ABSTRACTS

of Papers Presented to the American Mathematical Society

Volume 31, Number 4, Issue 162 Fall 2010

Editorial Committee

Robert J. Daverman, Chair
Georgia Benkart
Michel L. Lapidus
Matthew Miller
Steven H. Weintraub

Abstracts for

ISSN 0192-5857 Pages 655–886

AMS

SUBMISSION INFORMATION

ABSTRACTS PUBLISHED IN THIS JOURNAL are those submitted by authors who intend to present them at AMS meetings (see the front cover). The abstracts for each meeting are sorted by the two-digit 2010 Mathematics Subject Classification chosen by the author and appear in the order received. See the back cover for the 2010 Mathematics Subject Classification.

THE SUITABILITY OF A PAPER for presentation to the Society is judged from the abstract as outlined in Article X, Section 6 of the bylaws:

> Papers intended for presentation at any meeting of the Society shall be passed upon in advance by a program committee appointed by or under the authority of the Council; and only such papers shall be presented as shall have been approved by such committee. Papers in form unsuitable for publication, if accepted for presentation, shall be referred to on the program as preliminary communications or reports.

In addition, the editors of the *Abstracts* have adopted the following policy: In order to be accepted for publication, an abstract must have mathematical research content. It should not contain libelous, defamatory, or tasteless remarks, commercial promotions, nor political or religious arguments. Papers may not be presented if published in full before the date of the Society meeting or if previously presented to any learned Society except the National Academy of Sciences or the Royal Society of Canada. The AMS assumes no responsibility for the content or inappropriate remarks in any published abstract.

GENERAL INFORMATION ON ABSTRACTS is found at `http://www.ams.org/abstracts`.

ABSTRACTS ARE PRINTED from copy submitted by the author. Web submission is the required electronic format. To view the interactive template, visit the Abstracts submission page on the AMS website at `http://www.ams.org/cgi-bin/abstracts/abstract.pl`. Step-by-step submission instructions are included in the template. No knowledge of LaTeX is necessary; however, any mathematical displays or accent marks in text or in names must be coded in LaTeX. Requests for general information concerning abstracts may be sent to `abs-info@ams.org`.

THE ABSTRACT RECEIPT DEADLINES FOR ALL MEETINGS will be strictly enforced. Unfortunately, late papers cannot be accommodated. When all talks have been scheduled for a given meeting, the attendant abstracts will be available for viewing on the AMS website through the program display for that meeting.

NOTATIONS IN THIS JOURNAL are the following:

* Indicates who will present the paper at the meeting.

SUBSCRIPTION INFORMATION

CHANGES OF ADDRESS should be reported six weeks in advance to avoid disruption of service. Changes of address and all general correspondence should be sent to Member and Customer Services, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA (email: amsmem@ams.org or fax: 401-455-4026); dues payments and orders for AMS publications should be addressed to the Society at P.O. Box 845904, Boston, MA 02284-5904 USA; all correspondence relating to advance registration for meetings should be addressed to the Society, 201 Charles Street, Providence, RI 02904-2294 USA.

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 31 (2010) is US$144 list, US$115 institutional member, US$86 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. Add for postage: Surface delivery to destinations outside the U.S.—US$11, to India—US$16. Expedited delivery to destinations in North America—US$14, elsewhere—US$41. POSTMASTER: Send address change notices to Abstracts of Papers Presented to the American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA.

© 2010 by the American Mathematical Society. All rights reserved.
Printed in the United States of America.
♾ This journal is printed on acid-free paper and falls within
the guidelines established to ensure permanence and durability.

10 9 8 7 6 5 4 3 2 1 14 13 12 11 10

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
1067	January 6–9, 2011	New Orleans, LA	September 22	Vol 32, No. 1
1068	March 12–13, 2011	Statesboro, GA	January 20	Vol 32, No. 2
1069	March 18–20, 2011	Iowa City, IA	January 25	Vol 32, No. 2
1070	April 9–10, 2011	Worcester, MA	February 15	Vol 32, No. 3
1071	April 30–May 1, 2011	Las Vegas, NV	March 8	Vol 32, No. 3
1072	September 10–11, 2011	Ithaca, NY	July 19	Vol 32, No. 4
1073	September 24–25, 2011	Winston-Salem, NC	August 2	Vol 32, No. 4
1074	October 14–16, 2011	Lincoln, NE	August 23	Vol 32, No. 4
1075	October 22–23, 2011	Salt Lake City, UT	August 30	Vol 32, No. 4
1076	November 29–December 3, 2011	Port Elizabeth, South Africa	TBA	None

SYRACUSE, NY, October 2–3, 2010

Abstracts of the 1062nd Meeting.

00 ► General

1062-00-6 **Batool. Ghalandary*** (b.ghalandary@gmail.com), Tehran, Iran, and **Laleh Farhang Matin** (b.ghalandary@gmail.com), , Iran. *Exactly Solvable Reaction Diffusion Models on the Bethe Lattice through the empty interval method (EIM) with Analytical and Numerical approaches.*

The most general reaction- diffusion model on the Bethe lattice with nearest-neighbor interactions is introduced. the evolution equation of the system can be solved exactly through the empty interval method and comparing Analytical approach with Numerical .the stationary and the dynamics solution of such models are discussed. (Received April 29, 2010)

1062-00-136 **Matthew J Begue*** (matthew.begue@uconn.edu), 52 Kate Lane, Tolland, CT 06084, and **Tristan Kalloniatis** and **Robert Strichartz**. *Harmonic functions and the spectrum of the Laplacian on the Sierpinski carpet.* Preliminary report.

Kusuoka and Zhou have defined the Laplacian on the Sierpinski carpet using average values of functions on small cells and the graph structure of cell adjacency. We have implemented an algorithm that uses their method to approximate solutions to boundary value problems. As a result we have a wealth of data concerning harmonic functions with prescribed boundary values, and eigenfunctions of the Laplacian with either Neumann or Dirichlet boundary conditions. We will present some of this data and discuss some ideas for defining normal derivatives on the boundary of the carpet. (Received August 03, 2010)

1062-00-208 **Erik M Bollt*** (bolltem@clarkson.edu), Clarkson University, Department of Mathematics, Potsdam, NY 13699-5815, and **Aaron Luttman**. *Data Mining Remotely Sensed Image Sequences and Transport Analysis of Spatiotemporal Dynamical Systems.*

A broad range of scientific fields, such as climatology, oceanography, and fluid dynamics produce large data sets in the form of digital images or continuous-time, spatiotemporal video data from remotely sensed hyperspectral satellite data. There have been terrific advancements in variational methods for image processing, and likewise in dynamical systems, there have been tremendous advancements in analyzing transport in complex spatiotemporal dynamical systems. Nonetheless, there has been little specialization of the methods of image processing to develop techniques specifically suited to the complex dynamical systems typical of fluid systems, and the tools of

dynamical systems have not been brought to bear on data inferred directly from movies. The Frobenius-Perron operator for a dynamical system known allows transport modeling and phase decomposition into almost invariant sets. A particular application which interests us is remotely sensed ecological systems such as biological products including algae blooms, from which we will discuss modeling, transport analysis, and filtering. (Received August 09, 2010)

1062-00-268 **Jason Allen Anema*** (jaa72@cornell.edu), 400 Stewart Ave. apartment 1, Ithaca, NY 14850. *Counting spanning trees on fractal graphs.*

Presented is a way to calculate the number of spanning trees on graph approximations to self-similar symmetric finitely ramified fractals, such as the Sierpiński gasket. Kirchoff's Matrix-Tree Theorem shows that the number of spanning trees, on a finite graph, is equal to the product of the non-zero eigenvalues of the graph Laplacian. Using the method of spectral decimation, for this class of fractals, provides a way to find these eigenvalues and taking their product, giving on the number of spanning trees. Examples of this method will include the d-dimensional Sierpiński gasket and the Hexagasket. (Received August 10, 2010)

05 ► Combinatorics

1062-05-1 **Alan Frieze*** (alan@random.math.cmu.edu), 5000 Forbes Avenue, Pittsburgh, PA 15217. *Hamilton Cycles in Random Graphs.*

We will survey some of what is known about Hamilton cycles in the context of various classes of random and pseudo-random graphs, digraphs and hypergraphs. This will cover questions such as (i) when is a random graph likely to have a Hamilton cycle, (ii) how many will it have, (iii) how many edge disjoint Hamilton cycles can we pack and (iv) who will win in certain related combinatorial games. (Received August 10, 2010)

1062-05-11 **Rod Canfield*** (erc@cs.uga.edu), Department of Computer Science, Graduate Studies Building, University of Georgia, Athens, GA 30602, and **Carl Pomerance**, Department of Mathematics, Kemeny Hall, Hanover, NH 03755. *The maximum Stirling number(s) of the second kind.*

The Stirling numbers of the second kind, $S(n,k)$, count the partitions of an n-set into k blocks. For each n the maximum $S(n,k)$ is achieved either at a unique $k = K_n$, or is achieved twice consecutively at $k = K_n, K_n + 1$. Call those n of the latter type *exceptional*. Is $n = 2$ the only exceptional integer? The attempt to answer this question has led to some interesting analytic considerations. (Received May 17, 2010)

1062-05-15 **Eva Czabarka*** (czabarka@math.sc.edu), Department of Mathematics, University of South Carolina, Columbis, SC 29208. *Some combinatorial results on gene trees.*

Gene trees are leaf-labeled trees where the labels may be used repeatedly. They usually but not necessarily are assumed to be rooted and binary trees. In this talk we will present some results about counting gene trees, and some Gallai-type results on placing minimum number of duplication episodes on a given species tree explaining a set of gene trees. The enumeration results are joint work with P.L. Erdős, V. Moulton and V. Johnson and use multivariate generating functions. The min-max results on episodes are joint work with L.A. Székely and T.J. Vision. (Received May 31, 2010)

1062-05-29 **Dan Archdeacon***, Department of Mathematics and Statistics, University of Vermont, Burlington, VT 05405, and **Marston Conder** (m.conder@auckland.ac.nz) and **Jozef Siran** (j.siran@open.ac.uk). *Trinity Symmetry and Kaleidoscopic Regular Maps.*

We consider maps consisting of a graph G embedded on a surface S. The map is *regular* if its automorphism group is of order $2|E(G)|$, that is, if it acts transitively on the directed edges and hence has of the largest order possible for any group of orientation-preserving automorphisms. The map is *reflexive* if it also allows orientation-reversing automorphisms, so that its full automorphism group is of order $4|E(G)|$. The *left-right walks*, or Petrie polygons, form the faces of another map G^P on G. A map has *trinity symmetry* if it is isomorphic to its geometric dual and its Petrie dual G^P. An *exponent of a map* is an e such that replacing the rotation ρ at any vertex by the rotation ρ^e yields a map isomorphic to the original. The map is *kaleidoscopic* if every e coprime to its common degree d is an exponent.

Can a map be regular, reflexive, have trinity symmetry, and be kaleidoscopic? Such maps are beautiful to contemplate, difficult to imagine, questioned as to their existence, but after a great deal of thought have a nice construction from a trivial base graph.

In this talk we present these maps. (Received June 24, 2010)

1062-05-31 **Cristian Lenart*** (lenart@albany.edu), Department of Mathematics, State University of New York at Albany, 1400 Washington Avenue, Albany, NY 12222. *From Macdonald polynomials to a charge statistic in classical Lie types.* Preliminary report.

The charge is an intricate statistic on words, due to Lascoux and Schützenberger, which gives positive combinatorial formulas for Lusztig's q-analogue of weight multiplicities and the energy function on affine crystals, both of type A. As these concepts are defined for other Lie types, it has been a long-standing problem to express them based on a generalization of charge. I present a method to address this problem in classical Lie types, based on the recent Ram-Yip formula for Macdonald polynomials and the quantum Bruhat order on the corresponding Weyl group. (Received June 24, 2010)

1062-05-32 **Cheyne P Homberger*** (cheyne42@ufl.edu), UF Department of Mathematics, 358 Little Hall, PO Box 118105, Gainesville, FL 32611. *The Expected Number of Distinct Maximal Minors of a Permutation.*

We establish a few results on the number of distinct patterns of size $(n-1)$ contained in a given n-permutation. In particular, we find a correspondence between these and the number of consecutive adjacent entries of a permutation. Using this, we are able to derive exact formulas for the expectation and variance for the number of such patterns contained in a random permutation of size n, and make a few generalizations about patterns of other sizes. (Received June 27, 2010)

1062-05-39 **Jonathan L Gross*** (gross@cs.columbia.edu), 458 Computer Science, Columbia University, New York, NY 10027. *Algorithm for the Genus Distribution of a 3-Regular Outerplanar Graph.*

We present a quadratic-time algorithm for calculating the sequence of numbers g_0, g_1, g_2, ... of topologically distinct ways to draw a 3-regular *outerplanar graph* G (without edge-crossings) on each of the respective orientable surfaces S_0, S_1, S_2, ... The total number of ways over all surfaces is 2^n, where n is the number of vertices of G. The key algorithmic features are a characterization of 3-regular outerplanar graphs in terms of *plane trees* and a subsequent synthesis of the graphs by sequences of *edge-amalgamations* of building-block graphs according to *post-order traversals* of those plane trees. (Received July 11, 2010)

1062-05-40 **Eran Nevo**, Be'er Sheva, Israel, and **T. Kyle Petersen*** (tpeter21@depaul.edu), Chicago, IL. *What does the γ-vector count?*

Gal's conjecture asserts that γ-vectors of flag homology spheres are nonnegative. We conjecture that they are nonnegative because they are f-vectors of simplicial complexes. (Received July 12, 2010)

1062-05-55 **Asia Ivic Weiss***, Department of Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada, and **Daniel Pellicer**. *Uniform maps on surfaces of non-negative Euler characteristic.*

We classify uniform (vertex-transitive) polyhedral maps on surfaces of non-negative Euler characteristic and show that all of them have at most 10 orbits on flags. Furthermore we show that they are all quotients of maps obtained by certain operations applied to regular tessellations on the sphere and on the Euclidean plane. (Received July 21, 2010)

1062-05-79 **Jim Haglund*** (jhaglund@math.upenn.edu). *A polynomial identity for the Hilbert series of the space of diagonal harmonics.*

A special case of Haiman's identity for the character of the quotient ring of diagonal coinvariants under the diagonal action of the symmetric group yields a formula for the bigraded Hilbert series as a sum of rational functions in q,t. In this talk I will show how a summation identity of Garsia and Zabrocki for Macdonald polynomial Pieri coefficients can be used to transform Haiman's formula for the Hilbert series into an explicit polynomial in q,t with integer coefficients. An equivalent formulation expresses the Hilbert series as the constant term in a certain multivariate Laurent series. (Received July 27, 2010)

1062-05-101 **Sergi Elizalde***, Department of Mathematics, 6188 Kemeny Hall, Hanover, NH 03755. *Permutations and β-shifts.* Preliminary report.

Given a real number $\beta > 1$, a permutation π of length n is realized by the β-shift if there is some $x \in [0,1]$ such that the relative order of the sequence $x, f(x), \ldots, f^{n-1}(x)$, where $f(x)$ is the factional part of βx, is the same as that of the entries of π. Shifts are important dynamical systems because they exhibit some key features of low-dimensional chaos. Permutations realized by shifts when β is an integer have recently been characterized. We generalize some of these results to arbitrary β-shifts, by describing a method to compute, for any given

permutation π, the smallest β such that π is realized by the β-shift. We also give a way to determine the length of the shortest forbidden pattern of an arbitrary β-shift. (Received July 30, 2010)

1062-05-107 **Boris G Pittel*** (bgp@math.ohio-state.edu), Boris Pittel, Columbus, OH 43221. *Tight Markov chains and random compositions.*

For an ergodic Markov chain $\{X(t)\}$ on $\mathbb{N}$, with a stationary distribution π, let $T_n > 0$ denote a hitting time for $[n]^c$, and let $X_n = X(T_n)$. Guy Louchard popularized a conjecture that, for $n \to \infty$, T_n is almost Geometric(p), $p = \pi([n]^c)$, X_n is almost stationarily distributed on $[n]^c$, and that X_n and T_n are almost independent, if $p(n) := \sup_i p(i, [n]^c) \to 0$ exponentially fast. For the chains with $p(n) \to 0$ however slowly, and with $\sup_{i,j} \|p(i,\cdot) - p(j,\cdot)\|_{TV} < 1$, we show that a stronger claim is true for the sequence of hits of any $S_n \subset \mathbb{N}$ with $\pi(S_n) \to 0$. The conditions are met by the Markov chains that arose in Louchard's studies of two random integer compositions. We show that the chains sharply approximate both compositions. Using a chain approximation and the approximation of the hit sequence for $[n]^c$, we study the largest parts of each of the compositions. (Received July 31, 2010)

1062-05-113 **Sam Northshield*** (northssw@plattsburgh.edu), Dept. of Mathematics, SUNY, Plattsburgh, NY 12901. *A Lyness equation for trees.*

The Lyness equation, $x_{n+1} = (x_n + \alpha)/x_{n-1}$, can be thought of as an equation defined on the 2-regular tree: for x, y, z vertices of that tree where y has distinct neighbors x and z,

$$f(x)f(z) = f(y) + \alpha.$$

We generalize to the 3-regular tree T: we consider functions f on the vertices of T such that if w has distinct neighbors x, y and z, then

$$f(x)f(y) + f(x)f(z) + f(y)f(z) = f(w) + \alpha.$$

In the special case where an auxiliary condition

$$f(x) + f(y) + f(z) = \phi(f(w))$$

also holds for some ϕ, the solution is determined by (any) two values and, in some cases, an invariant can be found.

We also consider the equation $f(x)f(y)f(z) = f(w) + \alpha$. (Received August 02, 2010)

1062-05-118 **Kari Ragnarsson*** (kragnars@math.depaul.edu), Department of Mathematical Sciences, 2320 N Kenmore Avenue, Chicago, IL 60614, and **Bridget Eileen Tenner**. *The boolean complex of a Coxeter system.*

In any Coxeter group, the set of elements whose principal order ideals are boolean forms a simplicial poset under the Bruhat order. This simplicial poset defines a cell complex, called the boolean complex. We show that for a Coxeter system of rank n, the boolean complex is homotopy equivalent to a wedge of (n-1)-dimensional spheres. The number of such spheres can be computed recursively from the unlabeled Coxeter graph, and defines a new graph invariant called the boolean number. Explicit computation of boolean numbers of certain families of graphs indicate interesting enumerative properties related to derangements. We uncover this relationship and determine the combinatorial significance of the spheres by constructing and analyzing an explicit basis for the homology of the boolean complex. More precisely, to a given finite simple graph we assign a class of derangements of its vertex set, and to each derangement we associate a homology class in the maximal dimension of the boolean complex. Combining these steps we obtain a basis for the homology of the boolean complex, whose elements are indexed by derangement and represent the spheres in the complex. (Received August 02, 2010)

1062-05-123 **Bruce E. Sagan*** (sagan@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027, and **Carla D. Savage** (savage@cayley.csc.ncsu.edu), Department of Computer Science, North Carolina State University, Raleigh, NC 27695-8206. *Combinatorial interpretations of binomial coefficient analogues related to Lucas sequences.*

Let s and t be variables. Define polynomials $\{n\}$ in s, t by $\{0\} = 0$, $\{1\} = 1$, and $\{n\} = s\{n-1\} + t\{n-2\}$ for $n \geq 2$. If s, t are integers then the corresponding sequence of integers is called a *Lucas sequence*. Define an analogue of the binomial coefficients by

$$\left\{ \begin{matrix} n \\ k \end{matrix} \right\} = \frac{\{n\}!}{\{k\}!\,\{n-k\}!}$$

where $\{n\}! = \{1\}\{2\}\cdots\{n\}$. It is easy to see that $\left\{ \begin{matrix} n \\ k \end{matrix} \right\}$ is a polynomial in s and t. We give two combinatorial interpretations for this polynomial in terms of statistics on integer partitions inside a $k \times (n-k)$ rectangle. When $s = t = 1$ we obtain combinatorial interpretations of the fibonomial coefficients which are simpler than any that have previously appeared in the literature. (Received August 03, 2010)

1062-05-127 **Stephen J Graves*** (sgraves@uttyler.edu), The University of Texas at Tyler, 3900 University Blvd., Tyler, TX 75799. *Tessellations with Arbitrary Growth Rates.*

A tessellation is taken to be an infinite, 1-ended, 3-connected, locally finite, and locally cofinite plane map. When such a tessellation is the induced graph of a tiling of the hyperbolic plane, it is known that the asymptotic growth of the tessellation is exponential. We address an unpublished conjecture of Watkins, that growth rates of such tessellations can be made arbitrarily close to 1. Given any real number $\xi > 1$, we use analytic methods to construct a tessellation with growth rate ξ. (Received August 03, 2010)

1062-05-129 **Elizabeth Niese*** (eniese@math.vt.edu), Blacksburg, VA 24061, and **Nicholas Loehr**. *A q,t-analogue of the hook-length formula.*

The hook-length formula is an early result in algebraic combinatorics. The formula counts the number of standard Young tableaux of a particular shape μ. Macdonald introduced a q-analogue of the hook-length formula which was proved by Garsia and Haiman using the algebraic definition of Macdonald polynomials. In this talk we present a bijective proof of a q,t-analogue of the hook-length formula for combinatorial Macdonald polynomials when μ is a hook shape which specializes to Macdonald's original formula when $t = q$. A related result was obtained independently by Meesue Yoo in "Combinatorial Formula for the Hilbert Series of bigraded S_n-modules". Our bijection also leads to a combinatorial proof of a symmetry property for Macdonald polynomials. (Received August 03, 2010)

1062-05-139 **Robin Pemantle*** (pemantle@math.upenn.edu), 209 South 33rd Street, Philadelphia, PA 19104. *Automating multivariate asymptotics - recent progress.* Preliminary report.

The current project of the mvGF group (P., Wilson, Raichev, DeVries and others) is implementation of code that produces asymptotic formulae for the coefficients of multivariate rational generating function F = P/Q.

It is well known that coefficient asymptotics depend mainly on the geometry of the algebraic surface Q=0. One of the challenges in moving from theorems, which handle most cases in practice, to automated asymptotics is to combinatorialize the geometric data. A principal step is to compute a cell complex. Some new homotopy methods are required to deal effectively with algebraic schemes, e.g., storing and manipulating algebraic numbers without floating point.

This talk concerns some of the infrastructure necessary to carry out the combinatorialization. A completely automated and rigorous algorithm for the standard bivariate case is described in a forthcoming paper (DeVries, van der Hoeven + P. 2010). (Received August 03, 2010)

1062-05-141 **Simon M Smith*** (simon.smith@chch.oxon.org), Mathematics Department, Syracuse University, Syracuse, NY 13244. *Borrowing from the logicians.*

We present a brief introduction to an old theorem, known to logicians since the 1960s and discovered independently in the late 1980s by David Evans, concerning automorphism groups of countable relational structures. This theorem has proven to be incredibly useful when investigating the structure of automorphism groups of countably infinite graphs. For example, the theorem yields a one line proof of Seifter's result on the cardinality of the automorphism group of a 3-connected locally finite planar graph. (Received August 04, 2010)

1062-05-142 **Thomas W. Tucker*** (ttucker@colgate.edu), Colgate University, Hamilton, NY 13346. *The distinguishing chromatic number of a map.*

Given a map M without loops or multiple edges, the distinguishing chromatic number $DC(M)$ is the least number of colors needed to properly color the vertices of M so that the only color-preserving automorphism of M is the identity. Let $C(M)$ denote the usual chromatic number of the graph underlying M, and let $D(M)$ denote the distinguishing number of M, where vertex-colorings are not required to be proper. For graphs, $C(K_{m,n}) = 2$ while $DC(K_{m,n}) = m + n$, so the difference between the parameters C and DC can be arbitrarily large. For maps this is not the case. It is shown that $DC(M) \leq C(M) + 3$, with equality for only finitely many maps. If $g > 0$ is fixed, there are only finitely many maps M of genus g with $DC(M) > C(M) + 1$. For planar maps, $DC(M) \leq 6$ with equality for only finitely many maps. Proofs are complicated and depend on the author's work on the distinguishing number $D(M)$. (Received August 04, 2010)

1062-05-169 **Michelle B. Snider*** (msnider@math.cornell.edu). *Affine Patches on Positroid Varieties and Affine Pipe Dreams.* Preliminary report.

I will discuss affine patches in positroid varieties on the Grassmannian, indexed by juggling patterns. My main result corresponds these affine patches to Kazhdan-Lusztig varieties in the affine Grassmannian with a proof by construction. With a new term order, these spaces are related to subword complexes and Stanley-Reisner ideals. There is also an extension of pipe dreams in the affine case. (Received August 06, 2010)

1062-05-181 **Tomaž Pisanski*** (Tomaz.Pisanski@fmf.uni-lj.si), Jadranska 19, Ljubljana, Slovenia. *Symmetry type graphs.* Preliminary report.

A k-orbit map is a map whose automorphism group partitions the set of flags into k orbits. It is known, that each edge-transitive map is a 1-, 2- or 4-orbit map. Symmetry types are a refinement of k-orbit maps. They were used by several researchers. For a long time 14 types of edge-transitive maps have been known (Graver and Watkins; Širan, Tucker and Watkins). Recently k-orbit map were studied by Orbanić, Pellicer and Weiss, for $k \leq 4$. We present symmetry type graphs as a tool for classifying symmetry types of maps. Using this tool, we present all types of k-orbit maps for $k = 5, 6, 7$. In particular we determine k-orbit maps that are medials of other maps. In passing, we mention how to extend properly the Wilson census of rotary and chiral maps in order to close it under the "hexagon". Symmetry types may be extended from maps to polytopes. The approach taken here is based upon graphs (Dress) and not upon groups as in recent work on this topic (Hubard, Orbanić, Pellicer, Weiss). In particular, we may describe the concept of chirality of lesser symmetry in terms of symmetry type graphs. The talk is based on a joint work in progress with several researchers, including Alen Orbanić, Maria del Rio Francos, and Deborah Oliveros. (Received August 07, 2010)

1062-05-184 **Sergei Chmutov*** (chmutov@math.ohio-state.edu), 1680 University Drive, Mansfield, OH 44906. *Partial duality of graphs on surfaces.*

Partial duality is a generalization of the natural, Euler–Poincaré, duality of graphs embedded into a surface to a duality with respect to a subset of edges. It may be considered as an action of the group $\mathbb{Z}_2^m$ on the surface graphs with m edges. Partially dual graphs are embedded into different surfaces. Many invariants of graphs on surfaces behave nicely under partial duality. In particular, the Bollobás-Riordan polynomials of partially dual ribbon graphs are simply related to each other. This relation generalizes the classical relation for the Tutte polynomial of dual plane graphs. Also the partial duality has an important application in topology of knots and links. (Received August 07, 2010)

1062-05-185 **David J Galvin*** (dgalvin1@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556. *Unimodality (and otherwise) of some graph theoretic sequences.*

Many natural graph theoretic sequences are unimodal. For example, Heilmann and Lieb showed that if G is any graph and $m_k(G)$ is the number of matchings in G of size k, then the sequence $\{m_k(G)\}_{k\geq 0}$ is unimodal. As another example, Chudnovsky and Seymour recently showed that if G is any claw-free graph and $i_k(G)$ is the number of independent sets in G of size k, then the sequence $\{i_k(G)\}_{k\geq 0}$ is unimodal.

On the other hand, there are examples of graphs for which the sequence $\{i_k(G)\}_{k\geq 0}$ is not unimodal. In fact, Alavi, Erdős, Malde and Schwenk showed that the sequence $\{i_k(G)\}_{k\geq 0}$ can be made to be as far from unimodal as one wishes. They conjectured, however, that if G is a tree then $\{i_k(G)\}_{k\geq 0}$ is unimodal, and more recently Levit and Mandrescu conjectured the unimodality of $\{i_k(G)\}_{k\geq 0}$ for any bipartite G.

Very little progress has been made on either of these conjectures. In this talk I'll discuss what is known. I'll pay particular attention to a special case (regular bipartite graphs) where a "partial unimodality" can be established. I'll also discuss progress in an even more special case (the discrete hypercube), where there really ought to be a combinatorial argument. (Received August 07, 2010)

1062-05-186 **Timothy DeVries*** (tdevries@math.upenn.edu), Department of Mathematics, University of Pennsylvania, 209 S. 33rd Street, Philadelphia, PA 19104-6395, and **Robin Pemantle** and **Joris van der Hoeven**. *Automatic Asymptotics in the Bivariate Rational Case.* Preliminary report.

We present an algorithm for producing asymptotic formulae for the coefficients of a wide class of bivariate rational generating functions F = P/Q.

Starting with Cauchy's integral formula for coefficient extraction, we discuss how to reduce to a residue integral along the singular variety where Q = 0. By a Morse-theoretic decomposition of the singular variety we construct an equivalent integral amenable to the techniques of saddle point analysis. The algorithm we present then captures the salient points of this singular set decomposition and automates the process of passing from Cauchy's formula to saddle point methods, which yield the desired asymptotic formulae. (Received August 07, 2010)

1062-05-191 **Rebecca Smith*** (rnsmith@brockport.edu), 350 New Campus Drive, Brockport, NY 14420, and **Vince Vatter**. *Sorting Permutations with stacks and pop stacks.*

We consider the problem of sorting permutations using combinations of stacks and pop stacks. A stack is a last in first out sorting machine. A pop stack works the same way as a stack with the added restriction that when

one entry is popped from the pop stack, then all entries in the pop stack must be popped. (Received August 08, 2010)

1062-05-195 **Mark Daniel Ward*** (mdw@purdue.edu), Purdue University, Department of Statistics, 150 North University Street, West Lafayette, IN 47907-2067. *Asymptotic Analysis of Generalized Bernoulli Numbers.* Preliminary report.

The asymptotic properties of the Bernoulli numbers are well-known; they can be calculated as a straightforward exercise in analytic combinatorics, using the exponential generating function $B(z)$ of the Bernoulli numbers. In the present paper, we establish the asymptotic properties of a broad generalization of the Bernoulli numbers, namely, the coefficients of $(B(z))^\alpha$, where α is *any* positive real number. Our methods are sufficiently robust to give an additive asymptotic expansion to *any* desired degree of accuracy. This analysis requires us to precisely characterize the oscillations that occur in the asymptotic expansions of these generalized Bernoulli numbers. In addition to the rigorous proofs of the asymptotic properties, we display the results of several computations that shed insight on the oscillations in the asymptotics of the generalized Bernoulli numbers. (Received August 08, 2010)

1062-05-197 **Edward Swartz*** (ebs22@cornell.edu), Mathematics Dept., Ithaca, NY 14853. *Topology and Combinatorics of linear quotients of spheres.*

Let G be a finite (or compact) group acting linearly on a unit sphere. The classification of such actions is usually well understood via the (real) representation theory of G. In sharp contrast, the topology of the corresponding quotient spaces is very poorly understood. We will survey a few results and questions in this subject of particular interest to the speaker. (Received August 08, 2010)

1062-05-198 **Marko Boben*** (marko.boben@fri.uni-lj.si), Trzaska 25, 1000 Ljubljana, Slovenia, **Stefko Miklavic** (stefko.miklavic@upr.si), Slovenia, and **Primoz Potocnik** (primoz.potocnik@fmf.uni-lj.si), Slovenia. *Rotary polygons in configurations.*

A polygon A in a configuration $\mathcal{C}$ is called rotary if $\mathcal{C}$ admits an automorphism which acts upon A as a one-step rotation. We study rotary polygons and their orbits under the group of automorphisms (and antimorphisms) of $\mathcal{C}$. We determine the number of such orbits for several symmetry types of rotary polygons in the case when $\mathcal{C}$ is flag-transitive. (Received August 08, 2010)

1062-05-201 **Russ Woodroofe*** (russw@math.wustl.edu), Department of Mathematics, Campus Box 1146, One Brookings Drive, St. Louis, MO 63130. *Chordal clutters and k-decomposability.*

I'll present an extension of the definition of chordal from graphs to clutters (hypergraphs). The resulting family of clutters is a common generalization of chordal graphs, circuit clutters of matroids, and "acyclic" clutters. The independence complex of a chordal clutter is shellable, yielding a large family of simplicial complexes with every induced subcomplex shellable.

