D(f) = f'$. Then D has an adjoint D^*. We have closed form expressions for D^*, which were conjectured by computing D^* for small values of n and finding a pattern. (If $f(x)$ is a polynomial of degree $k \leq n$, then, while the value of $D(f(x))$ is independent of n, the value of $D^*(f(x))$ depends on n.) We also find formulas for D^* in terms of classical Legendre polynomials, shifted to the interval $[0, 1]$. Using these formulas it is easy to prove that our closed form expressions are correct. An alternate approach yields combinatorial identities involving the entries of the inverses of Hilbert matrices. (Received May 22, 2014)

51 ► Geometry

1103-51-88 **Todd A Drumm*** (tdrumm@howard.edu), **Virginie Charette**, **Jean-Philippe Burelle** and **William Goldman**. *The Geometry of the One-Holed Klein Bottle.* Preliminary report.

We will look at the hyperbolic structures of a one-holed Klein bottle. The geometry when the hole is actually a puncture is of particular interesest. We will also be investigating the deformations of these structures through Lorentzian geometry. (Received August 14, 2014)

1103-51-129 **Steven Rayan*** (stever@math.toronto.edu), Department of Mathematics, University of Toronto, 40 St. George Street, Toronto, Ontario M5S 2E4, Canada, and **Jonathan Fisher** (jmfisher@math.toronto.edu), Department of Mathematics, University of Toronto, 40 St. George Street, Toronto, Ontario M5S 2E4, Canada. *Stable Hitchin pairs at genus zero.* Preliminary report.

We will discuss various aspects of the geometry and topology of moduli spaces of Hitchin pairs on the complex projective line. Some of these aspects are in line with moduli spaces of Higgs bundles on curves of genus at least two, while others are unique to genus zero. (Received August 17, 2014)

53 ► Differential geometry

1103-53-3 **William M. Goldman*** (wmg@math.umd.edu), College Park, MD 20742. *Moduli spaces and the classification of geometric structures on manifolds.*

In the late 19th century, Sophus Lie and Felix Klein proposed that a *geometry* is governed by its group of symmetry transformations. This led Élie Cartan and Charles Ehresmann to develop a theory of geometric structures based on local symmetries. Consider a *topology* (a manifold Σ) and a *geometry* (a homogeneous space $X = G/H$). Classify all the possible ways of introducing the local geometry of X into Σ.

For example, a sphere admits no local Euclidean geometry: there is no metrically accurate Euclidean atlas of the earth. In contrast, the topology of the 2-torus admits a rich moduli space of Euclidean structures. The general classification involves a *deformation space* of marked (G, X)-structures on Σ, upon which the diffeotopy group $\pi_0\mathsf{Diff}(\Sigma)$ acts. Furthermore, the deformation space itself is *locally modeled* on the quotient space $\mathsf{Hom}\big(\pi_1(\Sigma), G\big)/\mathsf{Inn}(G)$, inheriting rich geometric and algebraic structures.

We survey several examples of the successful classification of geometric structures on manifolds, indicating several open problems in this subject. (Received August 01, 2014)

1103-53-65 **Tatyana Barron*** (tatyana.barron@uwo.ca). *Quantization on hyperkähler and multisymplectic manifolds.*

I will discuss how to use Kähler quantization to quantize hyperkähler manifolds and one type of multisymplectic manifolds. (Received August 11, 2014)

1103-53-82 **Jacques C. Hurtubise*** (jacques.hurtubise@mcgill.ca), Dept. Mathematics and Statistics, McGill University, 805 Sherbrooke St. W., Montreal, Quebec H3A 0B9, Canada, and **Christiane Rousseau**. *Unfolding of irregular singularities of ordinary differential equations.*

An irregular singular point of an ode in the plane is classified by Stokes matrices, once one fixes a formal normal form; on the other hand equations with regular singular points are in essence classified by their monodromy representations. The link between the two is not immediate. We present an unfolding of an irregular singular point which shows the unifying role played by Stokes matrices in both cases. Joint work with Christiane Rousseau. (Received August 13, 2014)

1103-53-91 **Jonathan Weitsman***, Department of Mathematics, Northeastern University, Boston, MA 02115. *b-Symplectic manifolds.*

We review recent progress in the geometry and topology of b-Symplectic manifolds. (Joint with Victor Guillemin and Eva Miranda) (Received August 14, 2014)

1103-53-101 **A Coley*** (aac@mathstat.dal.ca), dept math., halifax, NS B3H 3J5, Canada. *Scalar curvature invariants in pseudo Riemannian scaces.* Preliminary report.