In order to prove shellability we extend the definition of k-decomposable to non-pure complexes. As in the pure case, this yields a hierarchy of shellable simplicial complexes. (Received August 08, 2010)

1062-05-203 **Emanuele Delucchi*** (delucchi@math.binghamton.edu), Department of Mathematics, University of Bremen, 28359 Bremen, Germany, and **Laura Anderson** (laura@math.binghamton.edu), Department of Mathematics, Binghamton University, Binghamton, NY 13902-6000. *Complex Matroids.*

A substantial part of the richness of the theory of matroids and oriented matroids lies in the fact that they each can be axiomatized in a number of equivalent - or "cryptomorphic" - ways. In the last two decades some work has been devoted to the search for a combinatorial abstraction of linear dependency over the complex numbers as a parallel to the corresponding theories for general and real linear dependency, given respectively by matroid theory and oriented matroid theory. After a quick review of matroids and oriented matroids, we will present our attempt at a theory of "complex matroids" that shares much of the structural richness of oriented matroid theory. In particular, our theory has several cryptomorphic axiomatizations and a satisfactory notion of duality. Moreover, some of the subtleties arising in the development of this theory shed a new light on known aspects of matroid theory. (Received August 09, 2010)

1062-05-210 **Clark W Butler*** (butler.552@buckeyemail.osu.edu), Department of Mathematics - OSU, 100 Math Tower, 231 West 18th Avenue, Columbus, OH 43210. *Relation between the Relative Tutte and Bollobas-Riordan Polynomials.*

A relative plane graph is a planar graph with a distinguished subset of edges. There is a generalization of the Tutte polynomial to relative graphs. From a relative plane graph we demonstrate a construction of a graph

embedded into a surface which is equivalent to a ribbon graph. We also propose an inverse construction of a relative planar graph from a planar projection of a ribbon graph. We prove a relation between the Bollobás-Riordan polynomial of the ribbon graph and the Relative Tutte polynomial of the constructed planar graph under a natural variable specialization, generalizing the relation between the Bollobás-Riordan polynomial of a planar-embeddable ribbon graph and the Tutte polynomial of its underlying graph. This specialization leads to the Kauffman bracket polynomial of a virtual link diagram, as well as a duality relation of the Relative Tutte, which generalizes the celebrated duality relation of the Tutte polynomial. (Received August 09, 2010)

1062-05-211 **Jozef Širáň** (siran@lux.svf.stuba.sk), , Slovak Rep, and **Mark E. Watkins*** (mewatkin@syr.edu), Mathematics Department, 215 Carnegie, Syracuse University, Syracuse, NY 13244-1150. *Imprimitivity of Locally Finite, 1-Ended, Planar Graphs.*

Using results from group theory, we offer a concise proof of the imprimitivity of locally finite, 1-ended planar graphs, a result previously established by J .E. Graver and M. E. Watkins (2004) using graph-theoretical methods. (Received August 09, 2010)

1062-05-226 **Tomas J Boothby*** (tomas.boothby@gmail.com), 2551 Austin Ave, Coquitlam, BC V3K 3S2, Canada, and **Robert L Miller**. *Generation of Nonisomorphic Graph Embeddings.* Preliminary report.

This paper uses the ideas of canonical augmentation to generate nonisomorphic embeddings of graphs. We develop two augmentation schemes, one of which generates all nonisomorphic embeddings of all graphs on a fixed number of vertices, the other of which generates all nonisomorphic embeddings of a given graph. These methods have applications to problems such as computing the minimal and maximal genus of graphs, and have the benefit of building upon the general canonical augmentation framework developed by McKay. (Received August 09, 2010)

1062-05-229 **Emmanuel Briand** (ebriand@us.es) and **Rosa C Orellana*** (rosa.c.orellana@dartmouth.edu), Mathematics Department, 6188 Kemeny Hall, Hanover, NH 03755, and **Mercedes Rosas** (mrosas@us.es). *The Kronecker Product of Representations of the Symmetric Group.*

The Kronecker coefficients are the multiplicities obtained when we take the tensor product of two irreducible representations of the symmetric group. In this talk we will present recent results about the Kronecker coefficients obtained by studying a related family of coefficients: the *reduced Kronecker coeffcients*. The reduced Kronecker coefficients is a family of non-negative integers that until recently has been overlooked. In this talk we aim to introduce and present several results on the reduced Kronecker coefficients as well as to illustrate their applicability in the understanding of the Kronecker coefficients. In particular, we will present some results about the stability and complexity of the Kronecker coefficients.

Joint work with E. Briand and M. Rosas (Received August 09, 2010)

1062-05-253 **Patricia Hersh**, **John Shareshian*** (shareshi@math.wustl.edu) and **Russ Woodroofe**. *Subgroup lattices of finite solvable groups.*

I will discuss joint projects with Patricia Hersh and Russ Woodroofe. We obtain a lower bound for the connectivity of the order complex of a finite lattice (with top and bottom elements removed) in terms of the maximum length of a chain of modular elements in this lattice. We determine when this bound is tight. Using the ideas and results from this investigation, we find a new characterization of finite solvable groups that involves only the structure of their subgroup lattices: A finite group is solvable if and only if its subgroup lattice contains two chains of the same length, one maximal and the other consisting entirely of modular elements. We show also that if L is the subgroup lattice of a finite group G, then the bound mentioned above is tight if and only if G is solvable and every normal subgroup of G has a complement. (Received August 10, 2010)

1062-05-255 **Lowell Abrams**, Washington, DC , and **Daniel Slilaty***, Wright State University, Dayton, OH 45435. *Cellular automorphisms of the torus and Klein bottle.* Preliminary report.

A cellular automorphism of a graph G imbedded in surface S is an automorphism of the graph that takes facial boundary walks to facial boundary walks. In this talk we will discuss a list of cellular automorphisms of graphs in the torus and Klein bottle and how any cellular automorphism of a graph in one of these surfaces reduces to one in the list. We will also discuss some applications. (Received August 10, 2010)

1062-05-261 **James F. Davis*** (jfdavis@indiana.edu), Department of Mathematics, Indiana University, Bloomington, 47401. *Characteristic Classes of Matroid Bundles and Applications.*

Oriented matroids are a combinatorial incarnation of linear algebra. By considering oriented matroids parameterized by a poset, one is lead to the notion of a matroid bundle, which is a combinatorial incarnation of a vector bundle. In earlier work we proved the Combinatorialization Theorem, by which every vector bundle gives a matroid bundle, the Spherical Quasifibration Theorem which said that every matroid bundle gives a spherical quasifibration, and the Comparison Theorem which says that composite of the above two transformations coincides with the map that deletes the zero section of a vector bundle. Thereby we showed the matroid bundles have Stiefel-Whitney classes.

Stiefel-Whitney classes have application to intersection questions in convex geometry. In this talk we will review the theory of matroid bundles above and give applications to the existence of covectors, analogous to intersections of affine linear subspaces with convex sets. (Received August 11, 2010)

1062-05-265 **Robert Jajcay*** (robert.jajcay@indstate.edu), Dept of Math & CS, Indiana State University, Terre Haute, IN 47809. *Theory of Skew-Morphisms.*

The concept of a skew-morphism has been introduced in the 1990's during the speaker's visit to the Syracuse University. The existence of a skew-morphism is known to be equivalent to the regularity (i.e., regular action of the orientation preserving automorphism group in its action on the set of darts) of a Cayley map. Since their introduction, they also have been shown useful by a number of researchers in several different areas, and can also be seen as a purely group-theoretical concept related to cyclic extensions of groups.

In our talk, we survey the genaral properties of skew-morphisms of finite groups as well as some of their most important applications. (Received August 10, 2010)

1062-05-269 **Amir Barghi***, amir.barghi@dartmouth.edu, and **Peter Winkler**. *Firefighting on Random Geometric Graphs.* Preliminary report.

In the Firefighter Problem which was first introduced by Hartnell [1] in 1995, a fire starts at a vertex of a graph and in discrete time intervals spreads from burned vertices to their neighbors, unless they are protected by one of the f firefighters that are deployed every turn. Once protected, a vertex remains protected. We assume that the trees in a forest are randomly distributed with a fixed density and fire spreads from one tree to another if their distance is less than one. In this talk, we will discuss a technique from percolation that helps us prove that stopping the fire from spreading indefinitely, requires a linear relation between f and the density of the forest.

References

[1] B. L. Hartnell, *Firefighter! An Application of Domination*, presentation at the Twentieth Conference on Numerical Mathematics and Computing, University of Manitoba, 1995.

(Received August 10, 2010)

1062-05-280 **Gena Hahn*** (hahn@iro.umontreal.ca), IRO, Universite de Montreal, 2920 Chemin de la tour, Montreal, QC HT 1J8, Canada. *Constructing infinite vertex-transitive graphs.*

We describe a method for constructing a vertex-transitive graph from any infinite graph and relate this to other topics such as idempotence under various products. The talk is based on work with Bonato, Tardif and Woodrow. (Received August 11, 2010)

1062-05-281 **Aaron Robertson*** (arobertson@colgate.edu), **Francis Frey** and **Colin Twomey**. *Good For More Than Just Honey.*

We describe a new evolutionary algorithm based on the foraging behavior of honeybees and give some preliminary results on a standard suite of quadratic assignment problems. (Received August 11, 2010)

13 ► Commutative rings and algebras

1062-13-63 **Ragnar-Olaf Buchweitz*** (ragnar@utsc.utoronto.ca), Dept. of Computer & Mathematical Sciences, University of Toronto Scarborough, 1265 Military Trail, Toronto, Ontario M1E 1C4, Canada, and **Hubert Flenner**, Faculty of Mathematics, Ruhr-Universität Bochum, Germany. *Universal Annihilators.* Preliminary report.

Let R be a complete local noetherian ring of dimension d. What is the universal annihilator of $Ext_R^{d+1}(M,N)$ for finitely generated R–modules M, N?

If $d = 1$, a result of Wang (1994) shows this annihilator to contain the conductor ideal. In general, for R Gorenstein and containing a coefficient field, we show that this annihilator contains the annihilator of the

cokernel of a natural map from the d^{th} Hochschild homology of R to the ring, which in turn in the reduced case contains the annihilator of the cokernel of the characteristic class, the natural linear map from the module of differential forms $\Omega^d_{R/K}$ to the dualizing module $\omega_{R/K}$. This annihilator contains any Noether different and so also the Jacobian ideal thereby strengthening Wang's earlier results.

These results provide in particular a lower bound for the universal annihilator of the stable category of maximal Cohen-Macaulay modules over such a ring, a quantity of interest in string theory. (Received July 23, 2010)

1062-13-65 **Ri-Xiang Chen***, Department of Mathematics, Cornell University, Ithaca, NY 14853. *Minimal free resolutions of linear edge ideals.*

Froberg proved that an edge ideal has a linear free resolution if and only if the complement graph is chordal. In this talk, we will give a construction of these linear free resolutions. (Received July 23, 2010)

1062-13-74 **Winfried Bruns*** (wbruns@uos.de), Universität Osnabrück, Institiut für Msathematik, Albrechtstr. 28a, 49069 Osnabrück, Germany, **Christian Krattenthaler** (christian.krattenthaler@univie.ac.at), Universität Wien, Fakultät für Mathematik, Nordbergstrasze 15, 1090 Wien, Austria, and **Jan Uliczka** (Jan.Uliczka@web.de), Universität Osnabrück, Institiut für Msathematik, Albrechtstr. 28a, 49069 Osnabrück, Germany. *Hilbert depth of powers of the maximal ideal.*

The Hilbert depth of a module M is the maximum depth that occurs among all modules with the same Hilbert function as M. We discuss this notion and compute Hilbert depth for the powers of the irrelevant maximal ideal in a standard graded polynomial ring. (Received July 27, 2010)

1062-13-90 **Juan Migliore*** (migliore.1@nd.edu), Dept. of Mathematics, University of Notre Dame, Notre Dame, IN 46556, and **Rosa M. Miro-Roig** and **Uwe Nagel**. *The Weak Lefschetz Property for powers of linear forms.*

Let I be an artinian ideal generated by powers of general linear forms in a polynomial ring in r variables over a field k, which we will assume to have characteristic zero. Let L be a general linear form. The Weak Lefschetz Property (WLP) means that multiplication by L, from any component of R/I to the next, induces a homomorphism of finite dimensional vector spaces that has maximal rank. Schenck and Seceleanu showed that when $r = 3$, any such R/I has the WLP. We focus on the case of $r + 1$ forms, in several different settings, to determine when the WLP holds. It turns out to be far different from the $r = 3$ case. We give an almost complete answer for the case $r = 4$, and an analysis of the uniform and near-uniform case in more variables. Our approach is via the connection (thanks to Macaulay duality) to fat point ideals, and the analysis of these by several authors, together with a reduction to a smaller projective space. (Received July 28, 2010)

1062-13-95 **Gregory G Smith*** (ggsmith@mast.queensu.ca), Department of Mathematics & Statistics, Queen's University, Kingston, Ontario K7L 3N6, Canada, and **Mats Boij**, Department of Mathematics, Royal Institute of Technology (KTH), 100 44 Stockholm, Sweden. *Cones of Hilbert Functions.*

A well-known theorem of F.S. Macaulay characterizes the numerical functions that occur as the Hilbert function of a homogeneous $\Bbbk$-algebra. In this talk, we'll examine an alternative description for the collection of Hilbert functions. More precisely, we will describe the facets and extremal rays for the rational polyhedral cone generated by appropriate collections of Hilbert functions of modules over a standard graded polynomial ring. After contrasting this with Macaulay's result, we will also look at potential applications. (Received July 29, 2010)

1062-13-170 **Lars W. Christensen**, **David A. Jorgensen**, **Hamid Rahmati*** (hamid.rahmati@ttu.edu), **Janet Striuli** and **Roger Wiegand**. *Brauer-Thrall for totally reflexive modules.* Preliminary report.

Let $(R, \mathfrak{m}, k)$ be a commutative local ring. A finite R-module M is called totally reflexive if it is reflexive and $\operatorname{Ext}^i_R(M, R) = \operatorname{Ext}^i_R(M^*, R) = 0$ for all $i > 0$. Assume that R is not Gorenstein and that there are elements $w, x \in \mathfrak{m}$ such that $\operatorname{Ann}_R(x) = (w)$ and $\operatorname{Ann}_R(w) = (x)$. For every $n \in \mathbb{N}$, there exists an indecomposable totally reflexive module that is minimally generated by n elements. Moreover, if k is infinite then for every $n \in \mathbb{N}$, there are $|k|$ pairwise non-isomorphic indecomposable totally reflexive modules that are minimally generated by n elements. (Received August 06, 2010)

1062-13-189 **Emily E. Witt*** (emwitt@umich.edu), Dept of Mathematics, University of Michigan, 530 Church St, Ann Arbor, MI 48109. *Local cohomology with support in ideals of maximal minors.*

Suppose that k is a field and that $k[X]$ is a polynomial ring over k, where $X = [x_{ij}]$ is an $r \times s$ matrix of indeterminates. Let I be the ideal generated by the maximal minors of X. Interestingly, certain local cohomology modules $H^i_I(R)$ that have been found to vanish by Peskine and Szpiro when i is strictly larger than the height of I and k has positive characteristic have been found to be nonzero when k has characteristic zero by Hochster, Bruns, and Schwänzl. However, in the characteristic zero case, very few of these modules have been computed: the calculation has seemed difficult. Using results of Lyubeznik on D-modules, as well as the invariant theory of linearly reductive groups, we will determine the structure of these local cohomology modules in the characteristic zero case, including for which i they are nonzero, what their associated primes are, complete information for $i = rs - r^2 + 1$ (the top non-vanishing one), and substantial information about the nonzero $H^i_I(R)$ for other values of i. (Received August 08, 2010)

1062-13-212 **Gwyneth R Whieldon*** (whieldon@math.cornell.edu), Cornell University, Mathematics Department, 114 Malott Hall, Ithaca, NY 14850. *Resolutions of Nerves of Graphs.*

The nerve $\mathcal{N}(\Delta)$ of a simplicial complex Δ is a simplicial complex whose vertices correspond to facets of Δ and whose faces correspond to intersections of facets in Δ. We examine $\mathcal{N}(G)$, considering the graph as a simplicial complex, and identify structures and properties of the original graph G recognizable in the resolutions of the Stanley-Reisner ideal of $\mathcal{N}(G)$. Specifically, via the (multi)graded betti numbers of $I(\mathcal{N}(G))$, we enumerate all spanning trees of G, all maximal matchings of G, and numerous other features of our graph. Additionally, we produce new classes of edge ideals $I_{G'}$ with bounded regularity and other highly proscribed invariants. (Received August 09, 2010)

1062-13-217 **Andrew H Hoefel*** (andrew.hoefel@mathstat.dal.ca), Department of Mathematics and Statistics, Chase Building, Dalhousie University, Halifax, NS B3H 3J5, and **Jeff Mermin** (jeff.mermin@okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Gotzmann squarefree monomial ideals.*

Let $S = \Bbbk[x_1, \ldots, x_n]$ be the polynomial ring and $R = S/(x_1^2, \ldots, x_n^2)$ be the Kruskal-Katona ring. A homogeneous ideal $I \subset S$ (or R) is called Gotzmann if each graded component has the smallest possible Hilbert function given its number of generators. Gotzmann squarefree monomial ideals I of S can be classified using properties of IR. Though the problem of classifying Gotzmann monomial ideals of R seems more difficult, certain decomposition and reconstruction results can be given. Gotzmann ideals have a number of nice algebraic properties and Gotzmann monomial ideals of R arise in interesting combinatorial problems. (Received August 09, 2010)

1062-13-234 **Daniel Jesus Hernández*** (dhernan@umich.edu). *F-pure thresholds of hypersurfaces over fields of positive characteristic.*

To any polynomial over a perfect field of positive characteristic, one may associate an invariant called the F-pure threshold. This invariant, defined using the Frobenius morphism on the ambient ring, can be thought of as a positive characteristic analog of the well-known log canonical threshold in characteristic zero. In this talk, we will present some formulas for F-pure thresholds, and discuss the relationship between F-pure thresholds and log canonical thresholds. We also point out how these results are related to the longstanding open problem regarding the equivalence of F-pure type and log canonical singularities for hypersurfaces defined over the complex numbers. (Received August 10, 2010)

1062-13-244 **Harm Derksen*** (hderksen@umich.edu), Department of Mathematics, 530 Church St, Ann Arbor, MI 48109-1043, and **Gregor Kemper**. *Algorithms for Invariants of Unipotent Groups.*

There are various algorithms for finding generators of invariant rings of (linearly) reductive groups. For non-reductive groups, invariant rings may not even be finitely generated. Nagata proved that an invariant ring can be viewed as the ring of regular functions on a quasi-affine variety, even if the ring of invariants is not finitely generated. An algorithm will be presented for constructing such an affine variety if the group is a unipotent group and the ring on which it acts is a finitely generated factorial domain (for example, a polynomial ring). (Received August 10, 2010)

1062-13-247 **W. Frank Moore*** (frankmoore@math.cornell.edu), 310 Malott Hall, Cornell University, Ithaca, NY 14853-4201, **Sandra Spiroff** (spiroff@olemiss.edu), Department of Mathematics, University of Mississippi, University, MS 38677, and **Mark E. Walker** (mwalker5@math.unl.edu), Department of Mathematics, University of Nebraska - Lincoln, Lincoln, NE 68588. *On an invariant of graded isolated complete intersection singularities.* Preliminary report.

Let R be an isolated hypersurface singularity, and let M and N be finitely generated R-modules. As R is a hypersurface, the torsion modules of M against N are eventually periodic of period two (i.e., $\mathrm{Tor}_i^R(M,N) \cong \mathrm{Tor}_{i+2}^R(M,N)$ for $i \gg 0$). Since R has only an isolated singularity, these torsion modules are of finite length for $i \gg 0$. The theta invariant of the pair (M,N) is defined by Hochster to be $\ell(\mathrm{Tor}_{2i}^R(M,N)) - \ell(\mathrm{Tor}_{2i+1}^R(M,N))$ for $i \gg 0$. This pairing has been recently studied by Dao and Moore-Piepmeyer-Spiroff-Walker.

Dao also defined and studied a related pairing $\eta_c(M,N)$ for modules over an isolated complete intersection singularity of codimension c. In this work, we extend the methods used by Moore-Piepmeyer-Spiroff-Walker to study η_c, and show that in this case η_c is the zero pairing provided $c \geq 2$. We also discuss another pairing related to η_c defined in terms of the geometry of R. (Received August 10, 2010)

1062-13-278 **Mathias Lederer*** (mlederer@math.uni-bielefeld.de). *Components of Gröbner strata in the Hilbert scheme of points.*

We fix the lexicographic order on the polynomial ring $S = k[x_1, \ldots, x_n]$ over a ring k. We define the moduli space of ideals in S admitting a reduced Gröbner bases with a given finite standard set $\delta \subset \mathbb{N}^n$ such that the corresponding subscheme of $\mathbb{A}_k^n$ is étale over $\operatorname{Spec} k$. We determine the number of irreducible and connected components of that scheme in terms of a combinatiorial invariant of δ, thus proving a conjecture by Bernd Sturmfels. (Received August 10, 2010)

14 ► Algebraic geometry

1062-14-19 **Adrian Vasiu*** (adrian@math.binghamton.edu), Binghamton University, Department of Mathematical Sciences, P. O. Box 6000, Binghamton, NY 13902-6000. *Purity results in algebraic geometry in positive characteristic.*

This talk is a survey of recent purity concepts and results in algebraic geometry in positive characteristic. Open problems will be mentioned as well. (Received June 09, 2010)

1062-14-84 **Allen Knutson*** (allenk@math.cornell.edu). *Initial ideals of compatibly Frobenius split ideals.*

Let $f \in \mathbb{F}[x_1, \ldots, x_n]$ be degree n, with initial term $\mathit{init}\ f = \prod_{i=1}^n x_i$ (with respect to some term order). From the hypersurface $\{f = 0\}$, one can construct many other subschemes Y of affine space, by decomposing into irreducible components, intersecting those, and repeating this process.

Theorem.

(1) All of these intersections are reduced.

(2) If Y is one of (or even a union of) these varieties, then $\mathit{init}\ Y$ is a reduced union of coordinate subspaces.

(3) There is a natural decomposition of an $(n-1)$-simplex, with strata indexed by these $\{Y\}$, from which one can recover the poset thereof. If Y's closed stratum is a shellable ball, then Y is Cohen-Macaulay. If Y's open stratum is the interior of that ball, then Y is normal.

(4) For any reduced word for a Weyl group element v, there exists such an f for which the Ys encountered are the Kazhdan-Lusztig varieties $X_w \cap X_\circ^v$, and the conditions in part 3 hold. (This recovers the known result that Kazhdan-Lusztig varieties are normal and Cohen-Macaulay.)

The proof uses degenerations of Frobenius splittings. (Received July 27, 2010)

1062-14-159 **Kavita Sutar*** (sutar.k@husky.neu.edu), Department of Mathematics, Northeastern University, 360 Huntington Avenue, Boston, MA 02115. *Resolutions of defining ideals of orbit closures.*

The representation theory of quivers developed as a tool to understand the representations of finite-dimensional algebras. There is an interesting geometric aspect to representations of quivers which can be studied by applying tools from geometric invariant theory. The result is an intersection of flavors from representation theory, algebraic geometry, invariant theory and combinatorics.

For Dynkin quiver Q of finite representation type, we look at representation space of Q of fixed dimension vector (call it $Rep(Q,d)$), this is a vector space with an affine structure. There is a natural action of the group $Gl(d)$ whose corresponding orbit closures form an affine variety. For the class of orbit closures having a 1-step desingularization (as prescribed by Reineke), we find a resolution of the defining ideal of the orbit closures and give the minimal generators of this ideal . We classify the cases in which the coordinate ring is Gorenstein.

I will give a brief overview of the main tools used in above calculations and the results obtained so far. This is part of my thesis work under the supervision of my advisor, Prof. Jerzy Weyman. (Received August 05, 2010)

1062-14-167 **Aaron Abrams*** (abrams@mathcs.emory.edu), 400 Dowman Dr, Suite W401, Atlanta, GA 30322, and **Jamie Pommersheim**. *Area relations in triangulations of a square.*

Starting with a simplicial complex T that is homeomorphic to a 2-dimensional disk with four boundary points, we consider all ways to realize the complex in the plane such that the edges are straight line segments and the boundary is a square. We show that there is an irreducible polynomial, which depends on the combinatorics of T, that must be satisfied by the areas of the triangles. We present various results about the degree and the coefficients of this polynomial. (Received August 05, 2010)

1062-14-182 **Thomas S Bleier*** (tsbleier@syr.edu), 215 Carnegie, Syracuse University, Syracuse, NY 13244-1150. *The Hyperelliptic Locus in $\overline{\mathfrak{M}}_3$.*

Using a map of vector bundles, combined with the Thom-Porteous formula, Harris and Morrison are able to compute the class of the locus of hyperelliptic curves in $\mathrm{Pic}_{fun}(\mathfrak{M}_3)$. In this talk, we will look at how to extend this idea, using a technique due to Diaz for computing the class of the degeneracy locus of a map of coherent sheaves, combined with an Excess Porteous formula, in order to compute the class of the closure of the hyperelliptic locus in $\mathrm{Pic}_{fun}\overline{\mathfrak{M}}_3$. (Received August 07, 2010)

15 ► Linear and multilinear algebra; matrix theory

1062-15-161 **Bruce W Suter*** (bruce.suter@rl.af.mil), AFRL/RITB, 525 Brooks Road, Rome, NY 13441, and **Lixin Shen**. *Deblurring Images Contaminated with Spatially-Varying Noise.*

We will discuss a problem of image restoration using images that are contaminated by spatially varying noise. Existing methods for image restoration problem are based on minimizing an objective functional having the L1 fidelity term and the Mumford-Shah regularizer. We present a new algorithm on this problem by minimizing a new objective functional. The proposed functional has a content dependent fidelity term which assimilates the strength of fidelity terms measured by the L1 and L2 norms. The regularizer in the functional is formed by the L1 norm of tight framelet coefficients of the underlying image. We then present an iterative framelet based approximation/sparsity deblurring algorithm (IFASDA) for the proposed functional. Parameters in IFASDA are adaptively varying at each iteration and are determined automatically. In this sense, IFASDA is a parameter-free algorithm. This advantage makes the algorithm more attractive and practical. The effectiveness of IFASDA is experimentally illustrated on problems of image deblurring with Gaussian and impulse noise. Improvements in both PSNR and visual quality of IFASDA over a typical existing method are demonstrated. (Received August 05, 2010)

16 ► Associative rings and algebras

1062-16-4 **Andrei Zelevinsky*** (andrei@neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115. *Cluster algebras via quivers with potentials.*

Based on a joint work with H. Derksen and J. Weyman, we will discuss a representation-theoretic setup for cluster algebras in terms of quivers with potentials and their decorated representations. This setup allows us to prove most of the conjectures from the "Cluster algebras IV" paper (joint with S. Fomin) for cluster algebras associated with arbitrary quivers. (Received July 28, 2010)

1062-16-8 **Dieter Happel*** (happel@mathematik.tu-chemnitz.de), Fakultaet fuer Mathematik, Technische Universitaet Chemnitz, D-09107 Chemnitz, Germany. *Representation dimension of piecewise hereditary algebras.*

This is a report on joint work with Luise Unger.

Let Λ be a piecewise hereditary algebra over an algebraically closed field k. By definition there exists a hereditary abelian $k-$category $\mathcal{H}$ such that bounded derived categories $D^b(\Lambda)$ and $D^b(\mathcal{H})$ are equivalent as triangulated categories. The aim of this talk is to explain that the representation dimension rep.dim$\Lambda \leq 3$ fo a piecewise hereditary algebra Λ. We will first recall some necessary results on piecewise hereditary algebras and on the represntation dimension of an arbitrary finite dimensional $k-$algebra Λ. Then we will sketch the main ingredients of the result mentioned above. (Received May 13, 2010)

1062-16-52 **Akaki Tikaradze***, Department of mathematics, University of Toledo, 2801 W. Bancroft St., Toledo, OH 43606. *Irreducible representations of almost commutative algebras in positive characteristic.*

We will discuss Kac-Weisfeiler type statement for dimensions of irreducible representations of an almost commutative algebra in positive characteristic. It involves dimensions of symplectic leaves of the spectrum of the associated graded algebra. (Received July 20, 2010)

1062-16-121 **Frauke M Bleher*** (fbleher@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242-1419, **Ted Chinburg** (ted@math.upenn.edu), Department of Mathematics, University of Pennsylvania, Philadelphia, PA 19104-6395, and **Bart De Smit** (desmit@math.leidenuniv.nl), Mathematisch Instituut, Universiteit Leiden, 2300 RA Leiden, Netherlands. *Inverse problems for deformations of Galois representations.* Preliminary report.

We study the inverse problem for versal deformation rings of Galois representations which asks which complete local commutative Noetherian rings can arise as such versal deformation rings. We also study the inverse inverse problem which, given a versal deformation ring R, is to find all groups Γ and representations V of Γ such that R is the versal deformation ring of V. A main tool in our approach of these problems is to study extension groups Γ of finite groups G by abelian p-groups and to employ the spectral sequence which relates the cohomology of Γ to that of G. (Received August 03, 2010)

1062-16-140 **Markus Schmidmeier** and **Helene R. Tyler*** (helene.tyler@manhattan.edu), Department of Mathematics and Computer Scienc, Manhattan College, Riverdale, NY 10471. *Gabriel-Roiter families occurring in tubes.*

The Gabriel-Roiter measure was first introduced by Roiter in his 1968 proof of the first Brauer-Thrall conjecture. For a finite length module, the pair consisting of the GR-measure and the GR-comeasure defines the position of the module in the rhombic picture, as defined by Ringel. It turns out that modules in the same vicinity display similar behaviour with respect to Auslander-Reiten translation. In particular, the set of modules, which is given by intersecting a ray with a coray in a stable tube in the Auslander-Reiten quiver, corresponds to a limit point in the rhombic picture. We show that in the special case of quivers of type $\widetilde{\mathbb{A}_n}$ with suitable orientation, the system of limit points in the rhombic picture provides a tiling of the corresponding tube. (Received August 03, 2010)

1062-16-151 **Shiping Liu*** (shiping.liu@usherbrooke.ca), Département de mathématiques, Université de Sherbrooke, Sherbrooke, Quebec J1K 2R1, Canada. *Coverings of the derived categories of algebras.* Preliminary report.

This is a joint work with Raymundo Bautista. The theory of coverings of algebras is very useful in the study of representations of algebras. It is natural to ask if one can apply this theory to study the derived categories of a finite dimensional algebra. In this work, we are concerned with the problem as to when a Galois covering of finite dimensional algebras induces a Galois covering of their derived categories. Although the answer is probably negative in general, we shall provide an affirmative answer in a very special case. This result will be used in the future to study the derived categories of a finite dimensional with radical squared zero. (Received August 04, 2010)

1062-16-172 **Andrew Carroll** and **Jerzy Weyman*** (j.weyman@neu.edu), Department of Mathematics, Notheastern University, Boston, MA 02115. *Semi-invariants of string algebras.*

We will describe the rings of semi-invariants of string algebras of non-polynomial growth. Their structure is quite different from semi-invariants of extended Dynkin quivers. Apart from the usual description via Schofield semi-invariants for string algebras the representation spaces are often products of varieties of complexes. We exploit this feature to obtain explicit results. (Received August 06, 2010)

1062-16-204 **Ryan Kinser***, 196 Auditorium Rd, Unit 3009, Dept. of Mathematics, Storrs, CT 06226. *Representation rings of quivers.* Preliminary report.

We will discuss some recent work on the Clebsch-Gordan problem for quiver representations (i.e. determining tensor product multiplicities). (Received August 09, 2010)

1062-16-209 **Stephen Doty*** (doty@math.luc.edu), Department of Mathematics and Statistics, Loyola University Chicago, Chicago, IL 60626, and **Anthony Giaquinto** (tonyg@math.luc.edu), Department of Mathematics and Statistics, Loyola University Chicago, Chicago, IL 60626. *Constructing quantized enveloping algebras via finite dimensional algebras.* Preliminary report.

Certain finite dimensional algebras known as generalized q-Schur algebras ("Schur algebras" for short) may be defined by generators and relations found in previous work. Taking those generators and relations as a starting point, one can find cellular bases for the Schur algebras and thus prove their quasi-heredity directly. Furthermore, the Schur algebras fit together into an inverse system and one can locate the quantized enveloping algebras within the inverse limit. The framework also seems to produce the small quantum group in a natural way, when specialized at a root of unity. (Received August 09, 2010)

1062-16-220 **Ibrahim Assem**, Faculte des Sciences, Universite de Sherbrooke, 2500, boulevard de l'Universite, Sherbrooke, Quebec J1K 2R1, Canada, **Ralf Schiffler*** (schiffler@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269-3009, and **Vasilisa Shramchenko**, Faculte des Sciences, Universite de Sherbrooke, 2500, boulevard de l'Universite, Sherbrooke, Quebec J1K 2R1, Canada. *Cluster automorphisms.*

This talk is on a joint work with Assem and Shramchenko, in which we introduce and study cluster automorphisms of cluster algebras. These are automorphisms of the algebra which preserve the combinatorial cluster algebra structure. We compute the group of cluster automorphisms for Dynkin and Euclidean types using cluster categories and Riemann surfaces with marked points. (Received August 09, 2010)

1062-16-225 **Alex Dugas*** (adugas@pacific.edu), Stockton, CA 95204. *Periodic algebras arising as endomorphism rings.*

It is well-known that any maximal Cohen-Macaulay module over a hypersurface has a periodic free resolution of period 2. Auslander, Reiten and Buchweitz have used this periodicity to explain the existence of periodic projective resolutions for the finite-dimensional preprojective algebras of Dynkin type, which arise as stable endomorphism rings of Cohen-Macaulay modules. These algebras are in fact periodic, meaning that they have periodic projective resolutions as bimodules and thus periodic Hochschild cohomology as well. In this talk we give a generalization of this construction of periodic algebras in the context of Iyama's higher AR-theory. In particular, we study the endomorphism rings of periodic d-cluster tilting objects in triangulated categories. (Received August 09, 2010)

1062-16-237 **Grégoire Dupont** and **Hugh Thomas*** (hthomas@unb.ca). *A geometric interpretation of the transverse quiver Grassmannian.* Preliminary report.

The well-known Laurent phenomenon in cluster algebras states that an element g of the cluster algebra A can be expressed as a Laurent polynomial in the cluster variables of any cluster of A. If g can always be written as such a Laurent polynomial with *positive* coefficients, then g is called a "positive" element of A. A $\mathbb{Z}$-basis $\mathcal{B}$ of a cluster algebra A is called "canonically positive" if the positive elements of A are exactly the non-negative linear combinations of elements of $\mathcal{B}$. (These notions go back to Sherman-Zelevinsky, 2003.)

Based on the known examples of canonically positive bases due to Sherman-Zelevinsky and Cerulli, Dupont has conjectured a construction of the canonically positive basis in arbitrary finite and affine type, in terms of Euler characteristics of "transverse quiver Grassmannians". I will report on our attempts to improve the understanding of the conjecture, by interpreting the transverse quiver Grassmannian of submodules of a regular indecomposable M as the subvariety of the usual quiver Grassmannian consisting of modules which admit deformations locally (with respect to the $\mathbb{P}^1$ structure of the collection of tubes). (Received August 10, 2010)

1062-16-242 **Harm Derksen*** (hderksen@umich.edu), Department of Mathematics, 530 Church St, Ann Arbor, MI. *Representations of Algebras and the Graph Isomorphism Problem.*

For a given algebra R, it is relatively easy to determine whether two R-modules are isomorphic. The number of arithmetic operations in the base field needed is polynomial in n, where n is the dimension of the modules. Other isomorphism problems, such as the Graph Isomorphism are harder. It is not known whether two graphs can be tested for isomorphism in polynomial time. I will explain how the isomorphism problem for R-modules

can be used to obtain an algorithm for the Graph Isomorphism Problem which is more powerful then the higher dimensional Weisfeiler-Lehman algorithm. (Received August 10, 2010)

1062-16-246 **Thomas Brustle***, Bishop's University, and Universite de Sherbrooke, Sherbrooke, Quebec , Canada. *On the cluster category of a marked surface without punctures.*

We study the cluster category $C(S, M)$ of a marked surface (S, M) without punctures. We explicitly describe the objects in $C(S, M)$ as direct sums of homotopy classes of curves in (S, M) and one-parameter families related to non-contractible closed curves in (S, M). Moreover, we describe the Auslander-Reiten structure of the category $C(S, M)$ in geometric terms and show that the objects without self-extensions in $C(S, M)$ correspond to curves in (S, M) without selfintersections. As a consequence, we establish that every rigid indecomposable object is reachable from an initial triangulation. (Received August 10, 2010)

1062-16-248 **Gordana G Todorov*** (todorov@neu.edu), Northeastern University, 360 Huntington Avenue, Boston, MA 02115. *Trace subfunctors and modules over preprojective algebras.*

A motivation for this work came from the fact that there is a clear relation between finitely presented functors on the derived category of the cat- egory of modules over a hereditary algebra and modules over the associated preprojective algebra. The intention was to give yet another way of associating categories to the words in Coxeter groups. (Received August 10, 2010)

1062-16-274 **Daniel Labardini-Fragoso*** (labardini-fra.d@neu.edu), 360 Huntington Ave, Department of Mathematics, 567 Lake Hall, Boston, MA 02115. *Quivers with potentials and representations on triangulated surfaces.*

Every triangulation τ of a surface gives rise to a quiver with potential (QP) in a natural and explicit way. Furthermore, each arc on the surface gives rise to a representation of the QP associated to τ. In this talk we will present these constructions and discuss their behavior with respect to flips of triangulations and Derksen-Weyman-Zelevinsky's QP mutation. (Received August 10, 2010)

17 ► Nonassociative rings and algebras

1062-17-82 **Kailash C Misra*** (misra@math.ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695-8205. *Perfect Crystals for $U_q(G_2^{(1)})$.*

The crystals associated with integrable representations of quantum affine algebras provide an useful tool to study its combinatorics. To this end explicit realizations of crystals are essential. In 1990's it was shown that the crystal for an integrable highest weight representation of a quantum affine algebra can be realized as elements in the semi-infinite tensor product of a suitable perfect crystal. In this talk we will discuss a recently constructed coherent family of perfect crystals for the quantum affine algebra $U_q(G_2^{(1)})$. This is a joint work with M. Mohamad and M. Okado. (Received July 27, 2010)

1062-17-98 **Young Jo Kwak*** (kwaky@colorado.edu), 491 Geneva St, Aurora, CO 80010. *Automorphisms of some combinatorially defined Lie algebras over GF(2).*

We describe the automorphism group of an arbitrary member, $K(n)$, from an infinite family of Lie algebras defined over the two element field, $GF(2)$. The algebra $K(n)$ has a vector space basis consisting of the edges and vertices of the complete graph on n vertices, while the Lie bracket on $K(n)$ is defined to encode the incidence relation of the graph. The main result is that, when $n \neq 3$, the automorphism group of $K(n)$ is isomorphic to the group of affine transformations of n-dimensional space over $GF(2)$ which can be written in the form $d + Px$ with P orthogonal.

Also, we establish that the 14-dimensional simple Bi-Zassenhaus algebra $B(2, 1)$ is not isomorphic to the 14-dimensional simple algebra $G(4)$ discovered by Kaplansky, thereby answering a question of Jurman. (Received July 30, 2010)

1062-17-165 **Eric Sommers*** (esommers@math.umass.edu), Department of Mathematics and Statistics, University of Massachusetts, LGRT, Amherst, MA 01003. *Exterior powers of the reflection representation in Springer theory.*

We will discuss the structure of the W-invariants in $H^*(\mathcal{B}_e) \otimes \wedge^* V$, where $\mathcal{B}_e$ is the Springer fiber over the nilpotent element e in a simple Lie algebra $\mathfrak{g}$. Here, W is the Weyl group acting on the cohomology of the fiber via Springer theory and V is the reflection representation of W. This is closely related to a conjecture of Lehrer and Shoji when e is regular in a Levi subalgebra. This conjecture was proved by Henderson in types A, B, C.

We establish the Lehrer-Shoji conjecture in the remaining types (and discuss and prove an extension of the conjecture to all e). We will also discuss a connection to rational Cherednik algebras, which leads to a graded decomposition of the representation of W on L/tL, where L is the coroot lattice and t is a natural number prime to the Coxeter number h. (Received August 05, 2010)

1062-17-168 **Matthew Ondrus*** (mattondrus@weber.edu), Mathematics Department, Weber State University, 1702 University Circle, Ogden, UT 84408. *Modules for the Virasoro algebra that are locally finite over certain subalgebras.*

Whittaker modules have been well-studied in the context of complex semisimple finite-dimensional Lie algebras and more recently in several other settings including the Virasoro algebra. In the semisimple finite-dimensional case, several authors have studied a category of modules that includes both Whittaker modules and weight modules. In this talk, I will discuss ongoing work with E. Wiesner aimed at understanding an analogous category for the Virasoro algebra. I will describe some of the main results known thus far as well as how these results relate to various classical and recent results. (Received August 06, 2010)

1062-17-205 **Dimitar Grantcharov*** (grandim@uta.edu), Department of Mathematics, UT Arlington, Arlington, TX 76019, and **Ji Hye Jung**, **Seok-Jin Kang**, **Masaki Kashiwara** and **Myungho Kim**. *Highest weight modules and crystal bases for quantum queer superalgebras.*

The Lie superalgebra $q(n)$ is the second super-analogue of the general Lie algebra $gl(n)$. Due to its complicated structure, $q(n)$ is usually called "the queer superalgebra". In this talk we will discuss the structure of highest weight modules over the quantum queer superalgebra $U_q(q(n))$. We will also explain how to develop crystal basis theory for $U_q(q(n))$. (Received August 09, 2010)

1062-17-214 **Bojko Bakalov*** (bojko_bakalov@ncsu.edu), **Alessandro D'Andrea** and **Victor G. Kac**. *Irreducible representations of finite simple Lie pseudoalgebras.*

One of the algebraic structures that has emerged recently in the study of the operator product expansions in conformal field theory is that of a Lie pseudoalgebra. The finite simple Lie pseudoalgebras were classified in our previous work. We have shown that any finite irreducible module over a simple Lie pseudoalgebra of type W or S is either an irreducible tensor module or the kernel of the differential in a member of the pseudo de Rham complex. We now establish a similar result for Lie pseudoalgebras of type K, with the pseudo de Rham complex replaced by a certain contact reduction, which in the context of contact geometry was discovered by Rumin. (Received August 09, 2010)

1062-17-222 **Apoorva Khare*** (apoorva.khare@yale.edu), Department of Mathematics, Yale University, PO Box 208283, New Haven, CT 06520, and **Vyjayanthi Chari** and **Tim Ridenour**. *Faces of polytopes and Koszul algebras.* Preliminary report.

Given a complex semisimple Lie algebra $\mathfrak{g}$ and a finite-dimensional $\mathfrak{g}$-module V, we study the category $\mathcal{G}$ of finite-dimensional graded $\mathfrak{g} \ltimes V$-modules. Using a larger category, we are able to explicitly write down a projective resolution of each simple object of $\mathcal{G}$, and also compute all Ext's between any two simple modules.

For each face of the polytope spanned by the weights of V, we define a partial order on the set of simple objects in $\mathcal{G}$. For each interval, the corresponding truncated subcategory of $\mathcal{G}$ is equivalent to modules over an algebra that is basic, quasi-hereditary, and Koszul. (Received August 09, 2010)

1062-17-233 **Alex J Feingold*** (alex@math.binghamton.edu), Dept of Math Sci, Binghamton University, Vestal Parkway East, Binghamton, NY 13902-6000, and **Elizabeth G Jurisich** (jurisiche@cofc.edu), Department of Mathematics, The College of Charleston, Charleston, SC 29424. *Decomposition of a rank 2 hyperbolic Kac-Moody Lie algebra with respect to the Nicolai-Olive principal $so(1,2)$ subalgebra.* Preliminary report.

Let $H(3)$ be the rank 2 hyperbolic Kac-Moody Lie algebra with Cartan matrix $\begin{bmatrix} 2 & -3 \\ -3 & 2 \end{bmatrix}$. The Nicolai-Olive principal $so(1,2)$ subalgebra S is isomorphic to sl_2 with basis $\{J_+, J_-, J_3\}$ and brackets $[J_+, J_-] = -J_3$ and $[J_3, J_\pm] = \pm J_\pm$. We study the decomposition of $H(3)$ with respect to S, into a direct sum of irreducible S-modules. This decomposition is of the form $S \oplus V(\infty) \oplus \bigoplus_{k=3}^{\infty} m_k(V(k) \oplus V(-k))$ where $V(\infty)$ is infinite-dimensional having one-dimensional weight spaces for each weight $n \in \mathbb{Z}$. The other summands in the decomposition are either highest weight S-modules, $V(-k)$ with highest weight $-k$, or lowest weight S-modules, $V(k)$, with lowest weight k. The multiplicities, m_k, with which these occur, are the dimensions of the spaces of extremal vectors in these modules. Since the bracket of any two extremal vectors of positive weight is another one, these form a Lie subalgebra whose structure determines the subalgebra $\bigoplus_{k=3}^{\infty} m_k V(k)$. We believe this is a free

Lie algebra, with c_k free generators of weight k, and that the entire structure of the hyperbolic algebra reduces to knowing the sequence c_k, $k \geq 3$. (Received August 09, 2010)

18 ► Category theory; homological algebra

1062-18-258 **Randall E Cone*** (conere10@vmi.edu), Virginia Military Institute, Mallory Hall, Lexington, VA 24450. *Finite Generation of Ext-Algebras for Monomial Algebras.*

The use of graphs in algebraic studies is ubiquitous, whether the graphs be finite or infinite, directed or undirected. Green and Zacharia characterized finite generation of the cohomology rings of monomial algebras, and thereafter G. Davis determined a finite criteria for such generation in the case of cycle algebras. We describe the construction of a finite directed graph upon which criteria can be established to determine finite generation of the cohomology ring of "in-spoked cycle" algebras, a class of algebras that includes cycle algebras. (Received August 10, 2010)

20 ► Group theory and generalizations

1062-20-13 **Brian D Boe*** (brian@math.uga.edu), Math Department, University of Georgia, Athens, GA 30602, and **University of Georgia VIGRE Algebra Group**. *First Cohomology for Finite Groups of Lie Type: Simple Modules with Small Dominant Weights.* Preliminary report.

We study the cohomology group $\mathrm{H}^1(G(\mathbb{F}_p), L(\lambda))$ when λ is less than or equal to a fundamental dominant weight. We provide a complete description in types E_7 and E_8 when $p > 7$; in type G_2 when $p > 5$; and in all other types when $p > 3$. In particular we show that, under these restrictions, this cohomology group is at most one-dimensional, and is usually zero. Our work extends the 1975–6 results of Cline-Parshall-Scott, Jones, and Jones-Parshall, who considered the special case when λ is a minimal nonzero dominant weight; in that case, our work provides a different proof of their earlier results. (Received May 28, 2010)

1062-20-49 **Jane Gilman*** (gilman@nsf.gov), Mathematics Department, Smith Hall, Rutgers University, Newark, NJ 07079. *The Non-Euclidean Euclidean Algorithm.* Preliminary report.

Let G be a non-elementary two generator subgroup of $PSL(2, \mathbb{R})$. The discreteness algorithm determines whether or not G is discrete. It has both a geometric and an algebraic formulation. We re-interpret the algorithm as a type of *Euclidean Algorithm* using non-Euclidean distances given by translation lengths. The geometric discreteness algorithm thus becomes a *non-Euclidean Euclidean algorithm*. We show that this formulation of the algorithm simplifies the Gilman-Jiang proof of polynomial time complexity. (Received July 19, 2010)

1062-20-59 **Martin R. Bridson** and **Karen Vogtmann*** (vogtmann@math.cornell.edu), Department of Mathematics, Cornell University, 503 Malott Hall, Ithaca, NY 14853-4201. *Homomorphisms from Out(F_n) to Out(F_m).*

Every finite subgroup of the group $\mathrm{Out}(F_m)$ of outer automorphisms of a free group can be realized as a group of automorphisms of a finite connected graph with Euler characteristic $1-m$. This fact is useful for determining whether there are any interesting homomorphisms from $\mathrm{Out}(F_n)$ to $\mathrm{Out}(F_m)$ for $m \neq n$. If $m < 2n-1$ it turns out that every such homomorphism has image of order at most 2; the proof of this involves analyzing exactly which graphs with Euler characteristic $1-m$ can realize rank n symmetric and hyperoctahedral groups. (Received July 22, 2010)

1062-20-97 **Jon McCammond*** (jon.mccammond@math.ucsb.edu), Department of Mathematics, UC Santa Barbara, Santa Barbara, CA 93106. *Hyperbolic Coxeter groups and their finite simple cousins.* Preliminary report.

This talk will be a survey of the wide variety of Coxeter groups whose standard bilinear form (i.e. the one used in the Tits' representation) has only a single negative eigenvalue. Since all of these groups act faithfully on hyperbolic space, it makes sense to call them "hyperbolic Coxeter groups" despite the fact that this action is typically neither cocompact nor cofinite volume. One of the main things that I wish to highlight is the various ways in which these hyperbolic Coxeter groups are related to the finite sporadic simple groups. (Received July 29, 2010)

1062-20-99 **Jinkui Wan** and **Weiqiang Wang*** (ww9c@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22904. *Beyond Steinberg module multiplicity of the symmetric algebra over $GL_n(q)$.*

We establish explicit closed formulas for the composition multiplicities of a class of simple GLn(q)-modules ("around" the Steinberg module) in the symmetric algebra of the natural module. This is joint work with Jinkui Wan. (Received July 30, 2010)

1062-20-120 **Brian Parshall***, Department of Mathematics, University of Virginia, Charlottesville, VA 22903. *Filtering Weyl modules.* Preliminary report.

In this talk, I will discuss some recent joint work with Leonard Scott concerning filtrations of Weyl modules. The Weyl modules in question are either Weyl modules for semisimple, simply connected algebraic groups in positive characteristic or they are Weyl modules for quantum groups at roots of unity. In each case, the sections are completely reducible and the multiplicities of the irreducible constituents are calculated. Some applications are indicated, e.g., to q-Schur algebras and Hecke algebras. (Received August 02, 2010)

1062-20-126 **David A Nash*** (dnash@uoregon.edu), Le Moyne College, Mathematics Department, 1419 Salt Springs Road, Syracuse, NY 13214, and **Alexander S Kleshchev** (klesh@uoregon.edu), University of Oregon, Department of Mathematics, Eugene, OR. *On Graded Characters and Graded Decomposition Numbers Over Hecke Algebras and Symmetric Groups.*

We describe the graded representation theory of the Iwahori-Hecke algebra H_d of the symmetric group and suggest a new algorithm for calculating the graded decomposition numbers of H_d over a field of characteristic zero at a root of unity. (Received August 03, 2010)

1062-20-130 **Christopher M. Drupieski**, **Daniel K. Nakano*** (nakano@math.uga.edu) and **Nham V. Ngo**. *Cohomology for infinitesimal unipotent algebraic and quantum groups.*

In this talk we will study the structure of cohomology spaces for the Frobenius kernels of unipotent and parabolic algebraic group schemes and of their quantum analogs. Given a simple algebraic group G, a parabolic subgroup P_J, and its unipotent radical U_J, we determine the ring structure of the cohomology ring $\mathrm{H}^\bullet((U_J)_1, k)$. We also obtain new results on computing $\mathrm{H}^\bullet((P_J)_1, L(\lambda))$ as an L_J-module where $L(\lambda)$ is a simple G-module with high weight λ in the closure of the bottom p-alcove. Finally, we provide generalizations of all our results to the quantum situation. (Received August 03, 2010)

1062-20-153 **Rishi Nath*** (Rnath@york.cuny.edu), Department of Mathematics, York College: City University of New York, 94-20 Guy R. Brewer Blvd, Jamaica, NY 11451. *Combinatorics arising from the Navarro-Willems conjecture.*

Let p and q be distinct primes, G a finite group, and consider a p-block B_p and a q-block B_q (of G). In 1997, G. Navarro and W. Willems conjectured the following: If $Irr(B_p) = Irr(B_q)$ then B_p consists of a single character. Recently C. Bessenrodt showed that the 6-fold covering group of A_7 provides a counterexample when $p = 5$ and $q = 7$. This has not diminished the interest in the conjecture, which is true in a number of important cases.

In 2007, J. Olsson and D. Stanton proved that the conjecture holds for the symmetric groups. Their approach involves studying simultaneous p and q core partitions (related to the work of J. Anderson). Subsequent research in this area has taken on many directions; B. Ford, L. Sze et all are studying the conjecture for the alternating groups, others have begun investigation properties of simultaneous cores and bar-cores, and recently M. Fayers found a connection with an action of the affine symmetric group. In this talk we survey this area, generalize some results, and discuss new directions and open questions. (Received August 04, 2010)

1062-20-221 **Harald Ellers*** (hellers@allegheny.edu), Dept. of Mathematics, Allegheny College, 520 North Main St., Meadville, PA , and **John Murray**, National University of Ireland, Maynooth, Ireland. *Representation theory of centralizer algebras, and degenerate affine Hecke algebras.* Preliminary report.

Let (R, K, k) be a p-modular system with k algebraically closed, and let S_n be the symmetric group of degree n. If $l < n$, identify S_l with a subgroup of S_n. The authors are engaged in a project whose long-term goal is to understand the representation theory of the centralizer algebra $RS_n^{S_l} = \{a \in RS_n \mid ab = ba \text{ for all } b \in RS_l\}$. We would like to find the simple $kS_n^{S_l}$ modules and the blocks of $kS_n^{S_l}$. We would also like to find the decomposition matrices for the algebra $RS_n^{S_l}$, but this is a very difficult problem in general. The degenerate affine Hecke algebra $\mathcal{H}_{n-l}^k$ plays an important role. When $n - l$ is small enough that the formal characters of $\mathcal{H}_{n-l}^k$ are known, then all the problems can solved. We will discuss recent progress. (Received August 09, 2010)

1062-20-230 **Herman Servatius*** (hservat@wpi.edu), mathematical sciences, Worcester Polytechnic Institute, worcester, MA 016092280, and **Mary Servatius** (mary.servatius@upr.si), Mathematics, University of Primorska, Koper-Capodistria, Slovenia. *Recent progress in right angled Artin groups.*

A right angled Artin group is a finitely presented group whose only relations are that certain pairs of the generators commute. As Artin groups, these groups have geometric interest, with connections to hyperplane arrangements and mapping class groups. The groups are also of natural interest in combinatorial group theory, interpolating between free groups and free abelian groups. In this talk we discuss recent work and open problems on this class of groups. (Received August 09, 2010)

1062-20-243 **Daniel J. Kelleher*** (kelleher@math.uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269, **Benjamin A. Steinhurst**, Department of Mathematics, Cornell University, Ithaca, NY 14853, and **Chuen-Ming M. Wong** (chuenw@princeton.edu), Department of Mathematics, Princeton University, Princeton, NJ 08544. *From self-similar structures to self-similar groups.*

We explore the relationship between limit spaces of contracting self-similar groups and fractals. Exact conditions on a group are given under which its limit space has a self-similar structure and a p.c.f. self-similar structure. We explore which self-similar structures can be realized as limit spaces; this includes some non-p.c.f. structures. In particular we give a construction which produces, for a suitable class of p.c.f. fractal, a self-similar group which has a given fractal as its limit space. Examples illustrating our results are included (Received August 10, 2010)

22 ► Topological groups, Lie groups

1062-22-21 **Ellen J Goldstein*** (ellen.goldstein@tufts.edu), Mathematics Department, 503 Boston Ave., Medford, MA 02155. *Normality of Closures of Conjugacy Classes in Classical Groups.* Preliminary report.

Given a linear algebraic group G over the algebraically closed field K of arbitrary characteristic, let $\mathfrak{g}$ be its Lie algebra. The Zariski closure of the adjoint orbit $\overline{Gx}$ for $x \in \mathfrak{g}$ is a subvariety of $\mathfrak{g}$. If $G = \mathrm{GL}(V)$ for V a finite dimensional vector space over K, then $\overline{Gx}$ is a normal variety for all $x \in \mathfrak{g} = M_n(K)$ (Kraft-Procesi, Donkin). If $G = O(V)$ or $Sp(V)$, Kraft and Procesi proved that $\overline{Gx}$ is normal for certain $x \in \mathfrak{o}(V)$ or $\mathfrak{sp}(V)$ in the case where $\mathrm{char}(K) = 0$. Following Donkin's proof for the general linear case in arbitrary characteristic, we show for certain nilpotent $x \in \mathfrak{g}$ that $\overline{Gx}$ is normal when $\mathrm{char}(K) \neq 2$. The proof makes use of properties of modules admitting a good filtration as a substitute for the lack of complete reducibility in prime characteristic. (Received June 12, 2010)

1062-22-56 **Ara Basmajian** and **Bernard Maskit*** (bernie@math.sunysb.edu). *Linking hyperbolic isometries through involutions.*

Two orientation-preserving isometries, A and B, of hyperbolic n-space are *linked* if there are three involutions, α, β and γ, so that $A = \alpha\beta$ and $B = \beta\gamma$. It is well known that for $n = 2, 3$, every pair of non-elementary isometries is linked. If $n = 2$, the involutions reverse orientation, while if $n = 3$, they preserve orientation. For $n \geq 4$, we show that the generic pair of isometries cannot be linked. The proof involves the geometry of pairs and triples of 2-dimensional subspaces in $\mathbb{R}^n$, $n \geq 4$. (Received July 24, 2010)

26 ► Real functions

1062-26-174 **Armen Vagharshakyan*** (armenv@math.gatech.edu). *Recovering Singular Integrals from Haar Shifts.*

We recover one-dimensional Calderon-Zygmund convolution operators with sufficiently smooth kernels by means of a properly chosen averaging of certain dyadic shift operators. This extends the result of S. Petermichl on restoring the Hilbert transform via dyadic shift operators. As a corollary, a sharp A_2 inequality for the corresponding Calderon-Zygmund operators is derived from a corresponding inequality for dyadic shift operators. (Received August 06, 2010)

28 ► Measure and integration

1062-28-24 **John A. Rock*** (jrock@csustan.edu), **Michel L. Lapidus** (lapidus@math.ucr.edu), **Kate E. Ellis** (kellis1@csustan.edu) and **Michael C. Mackenzie** (michael.mackenzie@uconn.edu). *Partition zeta functions, multifractal spectra, and tapestries of complex dimensions.*

For a Borel measure and a sequence of partitions, we define a multifractal spectrum based on coarse Holder regularity. Specifically, the coarse Holder regularity values attained by a given measure and with respect to a sequence of partitions generate a sequence of lengths which in turn define certain Dirichlet series called the partition zeta functions. The abscissae of convergence of these functions define a multifractal spectrum whose concave envelope is the (geometric) Hausdorff multifractal spectrum which follow from a certain type of Moran construction. Moreover, our multifractal spectrum is shown to extend to a tapestry of complex dimensions for two specific atomic measures. (Received June 18, 2010)

1062-28-47 **Jun Kigami*** (kigami@i.kyoto-u.ac.jp), Graduate School of Informatics, Kyoto University, Kyoto, Kyoto 606-8501, Japan. *Quaiconformal modification of metrics on self-similar sets.*

Using tne notion of scales and their gauge functions, we give a necessary and sufficient condition for metrics on self-similar sets being quasiconformal to each other. As an application, the conformal dimension of the Sierpinski carpet is no greater than $\log \frac{9+\sqrt{41}}{2} / \log 3$, which is strictly less than the Hausdorff dimension of the Sierpinski carpet, $\log 8 / \log 3$. (Received July 19, 2010)

1062-28-116 **Jonas Azzam** and **Raanan Schul***, schul@math.sunysb.edu. *Taking shortcuts in Euclidean space.*

For a given connected set Γ in $d-$dimensional Euclidean space, we construct a connected set $\tilde{\Gamma} \supset \Gamma$ such that the two sets have comparable Hausdorff length, and the set $\tilde{\Gamma}$ has the property that it is quasiconvex, i.e. any two points x and y in $\tilde{\Gamma}$ can be connected via a path, all of which is in $\tilde{\Gamma}$, which has length bounded by a fixed constant multiple of the Euclidean distance between x and y. Thus, for any set K in $d-$dimensional Euclidean space we have a set $\tilde{\Gamma}$ as above such that $\tilde{\Gamma}$ has comparable Hausdorff length to a shortest connected set containing K. Constants appearing here depend only on the ambient dimension d. In the case where Γ is "nice", our constants are also independent the dimension d, and in this case, our theorem holds for Γ in an infinite dimensional Hilbert space. This is joint work with Jonas Azzam (Received August 02, 2010)

1062-28-135 **Anna Levina*** (alevina@kent.edu), 19178 Ridgeview Trail, Chagrin Falls, OH 44023, and **S. Robert Strichartz**. *Mean Value Properties of Harmonic Functions on the Sierpinski Gasket.* Preliminary report.

Harmonic functions on domains in Euclidean space have the following mean value property: the value at the center of a ball is equal to the mean value of the function on the ball. Also, for functions in the domain of the Laplacian, we can obtain the Laplacian at a point as the limit of the difference between the mean value on the ball of radius r and the value at the point, appropriately renormalized, as r goes to zero. We find analogous results on the Sierpinski gasket (SG) where for each point $z \in SG$ we seek a sequence of geometrically simple sets B_k converging to z with the above properties. For junction points the result is easy. We give a nonconstructive proof of the existence of such sets (intersections of SG with triangles) in the case of strictly generic points (where the address contains all digits infinitely often), and discuss an algorithm to find the sets. (Received August 03, 2010)

1062-28-154 **John Fun-Choi Chan** and **Sze-Man Ngai*** (smngai@georgiasouthern.edu), Department of Mathematical Sciences, Georgia Southern University, Statesboro, GA 30460-8093, and **Alexander Teplyaev** (alexander.teplyaev@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269-3009. *One-dimensional wave equations defined by fractal Laplacians.*

We study one-dimensional wave equations defined by a class of fractal Laplacians. These Laplacians are defined by fractal measures generated by iterated function systems with overlaps. We prove the existence and uniqueness of weak solutions. We also study numerical computations of the solutions and prove the convergence of the approximation scheme. This is a joint work with John F. Chan and Alexander Teplyaev. (Received August 04, 2010)

1062-28-164 **John M Mackay** and **Jeremy T Tyson*** (tyson@math.uiuc.edu), Department of Mathematics, University of Illinois, 1409 West Green St, Urbana, IL 61801, and **Kevin Wildrick**. *Modulus and Poincaré inequalities on non-self-similar Sierpiński carpets.*

Metric spaces equipped with a doubling measure which support a Poincaré inequality are ideal environments for first-order analysis and differential geometry. We extend the scope of this theory by verifying Poincaré inequalities for a new class of spaces. We characterize non-self-similar Sierpiński carpets in the plane which support curve families of nontrivial modulus and which support Poincaré inequalities, when equipped with Lebesgue measure. The answer is given in terms of certain precise summability conditions on the sequence of scales of the omitted squares. Our results yield new examples of compact doubling metric measure spaces which support Poincaré inequalities: these examples have no manifold points yet embed isometrically in Euclidean space. (Received August 05, 2010)

1062-28-183 **Kate E Ellis*** (kellis1@csustan.edu). *The Counting Functions for an Atomic Measure.*

It has been shown that the geometric counting function of a fractal string can be expressed in terms of a sum over its complex dimensions. For this talk, we will be working with an atomic measure supported on the boundary of the Cantor string. We will develop and analyze the geometric counting function of this fractal string. We will also discuss regularity, partition zeta functions, and complex dimensions as they pertain to our example. (Received August 07, 2010)

1062-28-215 **John M Mackay*** (jmmackay@illinois.edu), 1409 W. Green Street, Urbana, IL 61801. *The Assouad dimension of self-affine carpets.*

We calculate the Assouad dimension of the self-affine carpets of Bedford and McMullen. We also calculate the conformal Assouad dimension of those carpets that are not self-similar. (Received August 09, 2010)

1062-28-240 **Jasun Gong***, Department of Mathematics, 301 Thackeray Hall, University of Pittsburgh, Pittsburgh, PA 15260. *Sobolev Imbeddings and Higher-Order Extensions.* Preliminary report.

This is joint work with P. Hajłasz, P. Koskela, and X. Zhong.

Let $p > n$. Suppose that a domain Ω in $\mathbf{R}^n$ has the *$W^{1,p}$-extension property*; that is, there is a bounded linear operator

$$E : W^{1,p}(\Omega) \to W^{1,p}(\mathbf{R}^n)$$

so that $Ef|_\Omega = f$. It is clear that such domains satisfy the Sobolev imbedding theorem

$$|u(x) - u(y)| \le C\|\nabla u\|_p |x - y|^{1-n/p}.$$

Here we are interested in the converse direction, namely

Theorem. Let Ω be a domain in $\mathbf{R}^n$ and let $p > n$. The following are equivalent:

(1) Ω satisfies the Sobolev imbedding theorem;
(2) Ω has the $W^{1,q}$-extension property, for each $q \ge p$;
(3) For each $m \in \mathbf{N}$, Ω has the $W^{m,q}$-extension property, for each $q \ge p$; that is, there exists a bounded linear operator $E_m : W^{m,p}(\Omega) \to W^{m,p}(\mathbf{R}^n)$ so that $E_m f|_\Omega = f$.

If time permits, we will also discuss the borderline cases $p = \infty$ and $p = n$. In the first case, our main result recovers a classical theorem of H. Whitney. (Received August 10, 2010)

30 ► Functions of a complex variable

1062-30-14 **Sergiy Merenkov*** (merenkov@illinois.edu), 1409 W Green St, Urbana, IL 61801, and **Kevin Wildrick**. *Quasisymmetric uniformization of Ahlfors regular surfaces.*

I will discuss quasisymmetric uniformization of metric surfaces by circle domains in the sphere. (Received May 31, 2010)

1062-30-16 **Ara Basmajian*** (abasmajian@gc.cuny.edu), math. dept., 365 5th ave., NY, NY 10016-4309. *Universal length bounds for non-simple closed geodesics.* Preliminary report.

We investigate the relationship, in various contexts, between a closed geodesic with self-intersection number k (for brevity, called a k-geodesic) and its length. We show that for a fixed compact hyperbolic surface, the short k-geodesics grow like the square root of k. On the other hand, if the fixed hyperbolic surface has a cusp and is not the punctured disc, then the short k-geodesics grow logarithmically.