Scalar curvature invariants in pseudo Riemannian scaces (Received August 14, 2014)

1103-53-106 **Vincent Pecastaing***, Université Paris-Sud, France. *The conformal group of a compact Lorentz manifold.*

In dimension greater than or equal to 3, the conformal group Conf(M,g) of a pseudo-Riemannian manifold (M,g) is a Lie group. The general question we are interested in is the following : For which Lie groups G does there exist (M,g) such that Conf(M,g)=G, or at least Conf(M,g) contains G ? Generally, any Lie group can be realized as a subgroup of some conformal group. If we restrict ourselves to compact manifolds, the question is no longer trivial : for instance, in Riemannian signature, a result of Ferrand-Obata implies that such groups G are exactly compact groups or (subgroups of) the Möbius group PO(1,n+1).

In this talk, we will give a picture of what we currently know around this question in Lorentz signature, in the light of a classification result of Adams-Stuck-Zeghib (1995) who gave, up to local isomorphisms, the list of the possible isometry groups of a compact Lorentz manifold. (Received August 14, 2014)

1103-53-115 **Martin Pinsonnault*** (mpinson@uwo.ca), Middlesex College, The University of Western Ontario, London, Ontario N6A 5B7, Canada. *Geometry of Symplectomorphism Groups of Toric Manifolds.* Preliminary report.

Given a symplectic toric manifold M, the group of equivariant symplectomorphisms G_T can be shown to behave like a maximal torus in the full symplectomorphism group G. This analogy leads to a convexity theorem similar to the Schur-Horn theorem. In this talk, we will discuss other analogies that can be drawn and some natural problems that emerge from this picture. (Received August 15, 2014)

1103-53-190 **Gregory D Laun*** (glaun@math.umd.edu). *Coxeter Extensions of Affine Deformations of the Two-Holed Cross Surface.*

The space of proper affine deformations of the two-holed cross surface have been classified by Charette, Drumm, and Goldman. Let Σ be a two-holed cross-surface, or equivalently a one-holed Mobius band. Let π denote $\pi_1(\Sigma)$, the fundamental group. Then π is isomorphic to $\mathbb{F}_2$, the (nonabelian) free group on two generators. It is known that any irreducible representation $\phi : \mathbb{F}_2 \to \mathrm{SL}(2,\mathbb{C})$ embeds as an index-2 subgroup of a representation $\mathbb{Z}/2\mathbb{Z} * \mathbb{Z}/2\mathbb{Z} * \mathbb{Z}/2\mathbb{Z} \to \mathrm{PSL}(2,\mathbb{C})$. It is reasonable to ask therefore which affine deformations of ϕ also give rise to such "Coxeter extensions", which we here use to mean a *reflection group* that double-covers the image of the representation.

We discuss what is currently in the literature about reflection groups in connection with affine deformations, as well as results from work in progress. (Received August 19, 2014)

55 ► Algebraic topology

1103-55-39 **Peter Crooks***, peter.crooks@utoronto.ca. *Generalized Equivariant Cohomology and Stratifications.*

In the 1980s, Atiyah and Bott provided a framework for computing equivariant cohomology in the context of an equivariant stratification. Their approach has given rise to several important developments in the research

literature. Notably, Harada, Henriques, and Holm used equivariant stratifications to formulate a version of GKM Theory for generalized equivariant cohomology.

I will begin with a brief overview of generalized T-equivariant cohomology theories E_T^*, where T is a compact torus. I will then discuss some recent work concerning the $E_T^*(\mathrm{pt})$-module structure of $E_T^*(X)$, where X is an equivariantly stratified smooth complex projective $T_{\mathbb{C}}$-variety. We will subsequently assume that X^T is finite and that E_T^* is one of T-equivariant cohomology, T-equivariant K-theory, and T-equivariant complex cobordism. In this case, a Białynicki-Birula stratification gives an extremely explicit $E_T^*(\mathrm{pt})$-module structure. Lastly, I will show how the preceding ideas can be used to provide a relatively straightforward calculation of the generalized torus-equivariant cohomology of the affine Grassmannian of a simply-connected complex semisimple Lie group.