The length of a k-geodesic on any hyperbolic surface is known to be bounded from below by a constant that goes to infinity with k. In this paper, we show that the optimal constants $\{M_k\}$ grow like $\log k$. Moreover, we

show that for each natural number k, there exists a hyperbolic surface where the constant M_k is realized as the length of a k-geodesic. This was previously known for $k = 1$, where the figure eight on the thrice punctured sphere is the shortest non-simple closed geodesic. (Received June 03, 2010)

1062-30-23 **David Radnell** (dradnell@aus.edu), Department of Mathematics, American University of Sharjah, P.O. Box 26666, Sharjah, United Arab Emirates, and **Eric Schippers*** (eric_schippers@umanitoba.ca), Department of Mathematics, 342 Machray Hall, 186 Dysart Rd, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada. *A fiber structure on the Teichmuller space of a bordered Riemann surface.*

One of the central objects in two-dimensional conformal field theory is the "rigged moduli space" of Riemann surfaces with parametrized boundary curves. The "sewing operation" joins two parametrized Riemann surfaces along two boundaries, identifying points using the parametrizations. In joint work with David Radnell, we showed that the rigged moduli space of Riemann surfaces of a given type is a quotient of the Teichmuller space of bordered surfaces of the same type.

In this talk, I will give applications of this correspondence to Teichmuller theory. In further joint work, David Radnell and I constructed coordinates on the infinite-dimensional Teichmuller space of a Riemann surface with boundary. These coordinates arise from a fiber structure of Teichmuller space. This fiber structure arises naturally from an alternate model of the rigged moduli space in terms of non-overlapping mappings into the Riemann surface, combined with our earlier work described above. Another tool is Gardiner's construction of coordinates on finite-dimensional Teichmuller space using Schiffer variation. (Received June 15, 2010)

1062-30-28 **Albert Marden***, School of Mathematics, University of Minnesota, Minneapolis, MN 55455. *Plumbing.*

Start with one or two Riemann surfaces which have hyperbolic metrics of finite area: finitely punctured surfaces. Classical plumbing is to choose (i) a pair of the punctures p,q, (ii) small neighborhoods of them, and (iii) cut the neighborhoods out and join their boundaries together, thus creating either a handle, or joining two surfaces together. When this process is done precisely, it depends on an analytic parameter t. For small values of abs(t), one obtains a holomorphic family S(t) of surfaces. The process can be carried out for any number of puncture-pairs. These surfaces are connected and all have the same topological type. Are they conformally distinct from each other? This is necessary to know if one wants to "open-up" noded surfaces on the boundary of a Teichmueller space. Do the plumbing t-parameters have analytic extensions so as to provide global holomorphic parameters for Teichmueller space?

The answers will be provided in the talk, which will be a short exposition of part of ongoing joint work with Clifford Earle. (Received June 23, 2010)

1062-30-35 **Linda Keen*** (linda.keen@lehman.cuny.edu), Lehman College CUNY, Dept of Math and Computer Science, 250 Bedford Pk Blvd W, Bronx, NY 10068. *Generalized Riley Slices.* Preliminary report.

In this talk we will discuss how to extend the theory of pleating rays for those Kleinian groups in the Riley Slice of Schottky space to groups representing orbifolds outside the Riley slice. We will show how the dynamics of the boundary of this exterior space can be described by continued fractions. (Received July 07, 2010)

1062-30-68 **Irwin Kra*** (irwin@math.sunysb.edu), Dept of Math, SUNY, Stony Brook, NY 11794. *A pairing between quadratic differentials and free homotopy classes of closed curves.* Preliminary report.

Let S be a noded Riemann surface or orbifold of finite conformal type. We discuss a pairing $< c, \varphi >$ between free homotopy classes of simple closed curves c on S (in particular, curves in a decomposition of S into a finite number of pairs of pants) and holomorphic quadratic differentials on S. As an application we study isomorphisms between spaces of holomorphic quadratic differentials on surfaces of finite type. (Received July 25, 2010)

1062-30-75 **Alastair Fletcher*** (alastair.fletcher@warwick.ac.uk). *Iteration of quasiregular mappings.*

Quasiregular mappings in $\mathbb{R}^n$ can be considered as higher dimensional analogues of analytic mappings in the plane. In this talk, we will discuss some recent work on the iteration of quasiregular mappings and highlight some similarities and differences in comparison to the highly developed field of complex dynamics.

Since it is apparent that the notion of Fatou and Julia sets do not make sense in this setting, a key object in connecting quasiregular and complex dynamics is the escaping set $I(f)$, i.e. the set of points which iterate to infinity. The boundary of the escaping set is well known to coincide with the Julia set in the analytic case, and so we will look at properties of $\partial I(f)$ for quasiregular mappings.

Both quasiregular mappings of polynomial type and those with an essential singularity at infinity will be discussed, with examples. This talk will be largely based on joint work with Dan Nicks, Open University, UK. (Received July 27, 2010)

1062-30-76 **Petra Bonfert-Taylor*** (pbonfert@wesleyan.edu), PO Box 1327, Norwich, VT 05055, and **Edward C Taylor** (ectaylor@wesleyan.edu), PO Box 1327, Norwichv, VT 05055. *Quasiconformal homogeneity of planar domains.*

In this talk we will discuss geometric properties of quasiconformally homogeneous planar domains and their boundaries. (Received July 27, 2010)

1062-30-77 **Edward Taylor*** (ectaylor@wesleyan.edu), P.O. Box 1327, Norwich, VT 05055, and **Petra Bonfert-Taylor**, **Gaven Martin** and **Alan Reid**. *Recent results on the strong quasiconformal homogeneity of surfaces.*

We will discuss geometric and analytic properties of strongly quasiconformally homogeneous surfaces, including the derivation of a sharp lower bound (strictly greater than one) of the homogeneity constant of such a surface. (Received July 27, 2010)

1062-30-85 **Pekka Pankka**, Department of Mathematics, University of Helsinki, Helsinki, Finland, and **Jang-Mei Wu*** (wu@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *Quasisymmetric Parametrization of Decomposition Spaces.* Preliminary report.

Semmes-type metrics can be constructed when the decomposition space R^3/G admits a defining sequence of finite type. We discuss the connection between the growth and winding of such spaces and the existence of quasisymmetric parametrization. (Received July 27, 2010)

1062-30-108 **Kai Rajala*** (kai.i.rajala@jyu.fi) and **Xiao Zhong**. *Sharp Bonnesen inequality for John domains in* $\mathbb{R}^n$. Preliminary report.

Bonnesen's inequality gives a sharp bound for the difference of the circumradius and the inradius of a planar Jordan domain in terms of the isoperimetric deficit of the domain, showing that for almost isoperimetric domains the difference almost vanishes. Inequalities of this type do not hold in higher dimensions unless the class of domains is restricted such that cusps are ruled out. We present a sharp Bonnesen inequality in all dimensions, assuming John domain conditions from the domain and its complement. This is joint work with Xiao Zhong. (Received August 01, 2010)

1062-30-122 **Olena Ostapyuk*** (ostapyuk@math.ksu.edu), 138 Cardwell Hall, Manhattan, KS 66506. *Backward iteration in the unit ball.* Preliminary report.

I will consider holomorphic self-map f of the unit ball in $\mathbb{C}^N$. In the cases when f is elliptic or hyperbolic, I will show that a backward-iteration sequence for f with bounded hyperbolic step converges to some point on the boundary other than Denjoy-Wolff point. These points will be called boundary repelling fixed points (BRFPs) and will possess several nice properties. In particular, in the case when such points are isolated from other BRFPs, they will be completely characterized as limits of backward iteration sequences. It will be also possible to construct a (semi) conjugation to an automorphism of the ball. Unfortunately, unlike in one-dimensional case, not all BRFPs are isolated (a counterexample will be presented). Then I will describe some problems that arise in parabolic case. (Received August 03, 2010)

1062-30-124 **Ngin-Tee Koh*** (nkoh@syr.edu) and **Leonid V Kovalev**. *Area contraction for harmonic automorphisms of the disk.*

We show that a harmonic self-homeomorphism of a disk does not increase the area of any concentric disk. (Received August 03, 2010)

1062-30-128 **Michael T. Lacey** (Lacey@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, **Istvan Prause** (Istvan.Prause@helsinki.fi), P.O. Box 68 (Gustaf Hällströmin katu 2b), University of Helsinki, FI-00014 Helsinki, Finland, **Eric T. Sawyer** (sawyer@mcmaster.ca), Dept. of Mathematics & Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, **Xavier Tolsa** (xtolsa@mat.uab.cat), Departament de Matematiques, Universitat Autonoma de Barcelona, 08193 Bellaterra Barcelona, Spain, and **Ignacio Uriarte-Tuero*** (ignacio@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Two conjectures of Astala on distortion under planar quasiconformal mappings and related removability problems.*

In his celebrated paper on area distortion under planar quasiconformal mappings (Acta 1994), Astala proved that if E is a compact set of Hausdorff dimension d and f is K-quasiconformal, then fE has Hausdorff dimension at most $d' = \frac{2Kd}{2+(K-1)d}$, and that this result is sharp. He conjectured (Question 4.4) that if the Hausdorff measure $\mathcal{H}^d(E) = 0$, then $\mathcal{H}^{d'}(fE) = 0$.

UT showed that Astala's conjecture is sharp in the class of all Hausdorff gauge functions (IMRN, 2008).

Lacey, Sawyer and UT jointly proved completely Astala's conjecture in all dimensions (Acta, 2010). The proof uses Astala's 1994 approach, geometric measure theory, and new weighted norm inequalities for Calderón-Zygmund singular integral operators which cannot be deduced from the classical Muckenhoupt A_p theory.

These results are related to removability problems for various classes of quasiregular maps. I will mention sharp removability results for bounded K-quasiregular maps (i.e. the quasiconformal analogue of the classical Painleve problem) recently obtained jointly by Tolsa and UT.

I will further mention recent results related to another conjecture of Astala on Hausdorff dimension of quasicircles obtained jointly by Prause, Tolsa and UT. (Received August 03, 2010)

1062-30-133 **David M Freeman*** (freemadd@mail.uc.edu), University of Cincinnati, Raymond Walters College, 9555 Plainfield Rd, Cincinnati, OH 45236. *Metric inversions of bilipschitz homogeneous Jordan curves.* Preliminary report.

Suppose a Jordan curve has the property that both the curve and its image under a metric inversion are bilipschitz homogeneous. We demonstrate that such a curve is bounded turning. This allows us to apply previous results to conclude that such a curve (when doubling) is also Ahlfors Q-regular for some $1 \leq Q < +\infty$. (Received August 03, 2010)

1062-30-143 **Hiroshige Shiga*** (shiga@math.titech.ac.jp), O-okayama, Meguro-ku, Tokyo, 152-8551, Japan. *On the number of holomorphic families of Riemann surfaces.*

Let B be a Riemann surface of finite type. It is known that the number of locally non-trivial holomorphic families of Riemann surfaces of type (g, n) $(2g-2+n > 0)$ over B is finite. In this talk, we estimate the number of holomorphic families in terms of the hyperbolic geometry of B. (Received August 04, 2010)

1062-30-163 **Jun Hu*** (junhu@brooklyn.cuny.edu), Math. Dept., Brooklyn College of CUNY, Brooklyn, NY 11210, and **Oleg Muzician** (olegmoyz@hotmail.com), Ph. D Program in Mathematics, Graduate Center of CUNY, New York, NY 10016. *Conformally natural extension is far away from being extremal.*

In this talk, we show that the conformally natural extension (commonly called Douady-Earle extension) of the possibly simplest quasisymmetric circle homeomorphism is far away from being extremal. Numerical experiment data will be also presented. This is a part of a joint project with Oleg Muzician on conformally natural extensions of circle maps. (Received August 05, 2010)

1062-30-259 **Marie A Snipes*** (snipesm@kenyon.edu). *Brownian motion and distributions of harmonic measure in planar domains.*

The harmonic measure distribution function (HMD function) of a planar domain gives information about the behavior of Brownian motion in the domain. Specifically, given a domain D containing the origin, the HMD function h(r) gives the probability that a Brownian particle starting at 0 first hits the boundary of D within distance r of 0. For any domain, h(r) is a right-continuous function that increases from 0 towards 1. A long-term goal is to determine whether any such function can arise as the HMD function of some domain, and if possible, to explicitly construct the domain. We will survey results in this direction, focusing on the case where the HMD function is a step function. This is joint work with Lesley Ward. (Received August 10, 2010)

1062-30-279 **Marshall Williams*** (mcwill@uic.edu). *Geometric and analytic quasiconformality in metric measure spaces.*

We prove the sharp equivalence between analytic and (lower) geometric definitions of quasiconformality for a homeomorphism $f\colon X \to Y$ between metric measure spaces X and Y. Our result holds in great generality, assuming no metric hypotheses on either space.

Assuming in addition only a doubling condition on the measure ν, our results show that "annular quasiconformality" (quasipreservation of the modulus of certain annular condensers) implies (lower) quasiconformality. This yields a very short, though not entirely conceptually new, proof of Tyson's theorem that quasisymmetric mappings are geometrically quasiconformal. (Received August 11, 2010)

31 ► Potential theory

1062-31-27 **Nageswari Shanmugalingam***, Department of Mathematical Sciences, P.O.Box 210025, University of Cincinnati, Cincinnati, OH 45221-0025, **Estibalitz Durand**, Universidad Complutense de Madrid, Department of Mathematics, Madrid, Spain, and **Jesus Jaramillo**, Universidad Complutense de Madrid, Department of Mathematics, Madrid, Spain. *Geometric characterizations of infinity-Poincare inequality.*

Much of the recent development of analysis in metric measure spaces focused on the so-called $(1,p)$-Poincaré inequality for $1 \le p < \infty$. For certain values of p it is known that these inequalities are geometric in nature ($p = 1$, and in the event that the measure on the space is Ahlfors Q-regular, then $p = Q$). In this talk we will focus on the other extreme value of $p = \infty$, and describe the geometry lying behind this inequality. Surprisingly, unlike in the $p = 1$ and $p = Q$ case, the geometric characterization of ∞-Poincaré inequality is not quantitative. (Received June 22, 2010)

32 ► Several complex variables and analytic spaces

1062-32-30 **Maritza M. Branker**, Department of Mathematics, Niagara University, Niagara, NY , and **Malgorzata S. Stawiska*** (stawiska@ku.edu), Department of Mathematics, 1460 Jayhawk blvd., Lawrence, KS 66045. *Robin functions on toric manifolds.* Preliminary report.

We define Robin functions on toric manifolds that generalize Robin functions defined in classical pluripotential theory in $\mathbb{C}^n$. We also prove their basic properties. This is a joint work by Maritza M. Branker and Małgorzata Stawiska. (Received June 24, 2010)

1062-32-36 **Frederick Gardiner*** (frederick.gardiner@gmail.com) and **Zhe Wang** (wangzhecuny@gmail.com). *Extremal Properties for Teichmüller and Mori Annuli.*

The Teichmüller and Mori annuli are doubly connected domains satisfying certain extremal properties. We show how these properties are related to the minimum Dirichlet principle and the minimal axis theorem for pairs measured foliations transversely realizable on the four times punctured sphere (Received July 07, 2010)

1062-32-43 **Chia-chi Tung*** (chia.tung@mnsu.edu), Dept. of Math. and Stat., Minnesota State University, Mankato, Mankato, MN 56001. *On Hilbert Number and Hilbert Exponent for Holomorphic Mappings.*

In this work attempts are made to answer the question: for a subvariety $\mathfrak{Z}$ in a product of pure dimensional complex spaces, under what conditons a global or semiglobal Hilbert Nullstellensatz for $\mathfrak{Z}$ can be ascertained ? A main result obtained is the following: Assume that X, Y are normal complex spaces and $\mathcal{S} \subset X$ a subvariety of pure positive codimension q admitting a weakly normal defining map $g : X \to \mathbb{C}^p$. Then for each relatively compact open subset D of X, a Hilbert relation over Y holds for all holomorphic functions on $Y \times D$ vanishing on $Y \times (\mathcal{S} \cap D)$, with an explicitly determined Hilbert exponent $\mathfrak{h}_D$. Similar results hold for a subvariety in a product space (in particular, $Y \times \mathbb{P}^N(\mathbb{C})$). Also, conditions for a hypersurface in a product space to admit a principal generator and characterizations of solid pseudospherical harmonics on a semi-Riemann domain are given. (Received July 15, 2010)

1062-32-45 **thomas bloom*** (bloom@math.toronto.edu), Mathematics,University of Toronto, Toronto,Ontario, Canada, Toronto, Ontario M5S2E4, Canada. *Random Matrices and Potential Theory.*

We will discuss large deviation results for random matrices,emphasizing the role played by potential theory. We will briefly indicate the several-variable generalization, where recent developments in pluripotential theory play a role. (Received July 16, 2010)

1062-32-48 **Howard Masur*** (masur@math.uchicago.edu), 5738 S. University, Chicago, IL 60637, and **Keith Burns** and **Amie Wilkinson**. *Ergodicity of Weil-Petersson flow on Moduli space.*

Let S be a surface of genus g with n punctures. We require $3g-3+n>0$. Let $T(S)$ denote the Teichmuller space of S. We put the Weil-Petersson metric on $T(S)$. It descends to a metric on the quotient moduli space. We review some of the main properties of this metric and discuss the following result.

Theorem: The Weil-Petersson geodesic flow on the quotient moduli space is ergodic. (Received July 19, 2010)

1062-32-50 **Thomas Bloom** and **Norman Levenberg*** (nlevenbe@indiana.edu), Department of Mathematics, Indiana University - Rawles Hall, 831 East 3rd St, Bloomington, IN 47405. *Pluripotential Energy.*

We discuss a notion of the energy of a compactly supported measure in $\mathbf{C}^N$ for $N>1$ which we show is equivalent to that defined by Berman, Boucksom, Guedj and Zeriahi. This generalizes the classical notion of logarithmic energy of a measure in the complex plane $\mathbf{C}$; i.e., the case $N=1$ (joint work with T. Bloom). (Received July 19, 2010)

1062-32-60 **Francis Bonahon**, 3620 South Vermont Ave., Los Angeles, CA 90089-2532, and **Dragomir Saric*** (dragomir.saric@qc.cuny.edu), 65-30 Kissena Blvd., Flushing, NY 11367. *Infinitesimal Liouville currents, cross-ratios and intersection numbers.*

Many classical objects on a surface S can be interpreted as cross-ratio functions on the circle at infinity of the universal covering $\widetilde{S}$. This includes closed curves considered up to homotopy, metrics of negative curvature considered up to isotopy and, in the case of interest here, tangent vectors to the Teichmüller space of complex structures on S. When two cross-ratio functions are sufficiently regular, they have a geometric intersection number, which generalizes the intersection number of two closed curves. In the case of the cross-ratio functions associated to tangent vectors to the Teichmüller space, we show that two such cross-ratio functions have a well-defined geometric intersection number, and that this intersection number is equal to the Weil-Petersson scalar product of the corresponding vectors. (Received July 22, 2010)

1062-32-62 **John H Hubbard** and **Sarah C Koch*** (kochs@math.harvard.edu). *An analytic construction of the Deligne-Mumford compactification of $\mathcal{M}_{g,n}$.*

In 1969, Deligne and Mumford created a compactification $\overline{\mathcal{M}_{g,n}}$ of the moduli space $\mathcal{M}_{g,n}$ of curves of genus g with n marked points. The construction is in the language of stacks. In this talk, we outline an analytic construction of $\overline{\mathcal{M}_{g,n}}$, as the quotient of augmented Teichmüller space. (Received July 22, 2010)

1062-32-71 **William Harvey***, Maths Dept., King's College London, Strand, London, WC2R 2LS, England, and **Arthur Lloyd-Philipps**. *Symmetry and moduli spaces for low genus algebraic curves.* Preliminary report.

The canonical genus 3 curve is a plane quartic and has 28 bitangents: this famous configuration has automorphism group isomorphic to the Weyl group of E_7. In genus 4, a similar but more complicated structure comprising the tritangent planes to the canonical sextic curves in 3-space gives a representation of the Weyl group $W(E_8)$. These structures, along with the representation of $W(E_6)$ on the 27 lines in a cubic surface, admit interesting connections, found by Coxeter and du Val in the 1920s, with the combinatorial structure of certain higher dimensional regular polytopes.

For higher genus, the analogous structure comprises the set of multi-tangent hyperplanes to the canonical curve in (g-1)-dimensional space; the automorphism group $\mathcal{A}(g)$ is no longer a Weyl group and little seems to be known about these configurations. We show that the group $\mathcal{A}(g)$ is a finite group of permutations of the set of odd theta characteristics, which serves as an envelope for all automorphism groups of canonical genus g curves. (Received July 26, 2010)

1062-32-78 **Jasmin Raissy*** (jasmin.raissy@unimib.it), Dipartimento di Matematica e Applicazioni, Università degli Studi di Milano Bicocca, Via R. Cozzi, 53, 20125 Milano, Milano, Italy. *Holomorphic linearization of commuting germs of holomorphic maps.*

Given $h \geq 2$ germs of biholomorphisms of $\mathbb{C}^n$ fixing the origin, we investigate the shape a (formal) simultaneous linearization of the given germs can have, and we prove that if the germs commute and their linear parts are almost simultaneously Jordanizable then they are simultaneously formally linearizable. We next introduce a simultaneous Brjuno-type condition and prove that, in case the linear terms of the germs are diagonalizable, if the germs commute and our Brjuno-type condition holds, then they are holomorphically simultaneously linerizable. This answers to a multi-dimensional version of a problem raised by Moser. (Received July 27, 2010)

1062-32-80 **Marco Abate*** (abate@dm.unipi.it), Dipartimento di Matematica, Università di Pisa, Largo Pontecorvo 5, 56127 Pisa, Pisa, Italy, and **Alberto Saracco** (alberto.saracco@unipr.it), Dipartimento di Matematica, Università di Parma, Viale Usberti 53/A, 43124 Parma, Parma, Italy. *Carleson measures and uniformly discrete sequences in strongly pseudoconvex domains.*

We characterize, using the Bergman kernel, Carleson measures of Bergman spaces in strongly pseudoconvex bounded domains in $\mathbb{C}^n$, generalizing to this setting theorems proved by Duren and Weir for the unit ball. We also show that uniformly discrete (with respect to the Kobayashi distance) sequences give examples of Carleson measures, and we compute the speed of escape to the boundary of uniformly discrete sequences in strongly pseudoconvex domains, generalizing results obtained in the unit ball by Jevtić, Massaneda and Thomas, by Duren and Weir, and by MacCluer. (Received July 27, 2010)

1062-32-100 **Imre Patyi*** (matixp@langate.gsu.edu), Department of Mathematics, Georgia State University, 30 Pryor St, Atlanta, GA 30303-3083. *On pseudoconvex neighborhoods in a Banach space.*

We show that if X is a separable complex Banach space, $X_0 \subset X$ is a closed complex linear subspace (complemented or not), $\Omega_0 \subset X_0$ is a (relatively) open convex subset of X_0, and $U \subset X$ is open in the ambient space with $\Omega_0 \subset U$, then there is a pseudoconvex open subset $\Omega \subset X$ in the ambient space with $\Omega_0 \subset \Omega \subset U$. We apply this to show that the ambient cohomology groups $H^q(\Omega_0, {}_X\mathcal{O})$ vanish for $q \geq 1$, where ${}_X\mathcal{O}$ is the sheaf cohomology group of holomorphic cocycles defined in open neighborhoods of Ω_0 in the ambient space. (Received July 30, 2010)

1062-32-110 **Alexander J. Izzo*** (aizzo@math.bgsu.edu), Department of Mathematics and Statistics, Bowling Green State University, Bowling Green, OH 43403. *Function Algebras Invariant under Group Actions.*

We will answer a question raised by Ronald Douglas in connection with his work on a conjecture in operator theory due to William Arveson. Let S denote the unit sphere in $\mathbf{C}^n$. If A is a function algebra on S that contains the ball algebra $A(S)$ and whose maximal ideal space is S, and if A is invariant under the action of the n-torus on S, does it follow that $A = C(S)$? When $n = 1$, Wermer's maximality theorem gives immediately that the answer is yes. Surprisingly, in higher dimensions the answer depends on the dimension. The proof is related to a peak point theorem of John Anderson and the speaker and counterexamples to the peak point conjecture due to Richard Basener and the speaker.

We will also present related results of a more general nature concerning function algebras that are invariant under group actions. (Received August 01, 2010)

1062-32-202 **Muhammed A Alan*** (malan@math.jhu.edu), Johns Hopkins University Department of Math, 404 Krieger Hall, 3400 N. Charles Street, Baltimore, MD 21218. *Weighted Capacities in Pluripotential Theory.* Preliminary report.

Capacities are important tools in Potential Theory and Pluripotential Theory. We define weighted versions of Tchebychev constants and Alexander-Siciak capacity and give the relation between them. We also define weighted polynomials hulls of compact sets. (Received August 09, 2010)

1062-32-216 **Mohan Ramachandran***, University at Buffalo, 244 Mathematics Building, Buffalo, NY 14260. *Bochner-Hartogs dichotomy for complete Kahler manifolds.*

I will be talking about joint work with Terrence Napier.We show that any complete non-compact nonparabolic Kahler manifold with bounded geometry satisfies the following dichotmy.Either the manifold admits a proper holomorphic map to a Riemann surface or one can solve the dbar equation with compact supports for (0,1) forms. (Received August 09, 2010)

1062-32-232 **Alexander P Schuster**, San Francisco, CA , and **Dror Varolin***, Department of Mathematics, Stony Brook University, Stony Brook, NY 11794-3651. *Toeplitz Operators on Weighted Bargmann-Fock Space.*

We explore basic properties, such as boundedness, compactness, etc., of Toeplitz operators on weighted Bargmann-Fock spaces of entire functions. We use various L^2 methods to obtain these results. This is work in progress. (Received August 09, 2010)

33 ► Special functions

1062-33-112 **Ira M. Gessel*** (gessel@brandeis.edu), Department of Mathematics, MS 050, Brandeis University, Waltham, MA 02453. *The WZ method and zeta function identities.* Preliminary report.

There are several interesting formulas that give quickly converging series for generating functions for the zeta function, due to Almkvist, Borwein, Bradley, Granville, Koecher, Leshchiner, and Rivoal. For example, Koecher's formula is

$$\sum_{k=0}^{\infty} \zeta(2k+3)x^{2k} = \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^3\binom{2n}{n}} \left(\frac{1}{2} + \frac{2}{1-x^2/n^2}\right) \prod_{k=1}^{n-1} \left(1 - \frac{x^2}{k^2}\right).$$

Khodabakhsh and Tatiana Hessami Pilehrood used the WZ method of Wilf and Zeilberger to prove some of these formulas. I will explain how the WZ proofs of these identities are closely related to classical hypergeometric series identities, and how this connection allows us to generalize them. (Received August 02, 2010)

34 ► Ordinary differential equations

1062-34-117 **Toka Diagana*** (tokadiag@gmail.com), Department of Mathematics, Howard University, 2441 6th Street NW, Washington, DC 20059. *Existence Results for Some Abstract Second-Order Differential Equations.* Preliminary report.

This talk is mainly devoted to the existence of solutions to some abstract second-order differential equations. Various existence results will be discussed as well as some applications. (Received August 02, 2010)

1062-34-132 **Gaston M N'Guerekata*** (Gaston.N'Guerekata@morgan.edu), 1700 East Cold Spring Lane, Baltimore, MD 21251, **Van Minh Nguyen** (vnguyen@westga.edu), Department of Mathematics, University of West Georgia, Carrollton, GA 30118, and **Stefan Siegmund**, Dresden University of Technology, Department of Mathematics, 01062 Dresden, Germany. *On bounded solutions of periodic evolution equations.*

We consider the existence and uniqueness of bounded solutions of the periodic evolution equations $u' = A(t)u + \epsilon H(t,u) + f(t)$, where $A(t)$ is an unbounded operator depending 1-periodically on t, H is periodic in t with the same period as A, ϵ is small, and f is a bounded and continuous function not necessarily uniformly continuous. We present a new approach to the spectral theory of functions via the concept of "circular spectrum". Then we apply it to study a similar problem for the difference equation $u(t) = B(t)u(t-1) + f(t)$, B is a 1-periodic operator in a Banach space X, continuous in t, f is an X-valued bounded function. The solution of this problem turns out to yield a solution to the problem for the unperturbed evolution equations with general conditions on f. For small ϵ we show that the perturbed equation inherits some properties of the linear unperturbed equation on the existence and uniqueness of the bounded solutions. These extend recent results in the direction, saying that if the unitary spectrum of the monodromy operator does not intersect the circular spectrum of f, then the evolution equation has a unique mild solution with its circular spectrum contained in the circular spectrum of f. (Received August 03, 2010)

1062-34-231 **Zora Thomova*** (thomovz@sunyit.edu), SUNY IT, 100 Seymour Road, Utica, NY 13502. *How to introduce contact transformations for discrete equations.* Preliminary report.

The Lie point transformations and Lie contact transformations are well understood for the ordinary and partial differential equations. In the last 15 years considerable work has been done in developing symmetry techniques for the difference and differential-difference equations. We will describe the contact symmetries for ordinary differential equations and discuss possible ways of introducing a similar concept for the difference equations. (Received August 09, 2010)

1062-34-249 **Evelyn Stamey*** (estamey1@ithaca.edu), **Benjamin Steinhurst**, **Robert Kesler**, **Mandy Parshall** and **Christopher Kauffman**. *Quantum Mechanics on Laakso Spaces.* Preliminary report.

We define Laakso spaces and a Laplacian on them. Then we analyze the spectrum of the Hamiltonian given by the Laplacian and three potentials: infinite square well, infinitely tall parabolic well, and a Coulomb potential. Lastly, we calculate special values of the associated spectral zeta function to use in calculating an analogue to the Casimir effect. (Received August 10, 2010)

35 ► Partial differential equations

1062-35-2 **Yan Guo*** (guoy@dam.brown.edu), 182 George Street, Providence, RI 01912, **Benoit Pausader** (benoit@math.brown.edu), Box 1917, Brown University, Providence, RI 01912, and **Ian Tice** (tice@dam.brown.edu), Box F, Brown University, Providence, RI 01912. *Asymptotic stability in some fluid problems.* Preliminary report.

We will discuss recent results of time decay rate in Euler-Poisson system for ion dynamics in a plasma, as well as time decay of a viscous surface wave of a incompressible fluid. (Received July 28, 2010)

1062-35-17 **Tadele Mengesha*** (mengesha@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Nguyen Cong Phuc,**, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Global Weighted and Regularity Estimates for Nonlinear PDEs on Nonsmooth Domains.*

Global weighted L^p estimates are obtained for the gradient of solutions to nonlinear elliptic PDEs of the form

$$\operatorname{div} \mathbf{a}(\nabla u, x) = \operatorname{div} \mathbf{f} \quad \text{in } \Omega, \quad u = 0 \quad \text{on } \partial\Omega,$$

where Ω is a bounded nonsmooth domain. Morrey and Hölder space regularity of solutions are also established. These results generalize existing L^p estimates for nonlinear equations. The nonlinearities are at most of linear growth and assumed to have a uniform small mean oscillation in the second variable. The boundary of the domain, on the other hand, may exhibit roughness but assumed to be sufficiently flat. Our approach uses maximal function estimates, Vitali covering lemma from harmonic analysis, and also known regularity of solutions to reference homogeneous equations. (Received June 07, 2010)

1062-35-34 **Leonid A. Muravey*** (pm@mati.ru), 121552. Orshanskaya, 3 , Moscow, Russia., Moscow, Moscow 121552, Russia, and **Victor M. Petrov** (pm@mati.ru), 121552. Orshanskaya, 3 , Moscow, Russia., Moscow, Moscow 121552, Russia. *Coefficient Control for some nonlinear hyperbolic equation.*

Manufacture of VLSI, with the submicron elements determines the necessary of applying the up-to-date methods for creation of functional layers, such as XR and others for the protective mask, various methods, including the ion-beam etching process, for the relief pattern of the functional layers. The problem of calculation and optimization of the ion-beam etching process arises due to the deviation of geometrical sizes and the effect of the protective mask degeneration into the "maximum dispersion form". This problem can be solved using measurement of the ion-beam incidence with respect to the target and using the rotation of the ion beam etching in the case of very high speed. Then we have in half plane the non-linear equation with the initial condition describing the evolution of the protection mask profile, with coefficient $f(a(t))$ where mask boundary is ion-beam direction the inclination angle is control parameter $a(t)$ describes the characteristics of the mask f(f really it is known from the experiment). For the considered mask optimization problem using the control singular perturbation the L.S. Pontryagin maximum principle has been determined. (Received July 05, 2010)

1062-35-66 **Jingru Qu*** (jingru.qu@gmail.com), No. 238, Songling Road,Laoshan District, Qingdao, Shandong 266100, Peoples Rep of China. *Lax pair and exact solutions for a generalized variable-coefficients nonlinear Schrodinger equation.* Preliminary report.

In the paper, a Lax pair is presented for a generalized variable-coefficients nonliear Schrodinger equation in inhomogeneous optical fiber media with the loss/gain and the frequency chirping. Then on the basis of the Lax pair, some exact analytical solutions are constructed by solving its linear non-isospectrum problem. From our results, many known results of some nonlinear Schrodinger equation can be recovered by means of some suitable selections of the arbitrary functions and arbitrary constants. With computer simulation, the main soliton features of bright and dark solitons, and Jacobi elliptic functions solutions are shown by some figures. These results will be useful in optical pulse propagating in inhomogeneous optical fiber media. (Received July 25, 2010)

1062-35-83 **Katharine A Ott*** (katharine.ott@uky.edu), 715 Patterson Office Tower, Department of Mathematics, Lexington, KY 40506, and **Justin L Taylor** and **Russell M Brown**. *The mixed problem for the Laplacian in bounded Lipschitz domains.*

We consider the mixed boundary value problem for the Lapalacian in bounded Lipschitz domains Ω in $\mathbb{R}^n$, $n \geq 2$. The boundary is decomposed as $\partial\Omega = D \cup N$, with D and N disjoint. We specify Dirichlet data on D and Neumann data on N. The boundary between D and N is an important feature in the mixed problem. In this talk I will discuss existence and uniqueness of solutions to the mixed problem when the boundary between D and N is given by a Lipschitz graph and when the boundary between D and N satisfies a more general set of geometric conditions. (Received July 27, 2010)

1062-35-102 **Xuming Xie***, 1700 Cold Spring Lane, Baltimore, MD 21251. *Local smoothing effect and existence for the one-phase Hele-Shaw problem.* Preliminary report.

We study an initial value problem for the one phase Hele-Shaw problem with and without surface tension. We establish local well-posedness for the initial value problem in Sobolev space. Furthermore, we obtain that, on average in time and compared to the initial data, the solution gains 3/2 derivative of smoothness in spatial variable for nonzero surface tension case and 1/2 derivative for zero tension case. (Received July 31, 2010)

1062-35-111 **John L Lewis*** (john@ms.uky.edu), Mathematics Department, University of Kentucky, Lexington, KY 40506. *p Harmonic Measure in Space.* Preliminary report.

In this talk I will discuss recent work with co-authors concerning the Hausdorff dimension of a measure associated with a positive p harmonic function vanishing on the boundary of a sufficiently flat Reifenberg domain in Euclidean n space. We show that the dimension of this measure is at most n - 1 when p is no less than n. Using a method of Thomas Wolff we also construct examples for p larger than one of Wolff snowflakes - p harmonic functions, for which the Hausdorff dimension of the corresponding measure can be estimated. (Received August 01, 2010)

1062-35-115 **Guoping Zhang*** (hyzgp73@yahoo.com), 1700 E Cold Spring Ln, Baltimore, MD 21251. *Standing waves of the discrete nonlinear Schrödinger equation with sign changing nonlinearity.* Preliminary report.

My previous works only dealt with self-focusing and defocusing nonlinearity that means the coefficients in the nonlinearity are all negative (self-focusing case) or all positive (defocusing case). In this talk I am going to present my recent works on the standing waves of the discrete nonlinear Schrödinger (DNLS for short) equation with sign changing nonlinearity (that contains both self-focusing and defocusing terms). (Received August 02, 2010)

1062-35-125 **Ariel E. Barton*** (abarton@math.uchicago.edu), 375 Brown Street, #107, West Lafayette, IN 47906. *The Dirichlet problem with BMO boundary data and almost-real coefficients.*

Consider the Dirichlet problem in a Lipschitz domain in the plane. Suppose that the boundary data is in BMO. I will show that, if the coefficients are elliptic, have small imaginary part, and are independent of one of the coordinates, then gradients of solutions satisfy a Carleson-measure condition. (Received August 03, 2010)

1062-35-145 **Yin Tat Lee*** (YinTatLee@gmail.com), Room 1903, 421 King's Road, Hong Kong. *Wave equations on graphs and fractals.*

Instead of using spectral decomposition to understand the wave equation, we provide two numerical methods based on approximating the fractals by graphs and quantum graphs. Also, we use that method to study the wave equation on the regular tree. Finally, we propose a technique to avoid combinatorics problems when calculating the wave kernel. (Received August 04, 2010)

1062-35-147 **Robert S. Strichartz*** (str@math.cornell.edu), Malott Hall, Cornell University, Ithaca, NY 14853. *Spectral asymptotics revisited.* Preliminary report.

I will discuss two heuristic ideas concerning the spectrum of Laplacians, and I will give examples from the realms of manifolds, graphs and fractals of theorems that validate these heuristics. The first concerns Laplacians that do not have discrete spectra. Here I introduce the notion of "spectral mass" as an average of the diagonal of the kernel of the spectral projection operators, to serve as a substitute for the eigenvalue counting function (here the meaning of "average" depends on the context). The second is an asymptotic Schur's Lemma to describe the proportion of the spectrum corresponding to eigenfunctions transforming according to the irreducible representations of a finite symmetry group of the Laplacian. In particular, the Sierpinski gasket Laplacian has much smaller remainder terms than most nonfractal examples. (Received August 04, 2010)

1062-35-148 **Bo Guan** and **Qun Li*** (qun.li@wright.edu). *Complex Monge-Ampere type of equations and totally real submanifolds.*

In this talk we shall report results on the Dirichlet problem for complex Monge-Ampère type of equations in Hermitian manifolds with general (non-pseudoconvex) boundary. As applications of the main result we study some connections between the homogeneous complex Monge-Ampere equation and totally real submanifolds. (Received August 04, 2010)

1062-35-150 **Xuan Hien Nguyen*** (xhnguyen@math.ksu.edu), Kansas State University. *Construction of Self-Translating Surfaces under Mean Curvature Flow.*

It is possible to desingularize a finite family of grim reaper cylinders to obtain embedded self-translating surfaces for the mean curvature flow, provided no three grim reaper cylinders intersect on the same line, and no two have the same asymptotic plane. The strategy is to construct an approximate initial surface by desingularizing the intersection lines with Scherk minimal surfaces, then solve a perturbation problem to find the desired soliton. We discuss the problems encountered with the corresponding linear operator, and how to remedy them by tweaking the initial surface. (Received August 04, 2010)

1062-35-155 **Artem Pulemotov*** (artem@math.uchicago.edu), Department of Mathematics, The University of Chicago, 5734 S. University Avenue, Chicago, IL 60637. *Parabolic equations and the Ricci flow on manifolds with boundary.*

In the first part of the talk, we will focus on a second-order quasilinear parabolic equation in a vector bundle over a compact manifold M with boundary. Our goal is to formulate a short-time existence theorem for this equation. In the second part, we will discuss the Ricci flow on M. The objective is to propose new boundary conditions for the flow and state a series of short-time existence results. (Received August 04, 2010)

1062-35-194 **Umberto Mosco*** (mosco@wpi.edu), Department of Mathematical Sciences, 100 Institute Road, Worcester, MA 01609-2280, and **Maria Agostina Vivaldi** (vivaldi@dmmm.uniroma1.it), Dipartimento Me.Mo.Mat., Via A. Scarpa 1, I-00161 Roma, Italy. *Vanishing viscosity for fractal sets.*

We address the question whether bulk energy from a surrounding medium can be absorbed into a lower-dimensional fractal set. We consider an array of thin conductive fibers in an open domain of the plane with small viscosity. The resulting composite medium is described by a second order elliptic operator in divergence form with discontinuous singular coefficients. We study the asymptotic spectral behavior of the operator when, simultaneously, the viscosity vanishes and the fibers develop fractal geometry. We prove that the spectral measure of the operator converges to the spectral measure of a self-adjoint operator associated with the fractal limit of the fibers. Our approach is of variational nature and relies on Hilbert space convergence of quadratic energy forms. (Received August 08, 2010)

1062-35-200 **David Cruz-Uribe** and **Cristian Rios*** (crios@ucalgary.ca), 2500 University Drive NW, University of Calgary, Department of Mathematics, Calgary, AB T2N 1N4, Canada. *The Kato Problem for A_2-Elliptic Operators.*

Given a weight w in the Muckenhoupt class A_2, let $\mathbf{A}$ be an $n \times n$ matrix of complex-valued measurable functions such that for some $0 < \lambda < \Lambda < \infty$, and all ξ, $\nu \in \mathbb{R}^n$,

$$\begin{cases} \lambda w\left(x\right)|\xi|^2 \leq \operatorname{Re}\left\langle \mathbf{A}\xi, \xi\right\rangle, \\ |\left\langle \mathbf{A}\xi, \eta\right\rangle| \leq \Lambda w(x)|\xi||\eta| \end{cases}$$

Since w and w^{-1} can be unbounded, in general $\mathbf{A}$ is a degenerate elliptic matrix. We define the second order elliptic operator $\mathcal{L}_w = -w^{-1}\mathrm{div}\mathbf{A}\nabla$. We show that the Kato problem for uniformly elliptic operators extends to this degenerate case. More precisely, the domain of $\mathcal{L}_w^{1/2}$ is $H^1(w)$, and for all $f \in H^1(w)$,

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

The proof follows the scheme of the uniformly elliptic case proof due to Auscher, Hofmann, McIntosh, and Tchamitcian, but with significant differences and obstacles due to the weighted setting. (Received August 08, 2010)

1062-35-206 **Marta Lewicka*** (lewicka@math.umn.edu), Hill Center for the Mathematical Sciences, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019. *Scaling laws of prestrained elastic films and non-smooth isometric embeddings of Riemannian metrics.*

This talk will concern the analysis and the rigorous derivation of shell models for thin films exhibiting residual stress at free equilibria. A mathematical analysis of these phenomena departs from the model of 3d "non-Euclidean" energy, which measures the pointwise deviation of the given deformation of a body from orientation

preserving realizations of a Riemannian metric, given on this body. For metrics with non-zero Riemann curvature, the infimum of this energy is strictly positive.

We discuss the scaling of the energy minimizers in terms of the body's thickness and then rigorously derive the corresponding limiting theories, as the vanishing thickness Γ-limits. The theories are differentiated by the embeddability properties of the target metrics - in the same spirit as different scalings of external forces lead to a hierarchy of nonlinear elastic plate theories as recently displayed by Friesecke, James and Muller.

Relationships with existence of non-smooth (Sobolev type) isometric embeddings of 2d metrics into $\mathbb{R}^3$ will be exhibited, and recent parallel counterexamples and constructions (by Kohn and Venkataramani) will also be reported.

This is a joint work with Reza Pakzad. (Received August 09, 2010)

1062-35-207 **Gregory C Verchota*** (gverchot@syr.edu), Dept. Mathematics, 215 Carnegie Bldg., Syracuse University, Syracuse, NY 13244. *A linear elliptic operator without coercive Neumann problems in a convex domain.*

A linear homogeneous 4th order elliptic differential operator L with real constant coefficients and a bounded nonsmooth convex domain Ω are constructed in $\mathbb{R}^6$ so that L has no *coercive* integro-differential quadratic form over the Sobolev space $W^{2,2}(\Omega)$. Thus each variational Neumann problem for the homogeneous equation $Lu = 0$ in Ω lacks a bilinear form meeting the principal hypothesis of the Lax-Milgram theorem. When any quadratic form associated with L is placed on the boundary the resulting Rellich identity fails to control all 2nd derivatives of solutions in $L^2(\partial\Omega)$. Among the Neumann problems for L are those that are regular in the sense of Agmon-Douglis-Nirenberg in smooth domains. Each of these regular self-adjoint problems fails to be semi-bounded in the convex domain Ω, thus failing a sufficient condition for the Neumann eigenvalues to be contained in a half-line. (Received August 09, 2010)

1062-35-252 **Matthew Guay*** (mdg226@cornell.edu), **Robert Strichartz** and **Alexander Vladimirsky**. *Infinity-harmonic functions on the Sierpinski Gasket.*

I will discuss infinity-harmonic functions on the Sierpinski Gasket and how they relate to infinity-harmonic functions on sequences of graph approximations to the gasket. (Received August 10, 2010)

1062-35-276 **Stephen Kleene*** (skleene@gmail.com), 114 Clover Hills Drive, Rochester, NY 14618. *Positive and Negative Existence Results for Mean Curvature Flow Self Shrinkers.*

We present several negative results for existence of complete embedded self-shrinkers in the class of hypersurfaces of revolution. On the other hand, we present a construction of a complete embedded self shrinker with discrete rotational symmetries and high genus. (Received August 10, 2010)

1062-35-283 **Natasa Sesum*** (natasas@math.upenn.edu), 110 Frelinghuysen Rd., Piscataway, NJ 08854, and **Rafe Mazzeo** and **James Isenberg**. *Ricci flow on surfaces.*

We will present results on the Ricci flow on surfaces, that is, long time existence and convergence results for the flow on complete surfaces with hyperbolic and asymptotic conical ends. (Received August 11, 2010)

37 ► Dynamical systems and ergodic theory

1062-37-33 **Bernard P Brooks***, School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY 14623. *Discrete Diffusion in Systems of 1st Order Difference Equations.*

When considering the discretization of a reaction diffusion equation one must decide how to represent the spatial domain and choose between two choices for discrete diffusion: diffuse and then react or react and then diffuse. These choices place restrictions on the diffusion coefficients and might determine the presence of Turing instabilities. It will be shown that the react then diffuse is the better choice to correspond with the continuous theory of Turing instabilities. Spatial domains with periodic boundary conditions of 1, 2 and 3 dimensions will be shown. (Received July 02, 2010)

1062-37-44 **Harold M Hastings*** (harold.hastings@hofstra.edu), Dept. of Physics and Astronomy - Berliner 102, 151 Hofstra University, Hempstead, NY 11549-1510, and **Thomas Savino**. *Dynamics of the heart - a scaling analysis of RR interval series.*

We discuss a scaling analysis of RR interval series using "normal" interval series available at Physionet, in terms of power law behavior of differences between interval durations, and discuss a generalized stochastic difference equation for this behavior. (Received July 16, 2010)

1062-37-171 **Erik M Bollt*** (bolltem@clarkson.edu), Dept of Mathematics & Computer Science, Clarkson University, Potsdam, NY 13699-5815, and **Jie Sun** and **Takashi Nishikawa**. *Judging Model Reduction of Chaotic Systems via Optimal Shadowing Criteria.*

A common goal in the study of high dimensional and complex system is to model the system by a low order representation. We propose a general approach for assessing the quality of a reduced order model from high dimensional chaotic systems through shadowing, and combined with dimensionality reduction techniques. Rather than quantify the quality of a model based on predictions, which can be irrelevant for comparison of models since even excellent models can do poorly, we suggest that a good model should allow shadowing by modeled data for long times; this principle leads directly to an optimal shadowing criterion of model reduction. We shall gives examples with interval arithmetic computations to validate upper bounding of the shadowing time cost function used. Our discussions will include a motivating goal of shadowing criterion toward understanding low-dimensional models of coupled systems. (Received August 06, 2010)

1062-37-190 **Michel L Lapidus** (lapidus@math.ucr.edu), 900 Big Springs Rd., Surge Building, Riverside, CA 92521, and **Robert G Niemeyer*** (niemeyer@math.ucr.edu), 900 Big Springs Rd., Surge Building, Riverside, CA 92521. *Families of periodic orbits of the Koch snowflake billiard $\Omega(KS)$.*

The Koch snowflake KS is a nondifferentiable curve. We consider the compact planar region $\Omega(KS)$ with boundary KS to be a mathematical billiard table. A priori, such a table is not well defined, because there is no way of determining reflection in the boundary. In this talk, we give a construction of periodic orbits of the Koch snowflake billiard $\Omega(KS)$. Such a construction consists of inverse limit sequences of particular periodic orbits of the prefractal approximations $\Omega(KS_n)$. We provide experimental evidence suggesting the existence of a wider class of orbits, support for an analogue of the well known Veech dichotomy, and a possible approach to expressing $\Omega(KS)$ as a well-defined billiard with a well-defined phase space "$KS \times S^1$". (Received August 08, 2010)

1062-37-238 **Volodymyr Nekrashevych*** (nekrash@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Hyperbolic duality and analysis on fractals.*

We will discuss the notion of hyperbolic pseudogroups and groupoids, the duality theory for them, and applications of the duality for the study of analysis on fractals. Different examples of hyperbolic pseudogroups (coming from holomorphic dynamics, IFS, and Gromov hyperbolic groups) will be described. (Received August 10, 2010)

1062-37-275 **Evan Kwiatkowski*** (kwiatkowski.evan@gmail.com), 4 Jerome Avenue, Binghamton, NY 13905, and **Mengyang Cha**, **Juan Carlos Ortega** and **Janeth Moran**. *Minimal Dynamical Systems on Cantor Spaces.* Preliminary report.

Cantor spaces have unique properties; the purpose of our study is to investigate minimal dynamical systems on Cantor spaces. We examine Kakutani equivalence and flow equivalence of the systems, and prove that they imply each other. In addition, we discuss topological conjugacy between two specific types of Cantor minimal systems, namely, Denjoy systems and Sturmian subshifts. (Received August 10, 2010)

39 ► Difference and functional equations

1062-39-9 **Tyrus Berry*** (tyrus.berry@gmail.com), Science and Technology 1 Room 203, Fairfax, VA 22030, and **Timothy Sauer**, Science and Technology 1 Room 203, Fairfax, VA 22030. *Convergence of Periodically-Forced Rank-Type Equations.*

Consider a difference equation which takes the k-th largest output of m functions of the previous m terms of the sequence. If the functions are also allowed to change periodically as the difference equation evolves this is analogous to a differential equation with periodic forcing. A large class of such non-autonomous difference equations are shown to converge to a periodic limit which is independent of the initial condition. The period of the limit does not depend on how far back each term is allowed to look back in the sequence, and is in fact equal to the period of the forcing. (Received May 14, 2010)

1062-39-10 **Gabriel Lugo** and **Frank J. Palladino***, University of Rhode Island, Department of Mathematics, 5 Lippitt Road, Kingston, RI 02881. *Local Stability and the m-M theorem.* Preliminary report.

We prove a lemma that gives global asymptotic stability of an equilibrium under appropriate hypotheses. This lemma may be used to strengthen the consequences of the m-M theorem without additional hypotheses. (Received May 14, 2010)

1062-39-12 **Ran Pang*** (rxp1957@rit.edu), Rochester Institute of Technology, School of Mathematical Sciences, College of Science, Rochester, NY 14623, and **Michael A Radin** (michael.radin@rit.edu), Rochester Institute of Technology, School of Mathematical Sciences, College of Science, Rochester, NY 14623. *Monotonic and Periodic Character of non-negative solutions of a delayed third order non-autonomous rational difference equation.* Preliminary report.

Our goal is to investigate the convergence nature of the non-negative solutions and the existence and patterns of periodic solutions of a third order rational difference equation. In fact, we will discover the patterns of the periodic cycles depending on which initial conditions are 0 and the rearrangements of the terms of the periodic sequence. (Received May 20, 2010)

1062-39-18 **April Harry** and **Candace M. Kent*** (cmkent@vcu.edu), Virginia Commonwealth University, Department of Mathematics and Applied Math., P.O. Box 842014, Richmond, VA 23284-2014, and **Vlajko L. Kocic**. *Global Behavior of Solutions of a Periodically Forced Sigmoid Beverton-Holt Model.*

Our aim in this talk is to investigate the boundedness, the extreme stability, and the periodicity of positive solutions of the periodically forced Sigmoid Beverton-Holt model

$$x_{n+1} = \frac{a_n x_n^\delta}{1 + x_n^\delta}\,,\ n = 0\,, 1\,, \dots\,,$$

where $\{a_n\}_{n=0}^{\infty}$ is a positive periodic sequence with period p and $\delta > 0$. In the special case when $\delta = 1$, the above equation reduces to the well-known periodic Pielou logistic equation, which is known to be equivalent to the periodically forced Beverton-Holt model. (Received June 08, 2010)

1062-39-41 **Alex J Bryce*** (alex.bryce@mail.rit.edu), 16 Nathaniel Rochester Hall, Rochester, NY 14623. *Turing Instabilities in Systems of 1st Order Difference Equations.*

When analyzing a system of discrete reaction diffusion equations, one primary area of interest is locating where in parameter space Turing instabilities occur. It will be shown that Turing instabilities cannot occur in the 'react then diffuse' equations if all diffusion coefficients are equal. Replicator dynamics is a system of equations that is used in evolutionary game theory applications. Conditions for Turing instability in first order discrete replicator systems with diffusion will be discussed with computer simulations of the results. (Received July 12, 2010)

1062-39-42 **Tamas I Wiandt*** (tiwsma@rit.edu), 85 Lomb Memorial Dr, Rochester, NY 14623. *Attraction Intensities for Closed Relations on Hausdorff Spaces.*

We give an overview of extensions of different notions of intensity of attraction for closed relations on Hausdorff spaces. These notions were defined originally for maps, but through similar constructions they can be generalized for the wider setting of relations. We prove that two different approaches to intensity ultimately yield the same result. (Received July 13, 2010)

1062-39-46 **Alexander Pankov*** (Alexander.Pankov@morgan.edu), Mathematics Department, Morgan State University, Baltimore, MD 21251. *Solitary waves in Fermi-Pasta-Ulam lattices with saturable nonlinearities.*

We consider FPU lattices with saturable nonlinearities. For every wave speed in a natural range, we obtain the existence of traveling solitary waves. In addition, we discuss what happens outside the allowed wave speed interval and study the behaviour of the amplitude of the wave when the wave speed approaches the upper end point of the allowed interval. (Received July 17, 2010)

1062-39-53 **Hassan Sedaghat***, Department of Mathematics, Virginia Commonwealth University, Box 842014, Richmond, VA 23284-2014. *Reducing orders of difference equations: What, how and why.*

Reducing the order of a difference equation may uncover important structural aspects of the equation and provide valuable information about the behaviors of its solutions. We discuss what the main idea is, how to carry it out and why we may need to do it. We show how to decompose, or factor, a difference equation of order two or greater into two difference equations of lower orders in such a way that one of the two lower order equations

is independent of the other. This procedure applies to various different types of equations, including all linear difference equations. In the linear case, the method casts new light on familiar concepts such as eigenvalues and the role of the homogeneous part. (Received July 20, 2010)

1062-39-58 **N. Josephy**, Waltham, MA 02452, **M. Predescu*** (mpredescu@bentley.edu), Bentley University, Department of Mathematical Sciences, 353 MOR, Waltham, MA 02452, and **S. Woolford**, Waltham, MA 02452. *On the dynamics of a nonlinear system of difference equations.*

This talk deals with the analysis of solutions of a nonlinear system of difference equations. The system is a two stage discrete population model which includes nonlinearities of rational and exponential type. We investigate the global asymptotic behavior of solutions. (Received July 21, 2010)

1062-39-67 **Chris D Lynd*** (chris_lynd@my.uri.edu). *Infinitely Nested Radicals as Particular Solutions to a General First-Order Difference Equation.*

The sequence

$$\{z_n\} = \{c_0 \cdot \sqrt[r_1]{a_1}, c_0 \cdot \sqrt[r_1]{a_1 + c_1 \sqrt[r_2]{a_2}}, \ldots, c_0 \cdot \sqrt[r_1]{a_1 + c_1 \cdot \sqrt[r_2]{a_2 + \cdots + c_{n-1} \cdot \sqrt[r_n]{a_n}}}, \ldots\},$$

when defined, is denoted by the *right nested root*

$$c_0 \sqrt[r_1]{a_1 + c_1 \sqrt[r_2]{a_2 + c_2 \sqrt[r_3]{a_3 + \ldots}}}$$

We consider right nested roots where $\{c_n\}_{n=0}^{\infty}$ and $\{a_n\}_{n=0}^{\infty}$ are periodic sequences of real numbers and $\{r_n\}_{n=1}^{\infty}$ is a periodic sequence of integers greater than or equal to two. We show that right nested roots of this form can be produced from solutions to a difference equation.

We use the equilibrium points, periodic points, and their basins of attraction, to determine the convergence and limit points of the corresponding nested root. Our method of analysis extends previous convergence results to r^{th} roots, periodic parameters with an arbitrary period, and negative parameters. It also extends previous convergence results for *left nested roots*, and can be applied to continued fractions with periodic parameters.

In addition, for a general class of right nested roots, we demonstrate how to construct a nested root so that it converges to a predetermined number. (Received July 29, 2010)

1062-39-152 **Youssef Raffoul*** (youssef.raffoul@notes.udayton.edu), 300 College Park, Dayton, OH 45469-2316. *Inequalities That Lead To Exponential Stability And Instability In Delay Difference Equations.*

We use Lyapunov functionals to obtain sufficient conditions that guarantee exponential stability of the zero solution of the delay difference equation

$$x(t+1) = a(t)x(t) + b(t)x(t-h)$$

The highlight of the paper is relaxing the condition $|a(t)| < 1$. Instability criteria of the zero solution is obtained. Moreover, we will provide an example, in which we show that our theorems provide an improvement of some of the recent literature.
(Received August 04, 2010)

1062-39-173 **Elias Camouzis** and **Emmanouil Drymonis*** (mdrymonis@my.uri.edu), 5 Lippitt Road, Kingston, RI 02881-0816, and **Gerasimos Ladas** and **Wirot Tikjha**. *Patterns of Boundedness of a Rational System in the Plane.*

We present the patterns of boundedness of the 343 special cases of a rational system in the plane. We establish easily verifiable necessary and sufficient conditions, explicitly stated in terms of the parameters of the system, which determine the boundedness character of the system. Some global stability results are also presented. (Received August 06, 2010)

1062-39-228 **Gabriel Lugo*** (glugo@math.uri.edu). *Unboundedness of Systems of Two Rational Difference Equations.*

Some systems of rational difference equations that generate unbounded solutions, under some range of the parameters and some range of the initial conditions, will be presented. Techniques for showing this will be presented. (Received August 09, 2010)

1062-39-273 **Tamara Awerbuch*** (tamara@hsph.harvard.edu), Department of Population and Intern. Health, 655 Huntington Ave, Boston, MA 02115. *A system of Four Difference Equations for Exploring the Dynamics of Dengue Spread, and its Control (Work in Progress).*

We are expanding a previous system of three difference equations (Awerbuch-Friedlander T., Levins R. and Predescu M. Far East Journal of Applied Mathematics 37, 2: 215-228, 2009) to include the proportion of infected people that prompt the intervention.

Awareness (A) is prompted by the proportion of sick people (P) Control of Mosquitoes (M) is carried out directly by spraying, or by community intervention through the habitats (H).

Pn+1 = a*P(n) +[1 . . . ; exp(-i*Mn]*(1- P(n)) Mn+1 = l*Mn*exp(-gAn) + b*Hn*[(1- exp(-s*Mn)] Hn+1 = c*Hn/(1+p*An) + d/(1+q*An) An+1 = r* An + f*Pn

Preliminary results show that (0,0,1/(1-c),0) is an equilibrium point; and that there is also a positive equilibrium for (P, M, H and A). (Received August 10, 2010)

41 ► Approximations and expansions

1062-41-109 **Jianshu Luo***, Department of Mathematics,Syracuse University, Syracuse, NY , and **Lei Sun**. *Analyses the Statistical Characteristic and Data Compression of Remote Sensing Images.*

The transit, analysis and processing of Remote sensing image is important in national economics construction and military application. The characteristic of remote sensing data is analyzed in the terms of their contents, structure and data management. The depiction of this characteristic is the fundamental of constructing model of remote sensing image and connecting the basic characteristic and advanced meanings. By introducing wavelet analysis and performing wavelet transform on remote sensing image by fast analysis and reconstruction algorithm, using statistical parameter estimation and hypothesis testing, we find the statistical distribution of the wavelet coefficients of remote sensing images, and plot the statistical distribution figure for experimental images. Further more, we find that the high frequency wavelet coefficients of remote sensing image have the same non-Gaussian distribution as normal images. However, the high frequency wavelet coefficients of remote sensing image contain the coefficients which have more significant magnitude and higher power.We propose a compression algorithm based on biorthogonal lapped transform, which is of low complexity, low memory requirement and parallel computation. (Received August 01, 2010)

1062-41-266 **Shidong Li*** (shidong@sfsu.edu), Department of Mathematics, 1600 Holloway Ave, San Fracisco, CA 94132, **Zhenjie Yao**, College of Information Scineces, No 19 Yuquan Road, Beijing, Peoples Rep of China, and **Weidong Yi**, College of Information Sciences, Beijing, Peoples Rep of China. *Fusion frame and high resolution image fusion.* Preliminary report.

Orthogonal and non-orthogonal fusion frame theory will be discussed. Formulations of high resolution image fusion using fusion frames will be presented. These techniques use the impulse response function of cameras as the building block of the mathematical frames and fusion frames in the fusion process. By taking realistic camera physics into consideration, the proposed approach provides a natural and realistic modeling of the high-resolution image fusion problem. Deterministic and iterative fusion algorithms will be discussed. The fusion frame approach for high-resolution image fusion is also seen to be robust to realistic fusion problems from inhomogeneous image measurements (taken at different space or time or by different cameras). The effectiveness of this approach is demonstrated through both simulated and realistic examples. This is a joint work with Zhenjie Yao and Weidong Yi. (Received August 10, 2010)

42 ► Fourier analysis

1062-42-51 **Steven C Hofmann*** (hofmanns@missouri.edu), Dept. of Mathematics, University of Missouri, Columbia, MO 65211. *Harmonic measure and uniform rectifiability.*

We discuss the interplay between harmonic measure estimates and rectifiability properties of the boundary of a domain. (Received July 19, 2010)

1062-42-64 **Camil Muscalu*** (camil@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *Some remarks on the n - linear Hilbert transform, for $n \geq 2$.* Preliminary report.

We shall describe a recent theorem which states that any 5 - linear multiplier whose symbol is given by the product of two generic symbols of the 5 - linear Hilbert transform type, does not satisfy any L^p estimates of Hölder type. Several generalizations of this fact will also be discussed. (Received July 23, 2010)

1062-42-87 **Carlos Pérez**, Universidad de Sevilla, Seville, Spain, **Gladis Pradolini**, Universidad Nacional del Litoral, Santa Fe, Argentina, **Rodolfo H. Torres*** (torres@math.ku.edu), Department of Mathematics, University of Kansas, 1460 Jayhawk Blvd., Lawrence, KS 66045-7594, and **Rodrigo Trujillo-González**, Universidad de La Laguna, La Laguna, Spain. *Iterated commutators of multilinear singular integrals.*

Iterated commutators of multilinear Calderón-Zygmund operators and pointwise multiplication with functions in BMO are studied in products of Lebesgue spaces. Both strong type and weak end-point estimates are obtained, including weighted results involving the vectors weights of the multilinear Calderón-Zygmund theory recently introduced in the literature. Some better than expected estimates for certain multilinear operators are presented too. (Received July 28, 2010)

1062-42-96 **Alexander Volberg** (volberg@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Brett D. Wick*** (wick@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332-0160. *Bergman-type Singular Integral Operators and the characterization of Carleson measures for Besov–Sobolev spaces on the complex ball.*

The purposes of this talk are two fold. First, we extend the method of non-homogeneous harmonic analysis of Nazarov, Treil and Volberg to handle "Bergman–type" singular integral operators. The canonical example of such an operator is the Beurling transform on the unit disc. Second, we use the methods developed to settle the important open question about characterizing the Carleson measures for the Besov–Sobolev space of analytic functions B_2^σ on the complex ball of $\mathbb{C}^d$. In particular, we demonstrate that for any $\sigma > 0$, the Carleson measures for the space are characterized by a "T1 Condition". The method of proof of these results is an extension and another application of the work originated by Nazarov, Treil and the first author. (Received July 29, 2010)

1062-42-106 **Michael Greenblatt***, Department of Mathematics, Statistics, and, Computer Science, University of Illinois at Chicago, Chicago, IL 60607. *Maximal averages over hypersurfaces and the Newton polyhedron.*

Using some resolution of singularities and oscillatory integral methods in conjunction with appropriate damping and interpolation techniques, L^p boundedness theorems for $p > 2$ are obtained for maximal averages over a wide range of hypersurfaces. These estimates are sharp in many situations, including the convex hypersurfaces of finite line type considered by Iosevich, Sawyer, and others.

As a corollary, we also give a generalization of the result of Sogge and Stein that for some finite p the maximal operator corresponding to a hypersurface whose Gaussian curvature does not vanish to infinite order is bounded on L^p. (Received July 31, 2010)

1062-42-213 **Robert Azencott** (razencot@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008, **Saurabh Jain** (sjain@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008, and **Manos Papadakis*** (mpapadak@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008. *3D-rigid motion invariant texture discrimination.*

We introduce the concept of 3D-texture rotation. We provide the mathematical concepts for a novel algorithm to define and implement rotationally invariant multiscale discrimination of 3D-textures. We develop a concept of textute divergence that allows to classify two 3D-textures as the same or as different. We show how to umerically implement our method. We have numerically tested our rotationally invariant multiscale classification scheme on a set of 100 synthetic 3D-textures, which were generated by 100 arbitrarily selected, 3D co-occurence matrices. Our numerical results show that the rotational invariance of the proposed 3D-texture classification scheme is achieved with very high accuracy. (Received August 09, 2010)

1062-42-218 **Bernhard G Bodmann*** (bgb@math.uh.edu), 651 Philip G Hoffman Hall, Mathematics Department, University of Houston, Houston, TX 77204, and **Christopher L Liner**, 312 Science & Research Building 1, Dept. of Earth and Atm. Sciences, University of Houston, Houston, TX 77204. *Signal recovery from the zero-crossings of the short-time Fourier transform.*

First, we review the effect of quasi-periodization on the short-time Fourier transform when the window function is a Gaussian. The zero-crossings of an appropriately periodized short-time Fourier transform determine a signal up to an overall constant factor if the signal is band-limited and has finitely many non-zero sample values. More generally, at least approximate recovery is possible if the signal is sufficiently concentrated in time and frequency. We investigate a strategy for deconvolution based on zero-crossings, assuming that the signal is in the Feichtinger algebra, that is, it has an integrable short-time Fourier transform, and additional sparseness properties. The deconvolution is implemented by fixing zero crossings in the pass band and by minimizing a cost functional subject to this constraint. (Received August 09, 2010)

1062-42-235 **Peter Luthy*** (pml25@cornell.edu), 310 Malott Hall, Cornell University, Ithaca, NY 14850. *Multilinear maximal operators, ergodic averages, and AKNS systems.* Preliminary report.