This joint work with Tyler Holden. (Received August 03, 2014)

57 ► Manifolds and cell complexes

1103-57-86 **Christian K Zickert***, Mathematics Building, University of Maryland. *Coordinates for representations of 3-manifold groups.*

We discuss the shape and Ptolemy coordinates, which are coordinates on representation varieties coming from triangulations. The coordinates are 3-dimensional analogues of coordinates on higher Teichmüller spaces due to Fock and Goncharov. (Received August 13, 2014)

58 ► Global analysis, analysis on manifolds

1103-58-191 **Lisa Jeffrey*** (jeffrey@math.toronto.edu), Toronto, Ontario M5S 2E4, Canada. *The degree ofthe Chern-Simons line bundle.* Preliminary report.

(Joint work with Dan Ramras and Jonathan Weitsman)

The Chern-Simons line bundle (over the moduli space of flat connections on a trivial principal G-bundle on a 2-manifold) was studied using the Chern-Simons cocycle by Ramadas, Singer and Weitsman in 1989. We revisit this construction and use its methods to show that the degree of this line bundle is 1 in the case when the 2-manifold is a 2-torus and G=SU(2).

Our result resolves the following conjecture of Lawton and Ramras. Let G=SU(n) and let S be an arbitrary 2-manifold. The classifying map for the Chern-Simons line bundle is a homotopy equivalence in the limit as n approaches infinity.

References: S. Lawton, D. Ramras, Covering spaces of character varieties. Preprint arXiv:1402.0781 (2014)

T.R. Ramadas, I.M. Singer, J. Weitsman, Some comments on Chern-Simons gauge theory, Commun. Math. Phys. 126 (1989) 409-420.

(Received August 20, 2014)

65 ► Numerical analysis

1103-65-12 **Mihaela Cristina Drignei*** (mdrignei@pitt.edu), University of Pittsburgh at Bradford, Bradford, PA 16701. *A numerical solution to an inverse Sturm-Liouville problem by two spectra.*

We propose a numerical method for reconstructing the coefficient function in the canonical Sturm-Liouville differential equation from two known sequences of eigenvalues. We focus on the case of the two sequences being the Dirichlet and the Dirichlet-Robin eigenvalue-sequences. Our method is Newton-type. We shall describe the method and illustrate it with examples. We shall also compare it with two existing methods in literature: a quasi-Newton method, and a variational method. (Received August 13, 2014)

68 ► Computer science

1103-68-24 **Bin Han*** (bhan@ualberta.ca), Dept. of Mathematical and Statistical Science, University of Alberta, Edmonton, Alberta T6G 2G1, Canada, and **Zhiqiang Xu** (xuzq@lsec.cc.ac.cn), LSEC, Institute of Computational Mathematics, Academy of Mathematics and System Science, Chinese Academy of Sciences, Beijing, 100091, Peoples Rep of China. *The Robustness Property of Johnson–Lindenstrauss Lemma.* Preliminary report.

Johnson–Lindenstrauss Lemma concerns low-distortion embedding of points from high-dimensional into low-dimensional Euclidean space and plays a key role in the establishment of the restricted isometric property in compressed sensing and dimensionality reduction. In this talk, For arbitrary erasure of entries, we consider the almost norm preservation property of Gaussian random matrices and the Johnson–Lindenstrauss Lemma. When the ratio of missing/erased entries is small, we prove an optimal result on the robustness property of the almost norm preservation property of Gaussian random matrices and the Johnson–Lindenstrauss Lemma. When the ratio of missing/erased entries is large, we obtain an improved result on the robustness property of the Johnson–Lindenstrauss Lemma by using order statistics and Gaussian random matrices. (Received July 24, 2014)

1103-68-31 **Narad Rampersad*** (narad.rampersad@gmail.com). *Some properties of a Rudin–Shapiro-like sequence.* Preliminary report.