Boundedness properties of maximal operators and questions of pointwise convergence are deeply connected. For instance, in C. Fefferman's proof of Carleson's Theorem that the Fourier series of any square-integrable, periodic function on the line converges pointwise almost everywhere, the main argument establishes boundedness properties of a particular maximal operator. In ergodic theory, almost everywhere convergence properties of multilinear averages are of interest, and so boundedness properties of maximal multilinear operators are important. To that end, we discuss a generalization of such a multilinear result due to C. Demeter, T. Tao, and C. Thiele, which itself extends a bilinear theorem of M. Lacey. We will also discuss how this generalization relates to a family of differential equations known as AKNS systems. (Received August 10, 2010)

1062-42-236 **Wilfredo O Urbina*** (wurbinaromero@roosevelt.edu), Department of Mathematics and, Actuarial Sciences Roosevelt University, 430 S. Michigan Ave., Chicago, IL 60605, **Eduardo Gatto** (aegatto@depaul.edu), Department of Mathematical Sciences, DePaul University. 2320 N Kenmore Ave, Chicago, IL 60614, and **Ebner Pineda** (epineda@uicm.ucla.edu.ve), Departamento de Matemática, Decanato, de Ciencia y Tecnología. Universidad, CentroOccidental Lisandro Alvarado, Barquisimeto, Lara 3001, Venezuela. *Riesz Potentials, Bessel Potentials and Fractional Derivatives on Functions spaces for the Gaussian Measure.*

In this talk we will discuss the boundedness properties of Riesz Potentials, Bessel potentials and Fractional Derivatives on Gaussian Besov-Lipschitz spaces $B^{\alpha}_{p,q}(\gamma_d)$ and Gaussian Triebel-Lizorkin spaces $F^{\alpha}_{p,q}(\gamma_d)$. In a previous paper Gaussian Lipchitz spaces $Lip_{\alpha}(\gamma_d)$ were considered and then the boundedness of Fractional Integrals and Fractional Derivatives on them were studied in detail. We extend those results in the case of these more general function spaces with respect to the Gaussian measure. Also these results can be extended to the case of Laguerre or Jacobi expansions and even further to the general framework of diffusions semigroups. (Received August 10, 2010)

43 ► Abstract harmonic analysis

1062-43-72 **William Paul Meyerson*** (meyerson@ucla.edu), 555 Levering Avenue # 557, Los Angeles, CA 90024. *Lipschitz and biLipschitz Maps on Carnot Groups.*

Suppose A is an open subset of a Carnot group G and H is another Carnot group. We show that a Lipschitz function from A to H whose image has positive Hausdorff measure in the appropriate dimension is biLipschitz on a subset of A of positive Hausdorff measure. We then construct Lipschitz maps from open sets in Carnot groups to Euclidean space that do not decrease dimension. Finally, we discuss two counterexamples to explain why Carnot group structure is necessary for these results. (Received July 26, 2010)

44 ► Integral transforms, operational calculus

1062-44-20 **Ali A. Salim*** (almukdadi12@yahoo.com), The Netherlande, Zuid holland, Hofstraweg 420, 2171 NW Sassenheim, 2171 NW , Netherlands. *Evaluation of general elliptic integrals by elementary functions.*

Its known that there is no evaluation of elliptic integrals in terms of elementary functions.The current evaluation is either by numerical analysis or in terms of standard elliptic functions, which are also unsolved elliptic integrals of 1st, 2nd and 3d kind. Now, by use of a certain analytical techniques,we can evaluate the general forms of elliptic integrals which are involve a cubic or a quartic rational function in one variable under square root. Moreover,there are many significant integrals involving square roots of two different quadratic polynomials multiplied or devided, can also be solved in terms of elementary functions without transform to standard elliptic kinds. This achievement will be very useful in studying the elliptic functions, facilitating the engineering and physical analysis,solution of differential equations,etc... (Received June 10, 2010)

46 ► Functional analysis

1062-46-57 **Piotr Hajlasz*** (hajlasz@pitt.edu), University of Pittsburgh, Department of Mathemtics, 301 Thackeray Hall, Pittsburgh, PA 15260. *Approximation of Sobolev mappings into metric spaces.*

This will be a brief survey of recent results related to the problem of density of Lipschitz mappings in the space of Sobolev mappings from a manifold into a metric space or between metric spaces. The following topics will be discussed:

(1) A complete characterization (in terms of homotopy groups) of Lipschitz polyhedra Y such that for every space X supporting the p-Poincaré inequality, Lipschitz mappings are dense in the space of Sobolev mappings $W^{1,p}(X,Y)$.

(2) The Sobolev space of mappings from a manifold into a metric space $W^{1,p}(M,X)$ can be defined with a help of an isometric embedding of X into a Banach space (for example ℓ^∞). It turns out that the answer to the question whether Lipschitz mappings are dense in the space $W^{1,p}(M,X)$, may depend on the particular choice of the isometric embedding of X.

(3) The problem of approximation of Sobolev mappings into the Heisenberg group by Lipschitz mappings. Connection to Lipschitz homotopy groups of the Heisenberg group. (Received July 21, 2010)

1062-46-81 **Lawrence A. Harris***, Mathematics Department, University of Kentucky, Lexington, KY 40506-0027, and **Clifford J. Earle**, Mathematics Department, Cornell University, Ithaca, NY 14853-4201. *Inequalities for the Carathéodory and Poincaré metrics in open unit balls.*

Let Δ be the open unit disc of the complex plane and let ρ denote the Poincaré metric on Δ. It is shown in a previous paper by the authors and others that

$$|a-b| \le 2\tanh\frac{\rho(a,b)}{2} \quad \text{for all } a,b\in\Delta,$$

with equality if and only if $a=\pm b$. We consider the more general case where Δ is replaced by the open unit ball B of a complex Banach space X. We show that if d is any metric on B satisfying $\rho(\ell(a),\ell(b)) \le d(a,b)$ for all $a,b\in B$ and all continuous linear functionals ℓ on X of norm 1, then

$$\|a-b\| \le 2\tanh\frac{d(a,b)}{2} \quad \text{for all } a,b\in B. \tag{1}$$

For example, d could be any metric of a Schwarz-Pick system such as the Carathéodory or Kobayashi metric.

We obtain two necessary and sufficient conditions for equality to hold in (1) and then focus on determining spaces X where this implies that $a=\pm b$. Every Hilbert space has this property. If the open unit ball of a space with this property is a homogeneous domain, then the space must be a Hilbert space. We obtain a distortion form of the above result for Hilbert spaces and deduce an analogous form for real hyperbolic spaces. (Received July 27, 2010)

1062-46-144 **Marius V Ionescu*** (mionescu@colgate.edu), Department of Mathematics, Colgate University, 13 Oak Drive, Hamilton, NY 13346, and **Luke Rogers** (luke.rogers@uconn.edu), Department of Mathematics, University of Connecticut, 196 Auditorium Road, Unit 3009, Storrs, CT 06269. *Complex Powers of the Laplacian on Affine Nested Fractals as Calderón-Zygmund operators.*

We give the first natural examples of Calderón-Zygmund operators in the theory of analysis on post-critically finite self-similar fractals. This is achieved by showing that the purely imaginary Riesz and Bessel potentials on

nested fractals with 3 or more boundary points are of this type. It follows that these operators are bounded on L^p, $1 < p < \infty$ and satisfy weak 1-1 bounds. The analysis may be extended to infinite blow-ups of these fractals, and to product spaces based on the fractal or its blow-up. (Received August 04, 2010)

1062-46-162 **Zoltan M Balogh**, **Roberto Monti** and **Jeremy T Tyson*** (tyson@math.uiuc.edu), Department of Mathematics, University of Illinois, 1409 West Green Street, Urbana, IL 61801. *Frequency of Sobolev and quasiconformal dimension distortion.*

We study Hausdorff and Minkowski dimension distortion for images of generic affine subspaces of Euclidean space under Sobolev and quasiconformal maps. For a supercritical Sobolev mapping f defined on a domain in $\mathbf{R}^n$, we estimate from above the Hausdorff dimension of the set of affine subspaces parallel to a fixed m-dimensional linear subspace, whose image under f has positive $\mathcal{H}^\alpha$ measure for some fixed $\alpha > m$. As a consequence, we obtain new dimension distortion and absolute continuity statements valid for almost every affine subspace. Our results hold for mappings taking values in arbitrary metric spaces, yet are new even for quasiconformal maps of the plane. Our theory extends to cover mappings in Sobolev–Lorentz spaces as well as pseudomonotone mappings in the critical Sobolev class. In particular, we obtain new absolute continuity statements for quasisymmetric maps from Euclidean domains into metric spaces. (Received August 05, 2010)

1062-46-251 **Marius Ionescu** and **Luke G Rogers*** (luke.rogers@uconn.edu), 196 Auditorium Rd, Unit 3009, Storrs, CT 06269, and **Alexander Teplyaev**. *Derivations, Dirichlet forms and spectral analysis.*

I will outline some of our recent results on derivations and Fredholm modules on metric spaces with Dirichlet form. These encode some topological information: for example we show that if the space is a finitely ramified fractal then there is a non-trivial Fredholm module if and only if the space is not a tree. Natural examples include p.c.f. fractals and quantum graphs. (Received August 10, 2010)

1062-46-260 **Alexander Teplyaev*** (alexander.teplyaev@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269. *Spectral analysis on infinite Sierpinski fractafolds.*

A fractafold, a space that is locally modeled on a specified fractal, is the fractal equivalent of a manifold. For compact fractafolds based on the Sierpiński gasket, it was shown by Strichartz how to compute the discrete spectrum of the Laplacian in terms of the spectrum of a finite graph Laplacian. A similar problem was solved for the case of infinite blowups of a Sierpiński gasket, where spectrum typically is pure point of infinite multiplicity (and sometimes also have a singularly continuous component). Both works used the method of spectral decimation to obtain explicit description of the eigenvalues and eigenfunctions. In this paper we combine the ideas from these earlier works to obtain a description of the spectral resolution of the Laplacian for noncompact fractafolds. Our main abstract results enable us to obtain a completely explicit description of the spectral resolution of the fractafold Laplacian. For some specific examples we turn the spectral resolution into a "Plancherel formula". We also present such a formula for the graph Laplacian on the 3-regular tree, which appears to be a new result of independent interest. In the end we discuss periodic fractafolds and fractal fields.

This is a joint work with R.S. Strichartz. (Received August 10, 2010)

1062-46-264 **Maxim Zyskin*** (Maxim.Zyskin@Utb.edu), Dept Math, UTB, 80 Fort Brown, Brownsville, TX 78520. *On random integral currents, and counting lattice surfaces.*

Integral currents are generalized surfaces, which may be approximated by lattice surfaces. We show that for nice functions on a space of integral currents with compact support, for example for uniformly continuous and bounded functions, an invariant mean over integral currents can be uniquely defined. We also discuss bounds on number of surfaces on a finite lattice and of bounded norm. (Received August 10, 2010)

47 ► Operator theory

1062-47-25 **Palle E. T. Jorgensen*** (jorgen@math.uiowa.edu), Dept of Math MLH, University of Iowa, Iowa City, IA. *Analysis on Graphs.* Preliminary report.

This represents joint work with Erin Pearse. Our object is analysis on infinite weighted graphs. We make use of the theory of unbounded Hermitian operators in Hilbert space. While there is a large literature on discrete analysis treating such aspects as potential theory, probability, harmonic functions, and boundary theory; the questions we address here are different. For example, we obtain extensions of Shannon's theory of interpolation and sampling. Starting with an infinite graph G, and a suitable fixed positive weight function, we show that there are continua (certain sets X) extending G, and associated formulas for interpolation band-limited functions

on X from their values on G. Depending on the applications, we will be making use of several notions of metric and a variety of boundaries. (Received June 18, 2010)

1062-47-192 **Maria Cristina Pereyra*** (crisp@math.unm.edu), Department of Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131, and **Carlos Perez** and **DaeWon Chung**. *Sharp bounds for commutators on weighted Lebesgue spaces.*

In this talk we present optimal bounds for the commutator of singular integral operators and BMO functions. We show that if the operator bound in $L^2(w)$ is linear with respect to the A_2-characteristic of the weight w, then its commutator's operator bound must be at least quadratic with respect to the A_2-characteristic of the weight. Extrapolation then gives bounds in weighted $L^p(w)$. The results are sharp for all $1 < p < \infty$, and all dimensions as examples (Hilbert, Riesz and Beurling transforms) show. Note that the commutator itself is not a CZ singular integral operator (it is not of weak type (1,1) for example). (Received August 08, 2010)

49 ► Calculus of variations and optimal control; optimization

1062-49-94 **Alexander L Volberg*** (sashavolberg@yahoo.com), Dept of Math., MSU, East Lansing, MI 48824. *Monge–Ampère equation and Burkholder function.*

We show how one can find a celebrated Burkholder function by using Monge–Ampère equation. (Received July 29, 2010)

1062-49-175 **Yuesheng Xu*** (yxu06@syr.edu), Syracuse University, Department of Mathematics, Syracuse, NY 13244, and **Lixin Shen** (lshen03@syr.edu), Syracuse University, Department of Mathematics, Syracuse, NY 13244. *Proximal Fixed Point Algorithms for Total variation Image Denoising Models: Part I.* Preliminary report.

The total variation model is one of the earliest and efficient models for image denoising. The difficulty in minimizing functionals based on the total variation lies in non-differentiability of the total variation semi-norm and high dimension of image data. A number of ideas have been proposed to tackle this difficulty. In this talk, we will present a new treatment on the total variation model with the help of a careful study of the proximity operator and a formulation of the image denoising problem as fixed point equation. Mathematical insight of the proposed proximal fixed point algorithms will be provided. (Received August 06, 2010)

1062-49-176 **Lixin Shen***, Syracuse University, Department of Mathematics, Syracuse, NY 13244, and **Yuesheng Xu** (yxu06@syr.edu), Syracuse University, Department of Mathematics, Syracuse, NY 13244. *Proximal Fixed-point Algorithms for Total-Variation Image Denoising Models: Part II.* Preliminary report.

The total variation model is one of the earliest and efficient models for image denoising. The difficulty in minimizing functionals based on the total variation lies in non-differentiability of the total variation semi-norm and high dimension of image data. A number of ideas have been proposed to tackle this difficulty. In this talk, we will present a new treatment on the total variation model with the help of a careful study of the proximity operator and a formulation of the image denoising problem as fixed point equation. Mathematical insight of the proposed proximal fixed point algorithms will be provided. (Received August 06, 2010)

1062-49-188 **Yao Lu*** (yaol@med.umich.edu), Med-Inn Building C474, 1500 E. Medical Center Dr., Ann Arbor, MI 48109. *Regularization Methods for Digital Breast Tomosynthesis Reconstruction.*

Digital breast tomosynthesis (DBT) is an emerging imaging modality that can provide quasi-three-dimensional structural information of the breast. Low-dose x-ray projections of the breast are acquired at a small number of angles over a limited angular range. A set of tomosynthesized slices is reconstructed from the limited-angle projections. Detection of microcalcifications in DBT is challenging because of the large breast volume to be searched for small, subtle signals and the noise in the reconstructed volume. In this talk, we present some regularization methods developed for enhancement of microcalcifications in DBT. Potential microcalcifications are differentiated from the noisy background by the local geometric or statistical information. Different degrees of regularization are applied to the signal or noise classes such that the microcalcificaitons will be enhanced while noise is suppressed. (Received August 08, 2010)

1062-49-257 **Zhaoxia Yang*** (ychaox@mail.sysu.edu.cn), **Andrzej Krol** (krola@upstate.edu), **Yuesheng Xu** (yxu06@syr.edu) and **David H. Feiglin** (feiglind@upstate.edu).
Application of bias-noise curve for selecting hyperparameter for the total variation norm in the maximum a posteriori expectation maximization reconstruction in SPECT myocardial perfusion imaging.

The purpose of this study was to develop a more accurate method for estimation of the optimal value of hyperparameter for the Total Variation (TV) norm in the iterative Bayesian Maximum A Posteriori Ordered Subsets Expectation Maximization (MAP-OSEM) one step late tomographic reconstruction with Gibbs prior. Our aim was to reach the lowest bias at the lowest noise while maximizing uniformity and spatial resolution of the reconstructed myocardium in the parallel-beam collimator Single Photon Emission Computed Tomography (SPECT) myocardial perfusion imaging. Conventional approach is to use the highest curvature point on the L-curve to estimate the optimal value. However, we found the bias-noise curve obtained for the Region Of Interest (ROI) located inside the myocardium provides better estimation of the optimal value than the L-curve. Consequently, significantly higher quality of the reconstructed myocardium was attained , as compared to L-curve. We conjure that the bias-noise curve for a ROI located in the structure of interest (in our case the myocardium) provides local information on this structure, as opposed to the global information provided by the L-curve thus allowing better tuning of hyperparameter for the optimized reconstruction of this structure. (Received August 10, 2010)

1062-49-272 **Stacey Levine*** (sel@mathcs.duq.edu), 440 College Hall, Department of Mathematics & Computer Science, Pittsburgh, PA 15282. *A variational approach for exposure bracketing.* Preliminary report.

In this work we tackle the problem of fusing a set of images so that optimal information is obtained from each one. We propose a variational approach for fusing a set of bracketed images taken with different exposure times. The solution is a single image whose details and edges are extracted from a short exposure time image (typically low contrast) and color information is extracted from a long exposure time image (often suffering from motion blur). The approach is well posed and preserves level lines from the low contrast image. Numerical results demonstrate its effectiveness and improvements over the current state of the art. (Received August 10, 2010)

1062-49-282 **Nathan D Cahill*** (nathan.cahill@rit.edu), Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY 14623-5603. *Exploiting the Structure of Regularizers for Rapid Solutions of Variational Image Registration Problems.*

Variational image registration techniques combine image similarity measures with regularization terms in order to guarantee that the resulting functional minimization problem is well-posed. In practice, typical regularization terms are quadratic differential forms that can be either spatially homogeneous or adaptive. In this talk, we describe two different rapid computing paradigms for estimating the solution to the Euler-Lagrange equations resulting from various families of regularizers; one paradigm uses Fourier series solutions of the discretized Euler-Lagrange equations; the second employs convolution with a discretized Gaussian kernel to mimic the Green's function solution to coupled PDE systems related to the Euler-Lagrange equations. (Received August 11, 2010)

51 ► Geometry

1062-51-69 **Egon Schulte*** (schulte@neu.edu), Northeastern University, Department of Mathematics, Boston, MA 02115. *Highly Symmetric Complexes in Space.* Preliminary report.

We report on recent classification results for highly symmetric polyhedra-like structures in ordinary 3-space. In particular, we outline a full classification of regular "polygonal complexes" in 3-space, an ongoing joint project with Daniel Pellicer. Polygonal complexes are more general than polyhedra, in that they can have more than two faces meeting at an edge. (Received July 26, 2010)

1062-51-73 **Jeehyeon Seo*** (seo6@illinois.edu), 1409 W.Green Streeet, Urbana, IL 61801.
Bi-Lipschitz embeddability of the Grushin plane into Euclidean space.

Many sub-Riemmanian manifolds like the Heisenberg group do not admit bi-Lipschitz embedding into any Euclidean space. In contrast, the Grushin plane admits a bi-Lipschitz embedding into some Euclidean space. This is done by extending a bi-Lipschitz embedding of the singular line, using a Whitney decomposition of its complement. (Received August 10, 2010)

1062-51-86 **Barry Monson***, PO Box 4400, Fredericton, NB E3B 5A3, Canada. *Abstract Uniform Polytopes.* Preliminary report.

In the classical setting, a convex d-polytope $\mathcal{P}$ is said to be uniform if its facets are uniform and its symmetry group is transitive on vertices. To start this inductive definition in a pleasant way, we agree that uniform polygons should be regular. (Notice that the 1-skeleton of $\mathcal{P}$ will be a symmetric k-valent graph.)

The same definition can be transferred to the abstract (i.e. combinatorial) setting, where all polygons happen to be regular. Thus, the abstract uniform polytopes $\mathcal{P}$ form a huge, perhaps untamable, class of mostly unfamiliar objects, but certainly including all abstract regular polytopes, which are 'maximally' symmetric.

Here we discuss recent work by myself and others concerning the construction of uniform polytopes and their regular covers. (Received July 28, 2010)

1062-51-93 **Zhuomin Liu*** (zhl26@pitt.edu), 301 Thackeray Hall, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260, and **Mohammad Reza Pakzad** (pakzad@pitt.edu), 301 Thackeray Hall, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *A note on regularity and rigidity of codimension 1 Sobolev isometric immersions.* Preliminary report.

We prove regularity and developability of $W^{2,m}$ Sobolev isometric immersions of m-dimensional domains into R^{m+1}. A corollary is the strong density of smooth mappings in this class when the domain is convex. (Received July 29, 2010)

52 ► Convex and discrete geometry

1062-52-187 **Dmitriy Bilyk*** (bilyk@math.sc.edu), 1523 Greene Str., Department of Mathematics, Columbia, SC 29208. *On sets with low extremal and L^2 discrepancies.*

In this talk we shall discuss constructions of low discrepancy point distributions. It is well known, that many classical sets with low extremal discrepancy, such as the irrational lattice or the van der Corput set, fail to meet the optimal L^2 discrepancy estimates. Several remedies exist for this shortcoming. We shall describe some of these techniques, in particular, a "de-randomization" of classical probabilistic arguments. (Received August 08, 2010)

1062-52-227 **Patrik Noren*** (pnore@kth.se), Department of Mathematics, 100 44 Stockholm, Sweden, and **Alex Engstrom** (alex@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, 851 Evans Hall #3840, Berkeley, CA 94720. *Polytopes from exponential random graph models.* Preliminary report.

Several algorithms for maximum likelihood estimation for exponential random graph models depend on the structure of polytopes whose vertices enumerate subgraphs. For one such class of polytopes, introduced by Fienberg and Rinaldo, we present new structure results about facets and normal fans. (Received August 09, 2010)

53 ► Differential geometry

1062-53-3 **William P. Minicozzi*** (minicozz@jhu.edu), Department of Mathematics, JHU, 3400 N. Charles St., Baltimore, MD 21218. *Generic singularities of Mean Curvature Flow.*

In mean curvature flow (or MCF), a surface evolves to minimize its surface area as quickly as possible. One of the challenges of MCF is that the flow starting from a closed surface (like a sphere) always becomes singular and one of the most important problems is understanding these singularities. The simplest example comes from a round sphere, which evolves by staying round but having the radius shrink until it hits zero and then just disappears (or "becomes extinct"). Matt Grayson proved that this is the only type of singularity that occurs for simple closed curves in the plane. However, many other examples were discovered in higher dimensions (most of them by applied mathematicians doing numerical simulations).

I will describe recent work with Tobias H. Colding, MIT, where we:

1. Classify the generic singularities of MCF of closed embedded hypersurfaces.
2. Prove compactness of all (even non-generic) singularities.

I will also discuss an application, where we construct a "generic mean curvature flow". (Received July 28, 2010)

1062-53-26 **Ovidiu Munteanu*** (omuntean@math.columbia.edu), Math Department, Columbia University, Room 509, MC 4406, 2990 Broadway, New York, NY 10027. *Complete manifolds with positive spectrum.*

We study sharp upper bound estimates for the bottom of spectrum of the Laplace operator on complete Kahler manifolds. The structure of manifolds that achieve this upper bound will also be discussed. (Received June 21, 2010)

1062-53-54 **Scott A. Wolpert*** (saw@math.umd.edu), Department of Mathematics, College Park, MD 20742. *Geodesic-length functions and the Weil-Petersson curvature tensor (available on ArXiv).*

Liu-Sun-Yau use expansions for WP curvature for algebro-geometric results about the moduli space of Riemann surfaces. Burns-Masur-Wilkinson use expansions for geodesic-length functions ℓ_* and curvature tensor in their proof of WP geodesic flow ergodicity. Cavendish-Parlier use a bound for curvature to find the moduli space asymptotic WP diameter.

We present results for the curvature tensor using gradients $\lambda_a = grad\, \ell_a^{1/2}$: $R(\lambda_a, \lambda_a, \ , \ ) = 3|\langle \lambda_a, \ \rangle|^2/4\pi\ell_a + O(\ell_a)$ and disjoint geodesics, at most pairs coinciding, $R(\lambda_a, \lambda_b, \lambda_c, \lambda_d) = O((\ell_a\ell_b\ell_c\ell_d)^{1/2})$. For the surface systole, the sectional curvatures at S are at least $-(3+\epsilon)/\pi\Lambda(S)$ and, except for diagonal evaluation, the tensor evaluated for geodesic-lengths for a pants decomposition is continuous near the corresponding stratum of the augmented Teichmüller space. The tensor also has an asymptotic factorization corresponding to the nodes and components of the limiting noded surface. A classification is given for limits of almost flat tangent sections. The techniques are applied to find the asymptotic maximal ratio $(2/\pi\Lambda(S))^{1/2}$ of L^∞ and L^2 norms for holomorphic qds $Q(S)$. (Received July 21, 2010)

1062-53-61 **Xiangwen Zhang*** (xzhang@math.mcgill.ca), Department of Mathematics and Statistics, McGill University, 805 Sherbrooke W., Burnside Hall, Room 1020, Montreal, Quebec H3A 2K6, and **Sławomir Dinew** and **Xi Zhang**. *$C^{2,\alpha}$ estimate for the complex Monge-Ampére equation.*

In the talk a regularity result for the complex Monge-Ampère equation will be presented. We will prove that any $C^{1,1}$ plurisubharmonic solution u to the problem $\det(u_{i\bar{j}}) = f$ with f strictly positive and Hölder continuous has in fact Hölder continuous second derivatives. For smoother f this follows from the classical Evans-Krylov theory yet in our case it cannot be applied directly. To generate this $C^{2,\alpha}$ regularity estimate in the Hermitian setting, we will give the Bedford-Taylor interior C^2 estimate and a local version of the Calabi C^3 estimate on Hermitian manifolds. (Received July 22, 2010)

1062-53-70 **William Abikoff*** (abikoff@math.uconn.edu), Mathematics Department, U-3009, University of Connecticut, Storrs, CT 06278-3009, and **Clifford J Earle** (cliff@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853-4201. *Barycentric (Douady-Earle) Extension via MAY iterations.* Preliminary report.

Barycentric extensions of monotone degree $\pm$ 1 maps of the circle were studied by Abikoff, Earle and Mitra (Contemp. Math. 355(2004) 1-20) following earlier work of Abikoff and Ye and Milnor. We show that, using the formalism of moebius transformations with entries in Clifford algebras, the technique extends to higher dimensional real hyperbolic spaces. We will also discuss MAY iterations in complex hyperbolic space. (Received July 26, 2010)

1062-53-92 **Mao-Pei Tsui*** (Mao-Pei.Tsui@Utoledo.edu), Department of Mathematics, The University of Toledo, Toledo, OH 43606. *Mean curvature flow and the deformation of maps between manifolds.*

In this talk, we shall discuss how mean curvature flows (MCF) can be used to study several geometric problems related to maps between manifolds. (Received July 28, 2010)

1062-53-103 **Bing Wang*** (bingw@math.princeton.edu), 4817 Sheboygan Avenue, Room 218, Madison, WI 53705, and **Xiuxiong Chen**. *Space of Ricci flows.*

Under the noncollapsing condition, we show that Ricci flows with bounded scalar curvature, bounded half dimensional curvature integral norm have weak compactness property. This weak compactness property has applications in the convergence of Kähler Ricci flows on Fano manifolds and the moduli space of Ricci solitons. (Received July 31, 2010)

1062-53-105 **Xiangjin Xu*** (xxu@math.binghamton.edu), Department of Mathematical Sciences, Binghamton University-SUNY, Binghamton, NY 13902-6000. *Gradient estimates for the degenerate parabolic equation on manifolds and some Liouville-type theorems.* Preliminary report.

In this talk, we first prove a localized Hamilton-type gradient estimate for the positive solutions of the ecumenic degenerate parabolic equation:

$$u_t = \Delta F(u),$$

with $F'(u) > 0$, on a complete Riemannian manifold with Ricci curvature bounded below, $Ric(M) \geq -k$ with $k \geq 0$.

The second part of this talk, we apply the gradient estimates to the Fast Diffusion Equations (FDE) ($0 < p < 1$) and Porous Media Equations (PME) ($p > 1$):

$$u_t = \Delta(u^p), \qquad p > 0,$$

to obtain the gradient estimates in a larger range of p than the range of p for Harnack inequalities and Cauchy problems in the literature, and also prove some Liouville-type theorems for positive global solutions on noncompact complete manifolds with nonnegative Ricci curvature for the FDEs and the PMEs, which generalize Yau's celebrated Liouville Theorem for positive harmonic functions. (Received July 31, 2010)

1062-53-114 **L Wang*** (luwang@math.mit.edu), Department of Mathematics, 77 Massachusetts Avenue, Cambridge, MA 02139. *A Bernstein Type Theorem For Self-Similar Shrinkers.*

In this talk, we discuss the Bernstein theorem for self-shrinkers under mean curvature flow. Namely, we show that the only smooth entire graphical self-shrinkers in $\mathbb{R}^{n+1}$ are hyperplanes. The method we use parallels the Bernstein theorem for minimal hypersurfaces. (Received August 02, 2010)

1062-53-149 **Mihai Bailesteanu*** (mbailesteanu@math.cornell.edu), 120 Malott Hall, Cornell University, Ithaca, NY 14853. *Bounds on the Heat Kernel under the Ricci Flow.*

We establish an estimate for the fundamental solution of the heat equation on a closed Riemannian manifold M, evolving under the Ricci flow. The estimate depends on some constants arising from a Sobolev imbedding theorem. Considering the case when the scalar curvature is positive throughout the manifold, at any time, we will obtain, as a corollary, a bound similar to the one known for the fixed metric case. (Received August 04, 2010)

1062-53-156 **Longzhi Lin*** (lzlin@math.jhu.edu), Department of Mathematics, Johns Hopkins University, 3400 N Charles Street, Baltimore, MD 21218, and **Ling Xiao**. *Modified Mean Curvature Flow of Star-shaped Hypersurfaces in Hyperbolic Space.*

In this talk we will discuss the existence, uniqueness and convergence of the modified mean curvature flow (MMCF) of complete embedded star-shaped hypersurfaces in hyperbolic space with fixed prescribed asymptotic boundary at infinity. We shall see that this MMCF is the natural negative L^2-gradient flow of an energy functional. As a by-product, we recover the existence and uniqueness of smooth complete hypersurfaces of constant mean curvature in hyperbolic space with prescribed asymptotic boundary at infinity, which was first shown by Guan and Spruck. This is a joint work with Ling Xiao from Johns Hopkins University. (Received August 04, 2010)

1062-53-166 **Zheng Huang*** (zheng.huang@csi.cuny.edu), Department of Mathematics, CUNY- CSI, 2800 Victory Blvd., Staten Island, NY 10314, and **Biao Wang** (wangbiao2008@yahoo.com), Department of Mathematics, Central Connecticut State University, 1615 Stanley St., New Britain, CT 06050. *Closed Surfaces of Prescribed Mean Curvature in Hyperbolic Three-manifolds.* Preliminary report.

Using mean curvature flow in a class of complete hyperbolic three-manifolds, we obtain closed incompressible surfaces (of genus > 1) with prescribed mean curvature, in particular, CMC surfaces. (Received August 05, 2010)

1062-53-178 **Chi Li*** (chil@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544-1000. *On rotationally symmetric Kahler-Ricci solitons.*

Using Calabi's method, we construct rotationally symmetric Kahler-Ricci solitons on the total space of direct sum of fixed hermitian line bundle and its projective compactification, where the curvature of hermitian line bundle is Kahler-Einstein. These examples generalize the construction of Koiso, Cao and Feldman-Ilmanen-Knopf. (Received August 07, 2010)

1062-53-179 **Shihshu Walter Wei*** (wwei@ou.edu), Professor Shihshu Walter Wei, Department of Mathematics, The University of Oklahoma, Norman, OK 73019. *The unity and simplicity of p-harmonic geometry.*

We'll discuss the unity and simplicity of p-harmonic geometry by way of simple example rather than by philosophical generalities.

Let $F : [0, \infty) \to [0, \infty)$ be a strictly increasing C^2 function with $F(0) = 0$. Then one can define F-energy and $F-$*harmonic map* in a similar way to p-energy and p- harmonic map.

We unify the concepts of F-harmonic maps, minimal hypersurfaces in Euclidean space, maximal spacelike hypersurfaces in Minkowski space, and Yang-Mills Fields, and introduce *F-Yang-Mills fields*, F-degree, and generalized Yang-Mills-Born-Infeld fields (with the plus sign or with the minus sign) on manifolds. When $F(t) = t\,, \frac{1}{p}(2t)^{\frac{p}{2}}\,, \sqrt{1+2t} - 1\,,$ and $1 - \sqrt{1-2t}\,,$ the F-Yang-Mills field becomes an ordinary Yang-Mills field, p-Yang-Mills field, a generalized Yang-Mills-Born-Infeld field with the plus sign, and a generalized Yang-Mills-Born-Infeld field with the minus sign on a manifold respectively.

We will discuss their common features in geometric analysis and geometric measure theory.

We will also discuss *sharp geometric inequalities on manifolds*. Some applications to geometry, topology, differential equations, several complex variables, and geometric flows will be considered. (Received August 07, 2010)

1062-53-199 **Joerg Enders*** (joerg.enders@aei.mpg.de), Max Planck Inst. for Gravitational Physics, (Albert Einstein Institute), Am Muehlenberg 1, 14476 Golm, Germany. *On Type I Singularities in Ricci Flow.*

In this talk, we will focus on the structure of singularities in Type I Ricci flows. We will show that blow-ups around singular points converge to *nontrivial* gradient shrinking solitons, thus extending work of Naber. Using this, we will prove that different notions of singular set for Type I Ricci flows all coincide. In particular, this implies that the scalar curvature blows up at any singular point and that a finite volume of the singular set vanishes at the singular time. After the definition of a density for Type I Ricci flows we will conclude with a regularity theorem reminiscent of White's partial regularity result for mean curvature flow. This is joint work with Reto Müller and Peter M. Topping. (Received August 08, 2010)

1062-53-239 **Aaron Charles Naber*** (anaber@mit.edu) and **Tobias Colding**. *Lower Ricci Curvature, Convexity and Applications.*

We prove new estimates for tangent cones along minimizing geodesics in GH limits of manifolds with lower Ricci curvature bounds. We use these estimates to show convexity results for the regular set of such limits. Applications include the proofs of several conjectures dating back to the work of Cheeger/Colding and the ruling out of certain limit spaces, including the so called generalized trumpet spaces. We construct new examples which exhibit various new behaviors and show sharpness of the new theorems. This work is joint with Toby Colding. (Received August 10, 2010)

55 ► Algebraic topology

1062-55-284 **Jeremy T Brazas*** (jtv5@unh.edu), Kingsbury Hall, Dept. of Mathematics and Statistics, Durham, NH 03824. *The Topological Fundamental Group and Free Topological Groups.*

The topological fundamental group π_1^{top} is a homotopy invariant finer than the usual fundamental group. It assigns to each space a quasitopological group and is discrete on spaces which admit universal covers. For an arbitrary space X, we compute the topological fundamental group of the suspension space $\Sigma(X_+)$ and find that $\pi_1^{top}(\Sigma(X_+))$ either fails to be a topological group or is the free topological group on the path component space of X. Using this computation, we provide an abundance of counterexamples to the assertion that all topological fundamental groups are topological groups. A relation to free topological groups allows us to reduce the problem of characterizing Hausdorff spaces X for which $\pi_1^{top}(\Sigma(X_+))$ is a Hausdorff topological group to some well known classification problems in topology. (Received August 11, 2010)

57 ► Manifolds and cell complexes

1062-57-134 **Brigitte Servatius*** (bservat@wpi.edu), Mathematical Sciences, WPI, Worcester, MA 01609-2280. *The Cube and its Petrie Dual embedded in* $\mathbb{R}^3$.

A graph G with a cellular embedding on a surface S has a well-defined geometric dual G^*, and both G and G^* can be drawn on S in a nice way so that the vertices/faces of G^* correspond to the faces/vertices of G.

The Petrie dual of G embedded on S does not change G, but replaces the faces of G on S with Petrie paths, so the graph G can be thought of as the intersection of two surfaces, S and S^P.

We ask if, given an embedding of the cube graph G in $\mathbb{R}^3$, which we think of as a wire frame, can we say what the corresponding natural surface is? Is it always the cube or can it be the Petrie dual of the cube, or can it be both? (Received August 03, 2010)

1062-57-146 **Satyan L. Devadoss*** (satyan.devadoss@williams.edu), **Timothy Heath** and **Cid Vipismakul**. *Deformations of bordered Riemann surfaces and convex polytopes.*

We consider the moduli space of Riemann surfaces with boundary and marked points. Such spaces appear in open-closed string theory, particularly with respect to holomorphic curves with Lagrangian submanifolds. We consider a combinatorial framework to view the compactification of this space based on the pair-of-pants decomposition of the surface, relating it to the well-known phenomenon of bubbling. Our main result classifies all such spaces that can be realized as convex polytopes. A new polytope is introduced based on truncations of cubes, and its combinatorial and algebraic structures are related to generalizations of associahedra and multiplihedra. (Received August 04, 2010)

1062-57-224 **Alex Engstrom*** (alex@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, 851 Evans Hall #3840, Berkeley, CA 94720. *Topological representation of matroids from diagrams of spaces.*

Swartz proved that any matroid can be realized as the intersection lattice of an arrangement of codimension one homotopy spheres on a sphere. This was an unexpected extension from the oriented matroid case, but the construction is not explicit. Anderson later provided an explicit construction, but had to use cell complexes of high dimensions that are homotopy equivalent to lower dimensional spheres.

Using diagrams of spaces we give an explicit construction of arrangements in the right dimensions. Swartz asked if it is possible to arrange spheres of codimension two, and we provide a construction for any codimension. We also show that all matroids, and not only tropical oriented matroids, have pseudo-tropical representations.

We determine the homotopy type of all the constructed arrangements. (Received August 09, 2010)

58 ► Global analysis, analysis on manifolds

1062-58-104 **Jeffrey Streets***, 27 E Delaware, Pennington, NJ 08534. *Geometric flows on complex manifolds.*

In joint work with Gang Tian, I have introduced a natural geometric evolution equation generalizing the Kahler Ricci flow to certain nonKahler metrics. I will discuss the regularity properties of this flow, as well as a conjectural picture of the optimal regularity results, and finally some new concrete topological applications of this conjectural picture. (Received July 31, 2010)

1062-58-137 **Naotaka Kajino*** (kajino.n@acs.i.kyoto-u.ac.jp), Graduate School of Informatics, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto, 606-8501, Japan. *Heat kernel asymptotics for the measurable Riemannian structure on the Sierpinski gasket.*

Kigami [*Math. Ann.* **340** (2008), 781–804] has introduced the notion of the *'measurable Riemannian structure'* on the Sierpinski gasket, where we have the analogues of the basic objects in Riemannian geometry like the gradient vector fields of functions, the Riemannian volume measure μ and the geodesic metric $d_{\mathcal{H}}$. Moreover, Kigami has shown in the same paper that the associated heat kernel $p_t^{\mathcal{H}}(x,y)$ is subject to the two-sided Gaussian bound

$$p_t^{\mathcal{H}}(x,y) \asymp \frac{c_1}{\mu\big(B_{\sqrt{t}}(x,d_{\mathcal{H}})\big)} \exp\left(-\frac{d_{\mathcal{H}}(x,y)^2}{c_2 t}\right) \tag{1}$$

in spite of the fractal nature of the space.

In this talk various short time asymptotic behaviors of $p_t^{\mathcal{H}}(x,y)$ will be presented. In particular, we show the so-called *Varadhan's asymptotic relation*

$$\lim_{t\downarrow 0} 2t \log p_t^{\mathcal{H}}(x,y) = -d_{\mathcal{H}}(x,y)^2, \tag{2}$$

and also the existence of the limit $\lim_{t\downarrow 0} t^{1/2} p_t^{\mathcal{H}}(x,x) \in (0,\infty)$ for every junction point x.

JSPS Research Fellow PD (20·6088): The author is supported by the Japan Society for the Promotion of Science. (Received August 03, 2010)

1062-58-160 **Chenxu He*** (he.chenxu@lehigh.edu), Christmas-Saucon Hall, 14 E. Packer Ave, Bethlehem, PA 18015, **Peter Petersen** (petersen@math.ucla.edu), UCLA Mathematics Department, 520 Portola Plaza, Los Angeles, CA 90095, and **William Wylie** (wylie@math.upenn.edu), 209 South 33rd Street, Phialdelphia, PA 19104. *On m-Quasi Einstein Metrics.*

We say an n-dimensional Riemannian manifold is an m-Quasi Einstein metric if it is the base of an (n+m)-dimensional warped product Einstein manifold. We view the m-Quasi Einstein equation as a generalization of the Einstein equation (since an Einstein manifold is the base of a trivial product Einstein manifold). The m-Quasi Einstein equation is also closely related to the gradient Ricci soliton equation. In this talk I will give an overview of some earlier results about the classification of m-quasi Einstein metrics and show some new results under various curvature and symmetry conditions. This is joint work with Peter Petersen from UCLA and William Wylie from UPenn. (Received August 05, 2010)

1062-58-193 **Michel L Lapidus*** (lapidus@math.ucr.edu), Department of Mathematics, University of California, Riverside, CA 92521-0135, and **Hung Lu** (hlu@hpu.edu), Department of Mathematics, Hawai'i Pacific University, Honolulu, HI 96813-2785. *p-Adic Fractal Strings and Their Complex Dimensions, via Geometric Zeta Functions and Tube Formulas.*

The archimedean theory of fractal strings and their complex dimensions has been developed by the author and his collaborators, particularly Machiel van Frankenhuijsen, in a series of papers and research monographs. See, e.g., the book (by MLL & M-vF) "Fractal Geometry, Complex Dimensions and Zeta Functions", Springer, 2006 (2nd rev. and enl. ed. to appear in 2011). In this talk, we present a nonarchimedean (i.e., p-adic) counterpart of aspects of this theory, with particular focus on p-adic self-similar strings. We determine the structure of the complex dimensions (defined as the poles of a suitably defined zeta function) and show that every p-adic self-similar string is lattice" (or "arithmetic"), in a strong sense; we deduce that both the zeroes and the poles of the associated geometric zeta function are periodically distributed. We also obtain a (distributional) p-adic tube formula in this context, for the volume of suitably defined nonarchimedean tubular neighborhoods of the string. If time permits, we will conclude by proposing several open problems in this area, related in part to seemingly new aspects of p-adic harmonic and functional analysis. (Received August 08, 2010)

1062-58-223 **Joe P Chen*** (jpc64@cornell.edu), Department of Physics, Cornell University, Ithaca, NY 14853, and **Robert S Strichartz** (str@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *Spectral Asymptotics on Three-Dimensional Fractal Sponges.* Preliminary report.

Weyl's asymptotic formula states that the eigenvalue counting function $N(s)$ for the Laplacian $-\Delta$ on a compact d-dimensional Riemannian manifold satisfies $N(s) \sim s^{d/2}$ as $s \to \infty$. Defining the Weyl ratio as $W(s) := N(s)s^{-d/2}$, we have $W(s) \sim 1$. The situation is very different on fractals: d is replaced by the spectral dimension, and $W(s)$ might not have a limit. Recent asymptotic studies have focused on post-critically finite fractals and generalized Sierpinski carpets.

In this talk we will present results on 3-dimensional infinitely ramified fractals, including fully symmetric sponges (e.g. Menger sponge), homogeneous hierarchical sponges, and random hierarchical sponges. Using the finite element method, we numerically computed the Neumann Laplacian spectrum on each sponge. In every case, we found that the Weyl ratio $W(s)$ was segmented into distinct log periods: Notably, $W(s)$ restricted to the m-th period ("sounds of the drum") correlated strongly with the geometry of the m-th level construction of the fractal ("shape of the drum"). We will describe this so-called spectral segmentation heuristic, discuss its connection to Varadhan's asymptotics for the heat kernel, and comment on sub-Gaussian diffusion in sponges. (Received August 10, 2010)

1062-58-271 **Greg Francos***, Department of Mathematics, University of Pittsburgh, 301 Thackeray Hall, Pittsburgh, PA 15260, and **Piotr Hajlasz**. *Lusin-type Approximation of Higher-Order Functions of Bounded Variation.* Preliminary report.

A BV function is an L^1 function whose distributional derivatives are Radon measures of finite total variation. Given a BV function f, there exists a C^1 function that coincides with f outside a set of arbitrarily small Lebesgue measure. We extend this result to higher-order functions of bounded variation; i.e. functions $f \in W^{m-1,1}$ whose $(m-1)$st order derivatives are each in BV. Specifically, we show that such an function coincides with a C^m function outside a set of arbitrarily small Lebesgue measure. We also address whether such Lusin-type

approximations may be chosen to converge to f in $W^{m-1,1}$ and with respect to the stronger notion of 'strict convergence'. (Received August 10, 2010)

60 ► Probability theory and stochastic processes

1062-60-245 **Benjamin Steinhurst***, Department of Mathematics, Cornell University, Ithaca, NY 14850. *Uniqueness of Locally Symmetric Brownian Motion on Laakso Spaces.*

Barlow, Bass, Kumagai, and Teplyaev have recently shown (2010) that diffusions on generalized Sierpinski carpets that respect all of the local symmetries of the carpets are all equivalent up to time change. We extend their results to Laakso spaces having a similar cell structure to Sierpinski carpets but with not necessary scale invariance. In this situation explicit resistance estimates have been replaced with exit time estimates derived directly from the cell structure of the Laakso spaces. (Received August 10, 2010)

1062-60-250 **Richard E Neville*** (rn172587@albany.edu), 73 Norwood Avenue, Albany, NY 12208. *Finding A Sequence of Improvements To Hildebrand's Lower Bound Of the Chung Diaconis-Graham Random Process.* Preliminary report.

Chung, Diaconis, and Graham considered random processes of the form Xn+1 = anXn + bn (mod p) where p is odd, X0 = 0, an = 2 always and bn are i.i.d. for n = 0,1,2,... and Hildebrand later showed that if P(bn = -1) = P(bn = 0) = P(bn = 1) = 1/3, then there exists a constant c ≈ 1.00448 such that c(log2 p) steps are not enough to make Xn approach a uniform distribution on the integers mod p. This talk discusses a proof of an algorithmic method to determine improved (larger) values for c, thus raising the lower bound for the length of the walk needed for the process to approach uniformly distributed. (Received August 10, 2010)

1062-60-262 **Uta Renata Freiberg*** (freiberg@mathematik.uni-siegen.de), University of Siegen, FB6 - Mathematics, Walter-Flex-Strasse 3, 57068 Siegen, Germany. *Eigenfrequencies of V-variable Sierpinki gaskets.*

The concept of V-variable fractals (developed by Barnsley, Hutchinson and Stenflo) allows describing new families of random fractals, which are intermediate between the notions of deterministic and of random fractals including random recursive as well as homogeneous random fractals. The parameter V describes the degree of variability of the realizations. Brownian motion and Laplacian can be constructed from the associated Dirichlet forms. The properties of these objects are modified by the random environment. We obtain the spectral dimension (i.e. the exponent of the leading term of the eigenvalue counting function of the Laplacian) by applying Kesten-Furstenberg techniques. The results have been obtained in collaboration with Ben Hambly and John Hutchinson. (Received August 10, 2010)

65 ► Numerical analysis

1062-65-38 **Jian Zhang*** (jzhang_mail04@yahoo.com), Pomona, NY 10970. *A Novel Method for Trend Forecast and Curve-fitting Data.* Preliminary report.

A method for forecasting trends and curve fitting data is described. This method utilizes the simultaneous analysis of repetitive data sets or multiple related variables. The trajectory of the moving object can be forecasted by multivariate calculus. If the path of the interest object is F(x, y, z, t), and x, y, z are the other variables or repetitive data series. The ∂F(t)/(x,y,z) or ∂F(t) /∂(x,y,z) values are indicative of the potential turning points of F(t). This method provides better forecast and fit than common regression functions, moving averages or simplistic modeling of single data series. (Received July 08, 2010)

1062-65-180 **Aaron B Luttman*** (aluttman@clarkson.edu), Clarkson University, Box 5815, Potsdam, NY 13676. *A Variational Optical Flow Approach to Computing Oceanic Flows.* Preliminary report.

Optical flow is a technique from computer vision for computing vector fields that describe physical movement in a scene based on image data. The classical variational methods were designed to compute flows that are smooth and divergence free, which can be appropriate for rigid motions, but more recently methods have been developed based on total-variation regularization and the continuity equation from fluid dynamics that allow the computation of non-smooth and divergent flows. In particular, minimizing hybrid energies allows the computation of turblent flows describing dynamical processes. We present some recent approaches to computing flows from satellite imagery, with applications to modeling flow dynamics in oceanic waterways. (Received August 07, 2010)

1062-65-254 **Rosemary A Renaut*** (renaut@asu.edu), School of Mathematical and Statistical, Sciences, Arizona State University, 871804, Tempe, AZ 85287. *Multisplitting for Solving the Regularized Least Squares Problem with Krylov Subspace Recycling.* Preliminary report.

We consider a general approach for the solution of ill-posed and overdetermined systems of equations using the method of multi-splitting which was introduced for linear systems of equations in 1985 by O'Leary and White and extended for least squares problems by Renaut in 1995. It is easily extended for Tikhonov regularized least squares, by applying the relevant decomposition to the augmented functional. Convergence results for the least squares problem extend for the regularized case.

This work is novel in the context of least squares solvers and for general multisplitting. The use of Krylov subspace recycling for efficient solution of the local split problems, takes advantage of the fact that the local problems with fixed system but updated right hand side are solved multiple times throughout the global iteration to convergence. Updates of the underlying Krylov subspace for the multiple right hand side system improve the algorithm efficiency. The multisplitting algorithm allows different regularization operators and parameters for different domains.

Numerical validation is presented for the reconstruction of the Shepp-Logan phantom and a 1D restoration problem with variable noise in the signal. Using GPU's allows an efficient algorithm for image restoration. (Received August 10, 2010)

1062-65-270 **Yang Wang*** (ywang@math.msu.edu), Yang Wang, Department of Mathematics, Michigan State University, East Lansing, MI 48824-1270. *EMD Analysis of Visual Stylometry.*

In this talk we show how the tools of empirical mode decomposition (EMD) analysis can be applied to the problem of "visual stylometry," generally defined as the development of quantitative tools for the measurement and comparisons of individual style in the visual arts. In particular we introduce a new form of EMD analysis for images and show that it is possible to use its output as the basis for the construction of effective support vector machine based stylometric classifiers. We present the methodology and then test it on a collection of digital captures of drawings attributed to the great Flemish artist Pieter Bruegel the Elder (1525-1569), some of whose attributions are secure and some that are either known or suspected to be imitations. Our positive results indicate that this approach holds strong promise generally as a technique for visual stylometry. (Received August 10, 2010)

68 ► Computer science

1062-68-119 **Akram Aldroubi*** (akram.aldroubi@vanderbilt.edu), Dept. of Math. 1520 SC, Vanderbilt University, Nashville, TN 37240. *The subspace clustering problem and its application to motion tracking in video.*

The subspace clustering problem is a dimensionality reduction problem that has applications in movement tracking in video sequences and in facial recognition for example. It also has connections to many areas of mathematics, computer science and engineering such as the Generalized Principle Component Analysis (GPCA), learning theory, compressed sensing, and sampling with finite rate of innovation. In this talk, we will state the problem, present some mathematical results and algorithms for solving it, and show how its solution can be used to track moving objects in video sequences. (Received August 02, 2010)

1062-68-177 **Yilun Wang*** (yilun.wang@gmail.com) and **Wotao Yin** (wotao.yin@rice.edu). *Sparse Signal Reconstruction via Iterative Support Detection.*

We present a novel sparse signal reconstruction method "ISD", aiming to achieve fast reconstruction and a reduced requirement on the number of measurements compared to the classical ℓ_1 minimization approach. ISD addresses failed reconstructions of ℓ_1 minimization due to insufficient measurements. It estimates a support set I from a current reconstruction and obtains a new reconstruction by solving the minimization problem $\min\{\sum_{i\notin I}|x_i| : Ax = b\}$, and it iterates these two steps for a small number of times. ISD differs from the orthogonal matching pursuit (OMP) method, as well as its variants, because (i) the index set I in ISD is not necessarily nested or increasing and (ii) the minimization problem above updates all the components of x at the same time. We generalize the *Null Space Property* to *Truncated Null Space Property* and present our analysis of ISD based on the latter. We introduce an efficient implementation of ISD, called threshold–ISD, for recovering signals with fast decaying distributions of nonzeros from compressive sensing measurements.

MATLAB code is available for download from http://www.caam.rice.edu/~optimization/L1/ISD/. (Received August 07, 2010)

1062-68-196 **Micha Hofri*** (hofri@wpi.edu), Department of CS, WPI, 100 Institute Road, Worcester, MA 01609-2280. *Revisiting Quick Sort with Repeated Keys.* Preliminary report.

We revisit developments of the Quick Sort algorithm designed to handle efficiently files with many repeated values, a common situation in data processing. The measure of interest is the number of comparisons. While their expected number has been available, the variance is not, and it is of interest, due to the relatively large variance ratio of this measure. A computation and some numerical examples are given. (Received August 08, 2010)

76 ► Fluid mechanics

1062-76-37 **Ahmed Ahmed kaffel*** (kaffel07@gmail.com), 1404 J university city blvd, Blacksburg, VA 24060, and **Michael Renardy**. *On the stability of plane parallel viscoelastic shear flows in the limit of infinite Weissenberg and Reynolds numbers.* Preliminary report.

Elastic effects on the hydrodynamic instability of inviscid parallel shear flows are investigated through a linear stability analysis. We focus on the upper convected Maxwell model in the limit of infinite Weissenberg and Reynolds numbers. Specifically, we study the effects of elasticity on the instability of a few classes of simple parallel flows, specifically plane Poiseuille and Couette flows, the hyperbolic-tangent shear layer and the Bickley jet. The equation for stability is derived and solved numerically using the spectral Chebyshev collocation method. This algorithm is computationally efficient and accurate in reproducing the eigenvalues. We consider flows bounded by walls as well as flows bounded by free surfaces. In the inviscid, nonelastic case all the flows we study are unstable for free surfaces. In the case of wall bounded flow, there are instabilities in the shear layer and Bickley jet flows. In all cases, the effect of elasticity is to reduce and ultimately suppress the inviscid instability. (Received July 08, 2010)

86 ► Geophysics

1062-86-7 **Ahmed Ahmed kaffel*** (kaffel07@gmail.com), 1404 j university city blvd, Blacksburg, VA 24060. *Barotropic instability in Geophysical Fluid Dynamics.* Preliminary report.

The beta effect on the barotropic instability of parallel shear flows are investigated through a linear stability analysis. We focus on the primitive equations model of the geophysical fluid dynamics to study the beta effect on the instability of a few classes of simple parallel flows particularly for the plane Poiseuille and Couette flows and for the hyperbolic-tangent shear layer and the Bickley jet flows. The Rayleigh stability equation is derived and solved numerically using the spectral Chebyshev collocation method. This algorithm is computationally efficient and accurate in reproducing the eigenvalues. In the inviscid case all the Plane Poiseuille and Couette flows we study are stable. In the case of the shear layer and Bickley jet flows, there are instabilities. In these cases, the effect of the number beta is to reduce and ultimately suppress the inviscid instability. 1 (Received May 09, 2010)

92 ► Biology and other natural sciences

1062-92-263 **Jiehua Zhu*** (jzhu@georgiasouthern.edu), Mathematical Sciences, Georgia Southern University, 0203 Georgia Ave., Statesboro, GA 30460, and **Xiezhang Li** (xli@georgiasouthern.edu), Mathematical Sciences, Georgia Southern University, 0203 Georgia Ave., Statesboro, GA 30460. *Full row-rank matrix from strip-based projection model.*

Let $C\mathbf{u} = \mathbf{k}$ be an underdetermined linear system generated by the strip-based projection model in discrete tomography, where C is row-rank deficient. In the case of one scanning direction the linear dependency of the rows of C is studied in this paper. An index set H is specified such that if all rows of C with row indices in H are deleted then the rows of resultant matrix F are maximum linearly independent rows of C. Therefore, the corresponding system $F\mathbf{u} = \widetilde{\mathbf{k}}$ is equivalent to $C\mathbf{u} = \mathbf{k}$ and consequently, the cost of an image reconstruction from $F\mathbf{u} = \widetilde{\mathbf{k}}$ is reduced. (Received August 10, 2010)

97 ► Mathematics education

1062-97-22 **Anne L Porter*** (alp@uow.edu.au), University of Wollongong, Wollongong, NSW 2522, Australia. *The Grand Scheme for Supporting Learning in Mathematics Rich Disciplines.*

This talk focuses on three aspects of an Australian Learning and Teaching Council funded project Building Leadership Capacity in the Development and Sharing of Mathematics Learning Resources, Across Disciplines, Across Universities. The primary aim of this project is to develop leadership capacity, which in the simplest sense is to engage others in the sharing of predominantly video-based resources. The resources were to cover 100 level tertiary mathematics, statistics and bridging programs and thereby higher levels of university subjects in the disciplines that used 100 level mathematics and statistics. The sharing of technical expertise in relation to creation of resources has been one of the successes of this project, as different genres of video have been developed and trialed. This will be the first focus of my talk. The creation of resources has led to questions as to the best ways to combine resources and hence my second focus on learning design for the effective delivery of mathematics based subjects. With several trials of new learning designs, incorporating different assessment strategies the third focus is on developing strategies to get students to communicate what they know. (Received June 15, 2010)

03 ► Mathematical logic and foundations

1063-03-33 **Simon Thomas*** (sthomas@math.rutgers.edu), Mathematics Department, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Ramsey Cardinals and the HNN Embedding Theorem.*

The Higman-Neumann-Neumann Embedding Theorem states that any countable group G can be embedded into a 2-generator group K_G. In the standard proof of this classical theorem, the construction of the group K_G involves an enumeration of a set of generators of the group G; and it is clear that the isomorphism type of K_G usually depends upon both the generating set and the particular enumeration that is used. Some time ago, we proved that there does not exist a more uniform construction with the property that if $G \cong H$, then $K_G \cong K_H$. However, it turns out that we can obtain a much more striking result if we are willing to make use of a relatively mild large cardinal assumption. (Received July 14, 2010)

1063-03-86 **Slawomir Solecki*** (ssolecki@math.uiuc.edu), Department of Mathematics, 1409 W. Green St., University of Illinois, Urbana, IL 61801. *Groups generated by generic measure preserving transformations.*

Consider the Polish group of all measure preserving transformations of Lebesgue measure with the canonical weak topology. Using descriptive set theory, we show that for a generic transformation T in this group, the closed group generated by T is isomorphic to a subgroup of $L_0(\text{measure}, S^1)$ that is the image of a closed linear subspace of $L_0(\text{measure}, \mathbb{R})$ via the exponential map. This sharpens and generalizes older results of de la Rue, Sam Lazaro, and others. Several structural properties of the closed group generated by a generic T, established by Ageev and others, follow relatively simply from the above result. (Received August 06, 2010)

1063-03-93 **Greg Hjorth*** (greg.hjorth@gmail.com), Department of Mathematics and Statistics, University of Melbourne, Parkville, Melbourne, Victoria 3053, Australia. *Descriptive set theory and unitary group representations.*

Given a countable group G and a separable Hilbert space H, we denote the unitary group of H by U(H), and think of the unitary representations as being the collection of homomorphisms from G to U(H). This is a closed subset of the G fold product of U(H), and hence Polish in the product topology.

In the general case of H infinite dimensional, the questions which arise tend to be abstract and susceptible to the techniques of descriptive set theory. I will talk about recent work by set theorists on various issues of Borel complexity for the isomorphism relation of unitary representations. (Received August 09, 2010)

1063-03-101 **Grigor Sargsyan*** (grigor@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *On the strength of the negation of square.*

We will outline a recent new lower bound for the negation of square at a singular strong limit cardinal kappa which is bigger than aleph_omega. The case aleph_omega is still open. (Received August 10, 2010)

1063-03-123 **Greg Hjorth*** (greg.hjorth@gmail.com), University of Melbourne, Parkville, Victoria 3010, Australia. *Borel versus measure theoretic notions in the study of equivalence relations.*

I will compare Borel notions in descriptive set theory with their measure theoretic counterparts (from operator algebras, rigidity, ergodic theory) and survey some of the open problems which remain. (Received August 12, 2010)

1063-03-184 **Sean D. Cox*** (sean.cox@uni-muenster.de), Münster, Germany. *Natural ideals under PFA.*

I will discuss some natural ideals with completeness ω_2 which arise under PFA. This topic is motivated by recent results of Viale and Weiß. (Received August 16, 2010)

1063-03-198 **Michael Hrusak*** (michael@matmor.unam.mx), Instituto de Matematicas UNAM, Campus Morelia, Apartado Postal 61-3 (Xangari), 58089 Morelia, Michoacan, Mexico, and **Ondrej Zindulka**. *Cardinal invariants of monotone and porous sets.*

A metric space (X, d) is *monotone* if there is a linear order $<$ on X and a constant c such that $d(x, y) \leq c\, d(x, z)$ for all $x < y < z$ in X. We investigate cardinal invariants of the σ-ideal **Mon** generated by monotone subsets of the plane. Since there is a strong connection between monotone sets in the plane and porous subsets of the line, plane and the Cantor set, cardinal invariants of these ideals are also investigated. (Received August 16, 2010)

1063-03-207 **Dima S Sinapova*** (dsinapov@math.uci.edu), University of California Irvine, Department of Mathematics, Irvine, CA 92697. *Scales, the Singular Cardinal Hypothesis, and the tree property.*

We will discuss relative consistency results about singular cardinal arithmetic in the context of forcing and large cardinals. In particular, we will explore the relationship between the Singular Cardinal Hypothesis, Jensen's square principle, scales, and the tree property. (Received August 16, 2010)

1063-03-217 **James Cummings*** (jcumming@andrew.cmu.edu), Mathematical Sciences Dept, CMU, Pittsburgh, PA 15213-3890. *The tree property.*

I will discuss some recent results on the tree property. (Received August 16, 2010)

1063-03-218 **Natasha Dobrinen*** (natasha.dobrinen@du.edu), 2360 S Gaylord St, Denver, CO 80208, and **Stevo Todorcevic**. *Structure theorems for Tukey types of ultrafilters.*

We present some structure theorems for the Tukey types of ultrafilters on countable base sets. (Received August 16, 2010)

1063-03-219 **Paul B Larson*** (larsonpb@muohio.edu), Deparment of Mathematics, Miami University, Oxford, OH 45056. *Fragments of Martin's Maximum in the $\mathbb{P}_{\max}$ extension.*

Woodin has shown that Martin's Maximum for partial orders of size continuum holds in the $\mathbb{P}_{\max}$ extension of a model of $\mathrm{AD}_{\mathbb{R}}$ + "Θ is regular." We discuss the fragment of this forcing axiom which holds in the same extension under the weaker hypothesis of AD^+ + "Θ is regular" + "There exists a normal fine measure on $\mathcal{P}_{\omega_1}(\mathbb{R})$." (Received August 16, 2010)

05 ► Combinatorics

1063-05-54 **Hao Huang*** (huanghao@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90024, and **Benjamin Sudakov**. *A counterexample to the Alon-Saks-Seymour conjecture and related problems.*

Consider a graph obtained by taking an edge disjoint union of k complete bipartite graphs, Alon, Saks, and Seymour conjectured that such graphs have chromatic number at most $k + 1$. This well known conjecture remained open for almost twenty years. In this talk, we will show a counterexample to this conjecture. This construction will also lead to some related results in combinatorial geometry and communication complexity. In particular, it implies a nontrivial lower bound of the non-deterministic communication complexity of the "clique versus independent set" problem. (Received July 29, 2010)

1063-05-56 **Jason Fulman*** (fulman@usc.edu), **Jan Saxl** (J.Saxl@dpmms.cam.ac.uk) and **Pham Tiep** (tiep@math.arizona.edu). *Cycle indices for finite orthogonal groups of even characteristic.*

We develop cycle index generating functions for orthogonal groups in even characteristic, and give some enumerative applications. A key step is the determination of the values of the complex linear-Weil characters of the finite symplectic group, and their inductions to the general linear group, at unipotent elements. We also define and study several natural probability measures on integer partitions. (Received July 30, 2010)

1063-05-64 **Alexandr Kostochka*** (kostochk@math.uiuc.edu), 1409 W. Green St., Department of Mathematics, Urbana, IL 61801, **Mohit Kumbhat** (kumbhat2@uiuc.edu), 1409 W. Green St., Department of Mathematics, Urbana, IL 61801, and **Tomasz Luczak** (tomasz@amu.edu.pl), Faculty of Mathematics and Computer Science, ul. Umultowska 87, 61 614 Poznan, Poland. *Conflict-free colorings of uniform hypergraphs with few edges.*

A coloring of the vertices of a hypergraph $\mathcal{H}$ is *conflict-free* if for each edge e of $\mathcal{H}$, some color appears on exactly one vertex of e. The smallest number of colors required for such a coloring is called the *conflict-free chromatic number*, $\chi_{CF}(\mathcal{H})$, of $\mathcal{H}$. It turned out that conflict-free chromatic number has interesting applications and

interesting behavior. Pach and Tardos studied this parameter for graphs and hypergraphs. Among other things, they proved that for each $(2r-1)$-uniform hypergraph $\mathcal{H}$ with m edges, $\chi_{CF}(\mathcal{H})$ is at most $C\,m^{1/r}\log m$. They also asked whether the same result holds for r-uniform hypergraphs. We show that this is not true. Furthermore, we provide new lower and upper bounds on the minimum number of edges in an r-uniform simple hypergraph that is not conflict-free k-colorable. (Received August 02, 2010)

1063-05-77 **Dhruv Mubayi*** (mubayi@math.uic.edu), Dept of Math Stats and Comp Sci, University of Illinois, Chicago, IL 60607, and **Jozsef Balogh**. *The Structure of Typical Hypergraphs with Local Constraints.*

We prove hypergraph versions of the Erdos-Kleitman-Rothschild theorem, which states that almost all triangle-free graphs with vertex set [n] are bipartite. (Received August 06, 2010)

1063-05-78 **Tom Bohman*** (tbohman@math.cmu.edu), **Alan Frieze** and **Eyal Lubetzky**. *Self-correcting estimates from the differential equations method.*

We discuss applications of the differential equations method for random graph processes in which the bounds on additive variation from the expected trajectory decrease as the process evolves. These methods are illustrated in the context of a randomized algorithm for finding a large collection of triples on n vertices with the property that no pair of vertices is in more than one triple. Our algorithm is as follows. We begin with the complete graph on n vertices and proceed to remove the edges of triangles one at a time, where each triangle is chosen uniformly at random from the collection of all remaining triangles. The algorithm terminates when it arrives at a triangle-free graph. We show that with high probability the number of egdes in the final graph is at most $n^{7/4}$ times a polylogarithmic factor. (Received August 06, 2010)

1063-05-80 **Graeme Kemkes**, **Cristiane Sato** and **Nicholas Wormald***, Dept of C & O, 100 University Ave, Waterloo, ON N2L3G1, Canada. *Asymptotic enumeration of sparse 2-connected graphs.*

We determine an asymptotic formula for the number of 2-connected graphs on n vertices and m edges, provided that $m-n\to\infty$ and $m=O(n\log n)$ as $n\to\infty$. This is the entire range of m not covered by previous results. The proof involves determining properties of the core and kernel of random graphs with minimum degree at least 2. We also obtain formulae for graphs with given degree sequence for most ('typical') sequences. Our main result solves a problem of Wright from 1983 and determines his mysterious constant a. (Received August 06, 2010)

1063-05-87 **Ameera Naz Chowdhury*** (anchowdh@math.ucsd.edu), 9500 Gilman Drive # 0112, San Diego, CA 92093-0112. *On a Conjecture of Frankl and Füredi.* Preliminary report.