We introduce the sequence $(i_n)_{n\geq 0}$ defined by $i_n = (-1)^{\mathrm{inv}_2(n)}$, where $\mathrm{inv}_2(n)$ denotes the number of inversions (i.e., occurrences of 10 as a scattered subsequence) in the binary representation of n. We show that this sequence has many similarities to the classical Rudin–Shapiro sequence. If we let $S(n)$ denote the n-th partial sum of the sequence $(i_n)_{n\geq 0}$, then $S(n) = \sqrt{n}G(\log_4(n))$, where G is a bounded, periodic function with period 1. We establish that the maximum and minimum values of G are $\sqrt{2}$ and $\sqrt{3}/3$ respectively. We also give some combinatorial properties of the sequence $(i_n)_{n\geq 0}$. This is joint work with Philip Lafrance, Hamoon Mousavi, Jeffrey Shallit, and Randy Yee. (Received July 31, 2014)

1103-68-107 **Jérôme Fortier*** (jerome.fortier@gmail.com), LaCIM, Université du Québec à Montréal, CP 8888, Succ. Centre-ville, Montréal, Québec H3C 3P8, Canada. *Higher-order languages are circularly computable.*

We are interested in the problem of expressiveness of the following operations: finite products and coproducts of sets, induction and coinduction. These operations are the building blocks of a logical system that allows circularity in Gentzen-style proofs. Proofs in this system are seen as simple programs, while the cut-elimination process is viewed as a running automaton with a memory device. In this paper, we show that higher-order languages, those accepted by higher-order pushdown automata, are computable in this setting, by providing an explicit simulation of the automata by cut-elimination. (Received August 14, 2014)

70 ► Mechanics of particles and systems

1103-70-178 **Roman Smirnov*** (roman.smirnov@dal.ca), Department of Mathematics and Statistics, Dalhousie University, Halifax, NS B3H 4R2, Canada. *Orthogonal separable webs in differential geometry and mathematical physics.*

Orthogonal separable webs are mathematical objects with rich algebraic and geometric properties; they also enjoy a broad range of applications in mathematical physics. We will review recent results obtained in the study of orthogonal separable webs generated by Killing tensors. (Received August 19, 2014)

83 ► Relativity and gravitational theory

1103-83-109 **Ivan Booth*** (ibooth@mun.ca), Dept of Math and Stats, Memorial University, St. John's, NL A1C3G1, Canada. *Probing black hole physics with Melvin-Kerr-Newman spacetimes.*

We examine several aspects of black hole physics using the Melvin-Kerr-Newman (MKN) family of spacetimes. Roughly speaking these are black holes immersed in a background magnetic field and unlike the standard Kerr-Newman (KN) family they are not asymptotically flat. Among other properties we see that their angular momentum and charge are bounded by horizon area in exactly the same way as KN and also that they obey the uniqueness theorems for extremal horizons: these properties are in accord with standard theorems but are seen to be satisfied in interesting and non-trivial ways. Horizon geometries are compared to the corresponding KN

horizons. We examine how the laws of isolated horizon mechanics apply to the MKN family of solutions and compare that with a recent study by Gibbons, Pang and Pope. Finally we examine possible physical process interpretations of the mechanics. (Received August 15, 2014)

1103-83-135 **David Garfinkle*** (garfinkl@oakland.edu), Dept. of Physics, Oakland University, Rochester, MI 48309. *Gravitational wave memory.*

Gravitational wave memory is the change induced in a detector by the passage of a gravitational wave. This effect is explored using both exact and perturbative methods, as well as through analogy with a corresponding effect in electromagnetism. (Received August 17, 2014)

1103-83-146 **Sanjeev S Seahra***, sseahra@unb.ca. *Effects of nonstandard kinetic terms on resonant preheating.*

I discuss the effects of exotic kinetic terms in scalar field actions during resonant preheating after inflation. Using multiple scales analysis and dynamical systems techniques, I demonstrate that modifications due to generalized uncertainty principles, polymer quantization and string theory (DBI) effects generically frustrate parametric resonance. (Received August 18, 2014)

1103-83-151 **J Gegenberg*** (geg@unb.ca), **G Kunstatter** and **S Rahmati**. *Gravitational Yang-Mills Theory Revisited.*

I will summarize recent work with Kunstatter and Rahmati on gravity as a (modifed) Yang-Mills theory. This is a re-visit to an old program, but with a somewhat different focus. These theories are intrinsically torsion-full. I will primarily discuss a toy two dimensional version, displaying its solvability via Hamiltonian analysis. I will show that there is a Birkhoff Theorem, and I will comment on the coupling of matter to gravity. (Received August 18, 2014)

1103-83-161 **Hari K Kunduri*** (hkkunduri@mun.ca), Department of Mathematics and Statistics, Memorial University of Newfoundland, St John's, NL A1C 5S7, Canada. *Black hole non-uniqueness via spacetime topology in five dimensions.*

The domain of outer communication of five-dimensional asymptotically flat stationary spacetimes may possess non-trivial 2-cycles. I will discuss how this may lead to a gross violation of black hole uniqueness, beyond the existence of black rings. I will demonstrate this with a simple example: a four parameter family of supersymmetric black hole solutions, with spherical horizon topology and a 2-cycle in the exterior. There are black holes in this family with identical conserved changes to the well-konwn BMPV black hole, showing black hole non-uniqueness in this context. I also discuss a decoupling limit of these new solutions. (Received August 18, 2014)

1103-83-162 **Nathan K. Musoke*** (msknathan@dal.ca). *Holonomy of 4-Dimensional Neutral Signature Metrics.*

Some properties of holonomy from the literature will be presented and applied to the classification of 4-dimensional neutral signature metrics, specifically degenerate cases in the classification by scalar curvature invariants. Some explicit examples of four-dimensional neutral signature Walker (but not necessarily degenerate Kundt) spaces for which all of the polynomial scalar curvature invariants vanish are examined. (Received August 18, 2014)

1103-83-166 **Aghil Alaee*** (aak818@mun.ca), Mathematics and Statistics Department, Memorial University of Newfoundland, St.John's, NL A1C 5S7, Canada. *Mass Functionals for Initial Data with Symmetries.*

Consider a broad class of asymptotically flat, maximal slices satisfying the constraint vacuum Einstein equations admitting two commuting rotational symmetries. We construct a 'mass' functional for 't-phi' symmetric data which agrees with the ADM mass and show that when restricted to stationary, axisymmetric data, this functional has the same critical points as Carter's positive definite action for the stationary vacuum Einstein equations with the above spatial isometry group. The construction is a natural extension of S. Dain's mass functional for three-dimensional initial data sets. However, the proposed generalization is not manifestly positive definite. (Received August 18, 2014)

1103-83-168 **Dario A. Brooks*** (dr556081@dal.ca), 2 Donald Court, Dartmouth, NS B2W 4A3, Canada. *Invariant classification of four-dimensional neutral signature metrics.*

We investigate the mathematical properties of four-dimensional neutral signature Ricci flat Walker and Kundt spaces for which all of the polynomial scalar curvature invariants vanish. The main part of the talk will be focused on the equivalence problem in geometry applied to these VSI metrics. The main results of the project

are discussed in detail with emphasis given on the explanation of the equivalence method due to Cartan and Karlhede. We conclude the discussion showing that the equivalence algorithm provides all necessary information to determine the equivalence of these pseudo-Riemannian manifolds. (Received August 18, 2014)

1103-83-169 **John W Moffat*** (jmoffat@perimeterinstitute.ca), Perimeter Institute, Waterloo, Ontario N2L 2Y5, Canada. *Title: Modified Gravity and Dark Matter.*

Abstract: A modified gravitational theory is developed that can explain structure growth and the Planck cosmic microwave background (CMB) data. The rotation curves of galaxies and the dynamics of galaxy clusters are successfully determined without exotic dark matter. The modified gravity (MOG) theory is compatible with observational data from the solar system to cosmological Mega parsec scales. (Received August 18, 2014)

1103-83-194 **David McNutt*** (mcnuttdd@gmail.com), Halifax, NS , Canada. *A Survey of the Equivalence Problem in 3D.*

TBA (Received August 19, 2014)

90 ► Operations research, mathematical programming

1103-90-57 **Rongrong Wang*** (rongwang@math.ubc.ca), 1984 mathematics road, Vancouver, BC V6T1Z2, Canada, and **Ozgur Yilmaz** and **Rayan Saab**. *Sigma-Delta quantization in compressed sensing with sub-Gaussian measurements.* Preliminary report.

We analyze how efficiently Sigma-Delta quantization works for quantizing compressed (sub-Gaussian) measurements of sparse and compressible signals. To this end, we propose a one-stage reconstruction algorithm based on convex optimization that yields consistent reconstruction. The algorithm works in the cases of fine and coarse quantization including one- bit quantization, with a reconstruction error decaying inverse polynomially in the quantization order. We show that this decay rate is nearly optimal among all possible reconstruction algorithms by a geometric argument about quantization cells. When we optimize over all quantization orders, the algorithm can achieve root exponential error decay with respect to the "oversampling factor". Finally, we show that by further compressing the quantized data via a Johnson-Lindenstrauss embedding, exponential decay (as a function of the total bit budget) is achieved. This is joint work with Rayan Saab and Ozgur Yilmaz. (Received August 08, 2014)

1103-90-66 **Hassan Mansour*** (mansour@merl.com), Boston, MA 02122. *Multi-path elimination by sparse inversion in Through-The-Wall-Radar-Imaging.*

We study the problem of detecting sparse objects from subsampled uniform linear arrays in a Through-The-Wall-Radar-Imaging (TWRI) system. Our analysis combines techniques from compressed remote sensing and spectral compressed sensing. We propose a multi-path elimination by sparse inversion (MESI) algorithm that removes the clutter induced by internal wall reflections in TWRI without prior knowledge of the wall characteristics. Our approach iteratively recovers the primary impulse responses of targets behind the front wall then finds a delay convolution operator that best maps the primary impulse response of each target to the multi-path reflections available in the received signal. Since the number of targets and the number of reflecting surfaces is typically much smaller than the downrange extent of the scene, we employ ℓ_1 regularized sparse recovery in both the target detection and reflection-operator estimation. (Received August 11, 2014)

91 ► Game theory, economics, social and behavioral sciences

1103-91-41 **Ian Norris** and **Nandor Sieben*** (nandor.sieben@nau.edu), Northern Arizona University, Department of Mathematics and Statistics, Flagstaff, AZ 86011. *Biased Weak Polyform Achievement Games.*

In a biased weak (a, b) polyform achievement game, the maker and the breaker alternately mark a, b previously unmarked cells on an infinite board, respectively. The maker's goal is to mark a set of cells congruent to a polyform. The breaker tries to prevent the maker from achieving this goal. A winning maker strategy for the (a, b) game can be built from winning strategies for games involving fewer marks for the maker and the breaker. A new type of breaker strategy called the priority strategy is introduced. The winners are determined for all (a, b) pairs for polyiamonds and polyominoes up to size four. (Received August 03, 2014)

94 ► Information and communication, circuits

1103-94-16 **Joseph D Lakey*** (jlakey@nmsu.edu), Dept. Mathematical Sciences, NMSU, Las Cruces, NM 88003-8001. *Bandpass Prolates and an Application to Electroencephalography.*

The bandpass-limited functions that are most concentrated in a given time interval are called bandpass prolates. We present a method to compute these bandpass prolates starting from full band prolates, and use them to extract temporally concentrated bandpass projections of wideband signals. An application to the study of phase synchrony in EEG signals will be presented. (Received July 13, 2014)

1103-94-46 **Cheng Cheng** (cheng.cheng@knights.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816, **Yingchun Jiang** (guilinjiang@126.com), Department of Mathematics, Guilin University of Electronic Technology, Guilin, Guangxi , Peoples Rep of China, and **Qiyu Sun*** (qiyu.sun@ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Sampling and Galerkin reconstruction in reproducing kernel spaces.* Preliminary report.

In this talk, I will introduce a pre-reconstruction operator associated with a sampling scheme, propose a quasi-optimal Galerkin reconstruction, and also present detailed analysis of the Galerkin method for reconstructing signals with finite rate of innovation. (Received August 05, 2014)

1103-94-165 **Sinan Gunturk*** (gunturk@cims.nyu.edu), 251 Mercer Street, New York, NY 10012. *Near-Optimal Quantization for Random Frames.*

We introduce a new quantization and reconstruction algorithm for the so-called "Analysis Problem" in (finite) frame theory, and show that it provides a near-optimal solution in the case of random measurements. More specifically, we show that for any $L \geq 2$, if L quantization levels per measurement with respect to a Gaussian frame of m vectors are available to encode the unit ball in $\mathbb{R}^k$, then with overwhelming probability the reconstruction error of this new algorithm is bounded by $\sqrt{k}L^{-(1-\eta)m/k}$ where η is arbitrarily small for sufficiently large problems. Additional features of the proposed algorithm include low computational cost and parallel implementability. Time permitting, we will also discuss generalizations of this algorithm to compressive sampling as well as infinite dimensional systems.

Joint work with Evan Chou. (Received August 18, 2014)

2010 MATHEMATICS SUBJECT CLASSIFICATION

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00 General
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18 Category theory; homological algebra
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43 Abstract harmonic analysis
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46 Functional analysis
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49 Calculus of variations and optimal control; optimization
51 Geometry
52 Convex and discrete geometry
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54 General topology
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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
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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
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0192-5857(2014)35:3;1-T