Frankl and Füredi conjectured that if $\mathcal{F}\subset 2^X$ is a non-trivial λ-intersecting family of size m, then the number of pairs $\{x,y\}\in\binom{X}{2}$ that are contained in some $F\in\mathcal{F}$ is at least $\binom{m}{2}$ [P. Frankl and Z. Füredi. A Sharpening of Fisher's Inequality. *Discrete Math.*, 90(1):103-107, 1991]. We verify this conjecture in some special cases, focusing especially on the case where $\mathcal{F}$ is additionally required to be k-uniform and λ is small. (Received August 08, 2010)

1063-05-125 **Choongbum Lee*** (choongbum.lee@gmail.com), Department of Mathematics, UCLA, Los Angeles, CA 90095, and **Hao Huang** (huanghao@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095. *Quasi-randomness of graph balanced cut properties.*

Quasi-random graphs can be informally described as graphs whose edge distribution closely resembles that of a random graph. They have been a subject of intensive study during the last two decades and have seen numerous applications both in Combinatorics and Theoretical Computer Science.

Starting with the work of Thomason and Chung, Graham, and Wilson, there have been many works which established the equivalence of various properties of graphs to quasi-randomness, several of which related to the number of edges (or graphs) across a given cut. In this talk, we provide a new condition in this direction which is equivalent to quasi-randomness. This result answers an open question raised independently by Janson, and Shapira and Yuster. (Received August 12, 2010)

1063-05-136 **Jeff Kahn*** (jkahn@math.rutgers.edu). *Upper tails for cliques.*

I will speak on upper tails for cliques. (Received August 13, 2010)

1063-05-164 **Fan Chung*** (fan@ucsd.edu), University of California, San Diego, La Jolla, CA 92093-0112, and **Ronald L. Graham** (graham@ucsd.edu), University of California, San Diego, La Jolla, CA 92093. *Flipping edges and vertices in graphs.*

We study a certain random process on a graph G which is a variation of a classical voter model and is also a special case of the so-called Tsetlin library random walk. Initially each vertex of G is colored either in blue or red. At each step an edge is chosen at random and both endpoints change their colors to blue with probability p and to red otherwise. This edge-flipping process corresponds with a random walk on the associated state graph in which each coloring configuration is a node. We show that the eigenvalues for the random walk on the state graph can be indexed by subsets of the vertex set of G. For example, for the uniform case of $p = 1/2$, for each subset T of the vertex set V of G, the eigenvalue λ_T (with multiplicity 1) is the ratio of the number of edges in the induced subgraph of T over the total number of edges in G. We analyze the stationary distribution of the state graph of colorings of G for several special families of graphs, such as paths, cycles and trees. We also mention related problems in connection with memoryless games. (Received August 15, 2010)

1063-05-255 **Zoltan Furedi*** (z-furedi@illinois.edu), Department of Mathematics, 1409 W Green Str, Urbana, IL 61801. *Large B_d-free subfamilies.*

Let $f(\mathcal{F}, \Gamma)$ denote the size of the largest subfamily of $\mathcal{F}$ having property Γ, $f(\mathcal{F}, \Gamma) := \max\{|\mathcal{F}'| : \mathcal{F}' \subseteq \mathcal{F}, \mathcal{F}'$ has property $\Gamma\}$. Let $f(m, \Gamma) := \min\{f(\mathcal{F}, \Gamma) : |\mathcal{F}| = m\}$. First, we consider the case when Γ is the property that there are no four distinct sets in $\mathcal{F}$ satisfying $F_1 \cup F_2 = F_3$, $F_1 \cap F_2 = F_4$. Such families are called B_2-$free$. In 1972 Erdős and Shelah conjectured that $f(m, B_2\text{-}free) = \Theta(m^{2/3})$. We prove that Erdős and Shelah's conjecture is true and establish some general lower and upper bounds on $f(m, B_d\text{-}free)$, where B_d is the Boolean lattice of dimension d. This is a joint work with Janos Barat, Ida Kantor, Younjin Kim, and Balazs Patkos. (Received August 17, 2010)

1063-05-258 **Christian Borgs*** (borgs@microsoft.com), Microsoft Research New England, 1 Memorial Drive, Cambridge, MA 02142, and **Jennifer Chayes**, **Jeff Kahn** and **Laci Lovasz**. *Left and Right Convergence for Sequences of Graphs with Bounded Degrees.*

The theory of convergent graph sequences for dense graphs, defined in terms of graph homomorphisms, has led to many interesting connections, including connections to the theory of testing in computer science. For sparse graphs, an early notion of graph convergence, which has let to many interesting results in probability theory, was proposed by Benjamini and Schramm. It turns out that the latter notion can be equivalently defined by requiring that for each fixed graph F, the number of homomorphisms from F into the elements of the sparse sequence, G_n, converges when suitably normalized. We call this notion left-convergence. By contrast, right-convergence will be defined by considering the entropy of homomorphism from G_n into a small target graph H. In this talk I will show that for sufficiently dense graphs H, these two notions are equivalent. (Received August 17, 2010)

1063-05-266 **John Shareshian*** (shareshi@math.wustl.edu) and **Michelle Wachs** (wachs@math.miami.edu). *Eulerian quasisymmetric functions.*

I will discuss recent developments in our ongoing work involving quasisymmetric functions and permutation statistics. (Received August 17, 2010)

1063-05-276 **P Haxell***, University of Waterloo, Waterloo, ON N2L3G1, Canada. *On Schnyder's Theorem.*

We give a simple proof of Schnyder's Theorem, which states that a graph is planar if and only if the dimension of its incidence poset is at most three. (joint work with F. Barrera-Cruz) (Received August 18, 2010)

11 ► Number theory

1063-11-4 **Melanie Matchett Wood*** (mwood@math.stanford.edu), Stanford University, Department of Mathematics, Building 380, Sloan Hall, Stanford, CA 94305. *Moduli Spaces for Rings and Ideals.*

Number theorists study rings of algebraic integers and ideal classes in those rings. One approach to studying these rings and ideal classes is through geometric parametrizations. The first case is the classical correspondence between binary quadratic forms and ideal classes in quadratic rings. We will see how this classical correspondence can be viewed geometrically as an isomorphism of moduli spaces, and how it is just the first of many such explicit moduli spaces for number theoretic objects. (Received August 02, 2010)

1063-11-25 **M M Rao*** (rao@math.ucr.edu), Department of Mathematics, Riverside, CA 92521. *Probabilistic Approach to the Zeros of Zeta Functions.*

This talk concentrates on the probabilistic ideas in detailing the large zero free part of the complex plane and describing the location of most of the zeros. The works of A. Khintchine and A. Denjoy are included. (Received June 30, 2010)

1063-11-90 **Olav K Richter*** (richter@unt.edu), Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203-5017, and **Kathrin Bringmann** (kbringma@math.uni-koeln.de), Mathematical Institute, University of Cologne, Weyertal 86-90, 50931 Cologne, Germany. *Harmonic Maass-Jacobi forms.*

The real-analytic Jacobi forms of Zwegers' Ph.D. thesis play an important role in the study of mock theta functions and related topics, but they have not been part of a rigorous theory yet. In this talk, I will report on joint work with Bringmann introducing harmonic Maass-Jacobi forms, which include the classical Jacobi forms as well as Zwegers' functions as examples. Maass-Jacobi-Poincare series also provide examples. We compute their Fourier expansions, which yield Zagier-type dualities and also yield a lift to skew-holomorphic Jacobi-Poincare series. Finally, we link harmonic Maass-Jacobi forms to different kinds of automorphic forms via a commutative diagram. (Received August 08, 2010)

1063-11-106 **Paul Jenkins*** (jenkins@math.byu.edu), BYU Mathematics Department, 275 TMCB, Provo, UT 84602. *Coefficient congruences for weakly holomorphic modular forms of integral weight.*

Ramanujan showed that the coefficients $\tau(n)$ of Δ satisfy $\tau(pn) \equiv 0 \pmod{p}$ for $p = 2, 3, 5$. Similarly, Lehner proved that the coefficients $c(n)$ of the modular j-function satisfy the congruence $c(2^a 3^b 5^c 7^d n) \equiv 0 \pmod{2^{3a+8} 3^{2b+3} 5^{c+1} 7^d}$. We discuss congruences of this type for coefficients of weakly holomorphic modular forms of integral weight. (Received August 10, 2010)

1063-11-148 **Alina Bucur***, UCSD, 9500 Gilman Dr #0112, La Jolla, CA 92093, and **Chantal David**, **Brooke Feigon** and **Matilde Lalin**. *The number of points on curves over finite fields.*

We will talk about the distribution of the number of points on two families of curves over a finite field with q elements: cyclic covers of $\mathbb{P}^1$ and plane curves. The Katz-Sarnak general philosophy makes predictions about the statistics for such families in the large q limit as one fixes the genus. We will look at the complementary direction, namely at the behavior as the genus increases, but the field of definition is fixed. (Received August 14, 2010)

1063-11-152 **J. Brian Conrey*** (conrey@aimath.org), AIM, 360 Portage Ave, Palo Alto, CA 94306. *A cotangent sum.* Preliminary report.

We prove a reciprocity formula for a cotangent sum that arises in the Beurling-Nyman criterion for the Riemann Hypothesis. It is connected with the Lewis-Zagier theory of period functions of Maass forms. (Received August 14, 2010)

1063-11-163 **Jeffrey Stopple*** (stopple@math.ucsb.edu). *The Riemann zeros and Euler's 'numeri idonei'.* Preliminary report.

This work in progress tries to extend the results of Stark's thesis to discriminants with one class per genus. (Received August 15, 2010)

1063-11-170 **B. Brubaker**, **D. Bump** and **S. Friedberg*** (friedber@bc.edu), Mathematics Department, Boston College, Chestnut Hill, MA 02467-3806. *Combinatorial models for p-adic Whittaker functions.* Preliminary report.

The values of spherical Whittaker functions on reductive groups over nonarchimedean local fields are obtained as characters of representations, due to the formula of Casselman and Shalika. For example, in type A they are given by Schur polynomials. This description allows the evaluation of local integrals that arise in various Rankin-Selberg integrals. In this talk, I present several combinatorial models for the values of p-adic Whittaker functions on a *metaplectic cover* of such a group. One model involves crystal graphs, combinatorial objects that arise in the representation theory of quantum groups. The values of the p-adic Whittaker function may be regarded as giving a generalization of a character in which Gauss sums intervene. A second model involves constructions that are related to statistical mechanics. The p-adic Whittaker functions describe the states of an ice model, in which the Boltzmann weights are number theoretic. Even in the case of the trivial cover, this representation for the Schur polynomials is new. Moreover, there is an interesting interplay between these two

approaches. This is all joint work with B. Brubaker and D. Bump, and parts are joint with G. Chinta and P. Gunnells. (Received August 15, 2010)

1063-11-246 **Ben Brubaker*** (brubaker@math.mit.edu), 2-267 MIT, 77 Massachusetts Ave., Cambridge, MA 02139, and **Daniel Bump** and **Solomon Friedberg**. *Connections between automorphic forms, representations, and statistical mechanics.*

We'll present a collection of deformations of characters for highest weight representations using statistical mechanical models. These have applications to automorphic forms, as can be seen by the Casselman-Shalika formula which expresses local Whittaker functions in terms of characters on the Langlands dual group. A key feature of this new approach is that functional equations for automorphic forms can be demonstrated via certain instances of the Yang-Baxter equation. This is principally joint work with Friedberg and Bump, and will also touch on joint work with Chinta and Gunnells, and thesis work by my Ph.D. student Sawyer Tabony. (Received August 17, 2010)

1063-11-253 **Kristin Estella Lauter*** (klauter@microsoft.com), One Microsoft Way, Redmond, WA 98052, and **Eyal Z. Goren**. *A Gross-Zagier formula for quaternion algebras over totally real fields.*

The values of the elliptic modular j-function at imaginary quadratic numbers are called singular moduli. They generate the Hilbert class field of the imaginary quadratic field and are of fundamental importance in the study of elliptic curves and in algebraic number theory, including the study of elliptic curves over finite fields. The formula of Gross and Zagier for the factorization of the norm of differences of singular moduli can be viewed as a solution to the problem of counting simultaneous embeddings of the rings of integers of two imaginary quadratic fields into a maximal order in the quaternion algebra ramified only at p and infinity. In this talk I will describe results generalizing Gross and Zagier's formula to counting simultaneous embeddings of the rings of integers of two primitive quartic CM fields into certain orders in a quaternion algebra over a totally real field. This result has applications to the problem of constructing genus 2 curves for use in cryptography. (Received August 17, 2010)

14 ► Algebraic geometry

1063-14-118 **Aravind Asok*** (asok@usc.edu), Department of Mathematics KAP 108, 3620 S. Vermont Ave, Los Angeles, CA 90089, and **Christian Haesemeyer** and **Fabien Morel**. *Stable $\mathbb{A}^1$-homotopy theory and rational points.*

I will discuss obstructions to existence of rational points on smooth proper algebraic varieties arising from the Morel-Voevodsky stable $\mathbb{A}^1$-homotopy theory. These obstructions are a byproduct of a computation of the 0-th stable $\mathbb{A}^1$-homotopy sheaf of a smooth proper variety in terms of what are called "oriented 0-cycles." (Received August 11, 2010)

15 ► Linear and multilinear algebra; matrix theory

1063-15-285 **Blake A Hunter*** (blakehunter@math.ucdavis.edu), One Shields Ave., Davis, CA 95616, and **Thomas Strohmer** (strohmer@math.ucdavis.edu), One Shields Ave., Davis, CA 95616. *Performance Analysis of Compressive Spectral Clustering.*

Compressed sensing is one of the fastest growing areas of active research, and spectral clustering is one of the most widely used techniques for extracting the underlying global structure of a data set. We combine the distance preserving measurements of compressed sensing with the power of spectral clustering. Our analysis provides rigorous bounds on how small errors in the affinity matrix can affect the spectral coordinates and clusterability. This work generalizes the current perturbation results of two-class spectral clustering to incorporate multiclass clustering with k eigenvectors. We thoroughly track how an initial error in the entries of the affinity matrix affects the entire spectral clustering process to the final step in applying k-means in the spectral coordinates. We show that instead of requiring the local distances be made in the large ambient dimension, measurements can be made on the order of the dimension of the hidden underlying point cloud structure. Using the controllable error from taking compressed sensing measurements, we establish perturbation bounds of the affinity matrix, the eigenvectors, the spectral coordinates and the clustering memberships. (Received August 18, 2010)

16 ► Associative rings and algebras

1063-16-167 **J H Palmieri*** (palmieri@math.washington.edu), Box 354350, Department of Mathematics, University of Washington, Seattle, WA 98195-4350, and **J J Zhang**, Box 354350, Department of Mathematics, University of Washington, Seattle, WA 98195-4350.
Artin-Schelter regular algebras and the Steenrod algebra.

Artin-Schelter regular algebras may be viewed as generalizations, to the non-commutative setting, of polynomial algebras. For any finite-dimensional Hopf algebra H over a field of positive characteristic, we construct a reasonably small Artin-Schelter regular algebra mapping onto H. We apply this to the sub-Hopf algebras of the mod p Steenrod algebra. (Received August 15, 2010)

1063-16-264 **Efim Zelmanov*** (ezelmano@math.ucsd.edu). *Property T for Lie algebras and expansion properties of representations.* Preliminary report.

We will discuss properties of Lie algebras and Hopf algebras that are analogous to the property T. (Received August 17, 2010)

18 ► Category theory; homological algebra

1063-18-132 **Alissa S Crans*** (acrans@lmu.edu), Department of Mathematics, Loyola Marymount University, One LMU Drive, Suite 2700, Los Angeles, CA 90045, and **J. Scott Carter**, **Mohamed Elhamdadi** and **Masahico Saito**. *Categorical Quandles and Knots I: Definitions and Examples.*

A quandle is a set equipped with two binary operations satisfying axioms that capture the essential properties of group conjugation and algebraically encode the three Reidemeister moves. A *2-quandle is a categorified version of a quandle, in which the underlying set has been replaced by a category and the two binary operations have been replaced by functors. We will begin by reviewing the notion of categorification and continue with the definition of a (strict) 2-quandle. We will discuss examples of 2-quandles and explore relationships with strict 2-groups, which are equivalent to crossed modules of groups. (Received August 12, 2010)*

1063-18-187 **Daniel Murfet*** (daniel.murfet@gmail.com). *Residues and matrix factorisations in link homology.*

Khovanov and Rozansky have defined a homology theory for links using networks of matrix factorisations. The main difficulty in computing this homology theory lies in understanding a certain pushforward functor on matrix factorisations, and we will explain one way to approach this functor via residues. (Received August 16, 2010)

1063-18-225 **Radmila Sazdanovic*** (radmilas@sas.upenn.edu), Department of Mathematics, University of Pennsylvania, 209 South 33rd Street (David Rittenhouse Lab), Philadelphia, PA 19104-6395, and **Mikhail Khovanov**. *Functorification via SLarcs.*

Categorification lifts abelian groups to Grothendieck groups of categories. Functorification (or functorization) lifts homomorphisms between abelian groups to functors between categories. We use the ring of SLarcs to functorize several operations on the ring of one-variable polynomials. (Received August 16, 2010)

19 ► K-theory

1063-19-113 **Daniel A Ramras*** (ramras@nmsu.edu), New Mexico State University, Department of Mathematical Sciences, P.O. Box 30001, Department 3MB, Las Cruces, NM 88003. *Quillen-Lichtenbaum phenomena in stable representation theory.*

This talk will describe a variety of results and calculations connecting the stable representation theory of discrete groups to cohomology and topological K-theory. Stable representation theory refers to the study of finite dimensional (unitary) representations, after stabilizing with respect to rank. Conjectures of Carlsson relate stable representation theory to the algebraic K-theory of fields, making our results analogous to the Quillen-Lichtenbaum conjectures. In fact, the comparison between stable representation theory and topological K-theory exhibits failure in a low dimensional range precisely analogous to the low dimensional failure of the Quillen-Lichtenbaum conjectures. In the context of stable representation theory, this low-dimensional failure has a geometric explanation, and has applications to gauge theory. Parts of this work are joint with T. Baird. (Received August 11, 2010)

1063-19-156 **D. Benjamin Antieau*** (antieau@math.ucla.edu), UCLA, Department of Mathematics, 520 Portola Plaza, Los Angeles, CA 90095-1555. *The étale index of division algebras.*

We introduce the étale index of a division algebra. If D is a central division algebra over k, then the étale index is defined as the (positive) generator of the image of the rank map on $K_0^{etale}(D)$, the étale K-theory of D. When k is of finite étale cohomological dimension d, an upper bound is given on the étale index of D which depends on d and on the period of D (the order of the class of D in the Brauer group of k). This bound is expressed with the exponents of the stable homotopy groups of spheres and classifying spaces of finite abelian groups. The upper bound shows that the étale index differs from the index in general. (Received August 14, 2010)

1063-19-175 **Andrew J. Blumberg*** (blumberg@math.utexas.edu) and **Michael A. Mandell**. *Algebraic K-theory and homotopy limits of Waldhausen categories.*

I will describe recent work on the interaction of homotopy limits of categories and algebraic K-theory. I will also explain work in progress applying these results to Waldhausen's chromatic convergence conjecture for $A(*)$. (Received August 15, 2010)

20 ► Group theory and generalizations

1063-20-51 **Stephen D Smith*** (smiths@math.uic.edu), Dept Math, U Illinois-Chicago (m/c 249), 851 S Morgan, Chicago, IL 60607-7045. *Combinatorial and geometric methods applied to group cohomology.*

The Tits building is the fundamental geometry for a group of Lie type; and analogous simplicial complexes for various other simple groups were introduced in the 1970s by Buekenhout, Ronan-Smith, and others. The underlying combinatorial methods were further studied by Stanley, Björner, and others; and from the viewpoint of algebraic topology, the methods were extended to arbitrary finite groups by Brown, Quillen, Webb, and others—often with application to decomposition the p-part of the cohomology of a group in terms of that of suitable p-local subgroups.

In particular for the prime $p = 2$, each sporadic simple group has a suitable "2-local geometry" which satisfies an analogue of the cohomology decomposition for a Lie type group over its building geometry. This result had long been conjectured; but it had to be proved separately for each sporadic group—and in some of the larger cases, the proof had to await the development of increasingly more sophisticated methods. The theorem along with much of this background is developed in the recent book *Classifying spaces of sporadic groups* by Benson and Smith.

A more elementary introduction to the methods is being developed in a forthcoming book *Subgroup complexes* by Smith. (Received July 27, 2010)

1063-20-62 **Michael Aschbacher***, Caltech, Pasadena, CA 90025. *Overgroup lattices in finite groups.*

We determine those subgroups of finite groups of Lie type whose overgroup lattices contain a parabolic and are of one of several types. This is part of a program to show there exist finite lattices which are not intervals in the subgroup lattice of a finite group. (Received August 02, 2010)

1063-20-124 **Mark Sapir*** (m.sapir@vanderbilt.edu), SC1522, Department of Mathematics, Vanderbilt, University, Nashville, TN 37240. *On residually finite hyperbolic groups.* Preliminary report.

I will present some results and questions related to residual finiteness of hyperbolic groups. (Received August 12, 2010)

1063-20-206 **Simon D Guest*** (simon_guest@baylor.edu), One Bear Place, #97328, Waco, TX 76798, and **Cheryl E Praeger**. *Proportions of elements of certain orders in classical groups.*

Let G be a finite group. We say that an element g in G has 2-part order 2^j if 2^j is the largest power of 2 dividing the order of g. To analyze recognition algorithms for classical groups, we are sometimes presented with the following question. Take the direct product of two classical groups $A \times B$ and choose a random element (a, b); determine the probability that (a, b) powers up to an element of the form $(z, 1)$, where z is an involution in A. We require that the 2-part order of a be greater than the 2-part order of b. In order to estimate this probability, we first establish lower bounds on the proportion of elements in the symmetric group with a given 2-part order. We will describe the relationship between maximal tori in a classical group and its Weyl group. Since the Weyl group of a classical group involves the symmetric group, we can use the lower bounds for the symmetric group, together with this relationship, to obtain corresponding lower bounds for classical groups of odd characteristic. If A and B have dimension m and $n - m$, and $m \in [n/3, n/2]$ (for example if $A \times B$ is the centralizer of a strong

involution), then we show that the probability that (a, b) powers up to $(z, 1)$ is at least an explicit constant. (Received August 16, 2010)

22 ► Topological groups, Lie groups

1063-22-157 **Christian Rosendal***, University of Illinois at Chicago, 851 S. Morgan Street, Chicago, IL 60607-7045. *Polish groups acting on trees.*

We consider actions of completely metrisable groups on simplicial trees in the context of the Bass–Serre theory. Our main result characterises continuity of the amplitude function corresponding to a given action. Under fairly mild conditions on a completely metrisable group G, namely, that the set of elements generating a non-discrete or finite subgroup is somewhere dense, we show that in any decomposition as a free product with amalgamation, $G = A *_C B$, the amalgamated groups A, B and C are open in G. (Received August 14, 2010)

1063-22-260 **Narutaka Ozawa***, Department of Mathematical Sciences, University of Tokyo at Komaba, Tokyo, 153-8914, Japan. *Quasi-homomorphism rigidity with noncommutative targets.*

As a strengthening of Kazhdan's property (T), property (TT) was introduced by Burger and Monod. In this talk, I will add more rigidity to (TT) and introduce property (TTT). This property is suited for the study of rigidity phenomena for quasi-homomorphisms with noncommutative targets and ϵ-representations. (Received August 17, 2010)

26 ► Real functions

1063-26-50 **Ciprian Demeter*** (demeterc@indiana.edu), Indiana University, Rawles Hall, 831 East 3rd St, Bloomington, IN 47405. *Proof of the HRT conjecture for special configurations.*

The strong HRT conjecture asserts that the time-frequency translates of any nontrivial function in $L^2(\mathbb{R})$ are linearly independent. The weak HRT conjecture has the same formulation, but this time for Schwartz functions. Prior to our work, the only result of a reasonably general nature was Linnell's proof in the case when the translates belong to a lattice. I will first describe an alternative argument to Linnell's (joint work with Zubin Gautam), inspired by the theory of random Schrödinger operators. Then I will explore both some solo and joint work (with Zaharescu) involving a number theoretical approach to the HRT conjecture, for some special 4 point configurations. (Received July 27, 2010)

34 ► Ordinary differential equations

1063-34-21 **Adolfo J Rumbos*** (arumbos@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Avenue, Claremont, CA 91711, and **David A Bliss** (david.a.bliss@jpl.nasa.gov), School of Mathematics, Claremont Graduate University, Claremont, CA 91711. *Periodic Boundary Value Problems and the Fučík Spectrum under Conditions of Resonance.* Preliminary report.

We prove the existence of solutions to the nonlinear 2π-periodic problem

$$u''(x) + \mu u^+(x) - \nu u^-(x) + g(x, u(x)) = f(x)\,, \quad x \in (0, 2\pi)\,,$$
$$u(0) = u(2\pi)$$
$$u'(0) = u'(2\pi)$$

where the point (μ, ν) is a point of the Fučík spectrum and the primitive of the nonlinearity, $g(x, u(x))$, satisfies a Landesman-Lazer type condition. We use a variational method based on the generalization of the Saddle Point Theorem. (Received June 23, 2010)

1063-34-40 **Donald A Lutz*** (lutz@math.sdsu.edu), San Diego, CA 92182-7720, and **Sigrun Bodine**, Tacoma, WA. *Asymptotic equivalences for linear dynamic equations.*

For systems of linear differential equations as well as for difference equations, several different concepts of asymptotic equivalence have been introduced in the literature. For each type of equivalence one can ask what perturbations leave it invariant. Several results of this type will be discussed and in particular, a generalization of a classical result of N. Levinson concerning perturbations nondiagonal differential equations will be presented. (Received July 19, 2010)

35 ► Partial differential equations

1063-35-10 **Richard Mikula*** (rmikula@lhup.edu), 401 W. 4th Street, Lock Haven, PA 17745.
Prescribing Gauss-Kronecker curvature, and the Weingarten curvature problem.

We consider the problem of prescribing Gauss-Kronecker curvature in Euclidean space and in space forms. In particular, by a degree theory argument for a fully nonlinear Monge-Ampere elliptic PDE, we prove the existence of a closed convex hypersurface in 3-dimensional Euclidean space which has its Gauss-Kronecker curvature equal to F, a prescribed positive function, which is invariant under a fixed-point free subgroup G of the orthogonal group O(3), requiring that F satisfy natural growth assumptions near the origin and at infinity. Some higher dimensional results are also discussed, as well as results in the setting of space forms. (Received April 05, 2010)

1063-35-15 **Tadele Mengesha*** (mengesha@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Nguyen Cong Phuc,**, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Weighted and Regularity Estimates for Nonlinear PDEs on Nonsmooth Domains.*

Global weighted L^p estimates are obtained for the gradient of solutions to nonlinear elliptic Dirichlet boundary value problems over a bounded nonsmooth domain. Morrey and Hölder space regularity of solutions are also established. These results generalize existing L^p estimates for nonlinear equations.The nonlinearities are sublinear and assumed to have a uniform small mean oscillation, i.e can have mild discontinuity. The boundary of the domain may exhibit roughness but assumed to be sufficiently flat. We will use maximal function estimates and Vitali covering lemma from harmonic analysis, and also known regularity of solutions to reference homogeneous equations with smooth coefficients. (Received June 04, 2010)

1063-35-38 **Natasa Sesum*** (natasa.sesum@gmail.com), One Franklin town blvd. a405, Philadelphia, PA 19103, and **Nam Q Le**. *The extension results for the mean curvature flow.*

In the talk we will present some joint results on the mean curvature flow with Nam Le. We will show that if the flow is a type I flow then the mean curvature controls the flow in the sense that the blow up of the second fundamental form can not occur. We will also discuss some improved extension results in the case of surfaces. We will also give a rate of the blow up of mean curvature. (Received July 19, 2010)

1063-35-74 **M Cristina Caputo*** (cristinacaputo@gmail.com), Mathematical Sciences SCEN 301, 1 University of Arkansas, Fayetteville, AR 72701, and **Nestor Guillen**. *"Recent results on nonlocal almost minimal boundaries.*

Nonlocal almost minimal boundaries can be seen as an extension to the nonlocal case of the almost minimal surfaces introduced by Almgren in geometric measure theory. We prove that flat non-local almost minimal boundaries are smooth. This can be viewed as a non-local version of the Almgren-De Giorgi-Tamanini regularity theory. The main result has several applications, among these $C^{1,\alpha}$ regularity for sets with prescribed nonlocal mean curvature in L^p and regularity of solutions to non-local obstacle problems. Also it will be introduced a nonlocal mean curvature flow . This is a joint work with N. Guillen (Received August 04, 2010)

1063-35-99 **Jiahong Wu*** (jiahong@math.okstate.edu), 401 Mathematical Sciences, Department of Mathematics, Stillwater, OK 74078. *Models generalizing the 2D Euler and the surface quasi-geostrophic equations.*

This talk presents very recent studies on a family of 2D active scalar equations in which the velocity field is divergence free and determined by the scalar through the operator $\nabla^\perp(\sqrt{-\Delta})^{-2+\beta}\,(\log(1-\Delta))^\gamma$ with $0 \le \beta \le 1$ and $\gamma \ge 0$. The 2D Euler vorticity equation corresponds to the special case $\beta = 0$ and $\gamma = 0$ while the surface quasi-geostrophic equation to the case $\beta = 1$ and $\gamma = 0$. We establish the global regularity for the case when $\beta = 0$ and $\gamma \le 1$, a model that is logarithmically worse than the 2D Euler equation. In addition, several regularity criteria for the model with $0 \le \beta \le 1$ and $\gamma = 0$ are obtained. This is a joint work with Dongho Chae and Peter Constantin. (Received August 09, 2010)

1063-35-103 **Felix Otto**, **Christian Seis** and **Dejan Slepcev*** (slepcev@math.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15217. *Crossover in the coarsening rates in demixing of binary viscous fluids.*

When a binary fluid mixture is quenched, two domains of two different equilibrium volume fractions form. The phases are divided by a characteristic interfacial layer. The dynamics is driven by the energy which concentrates along the interfacial layer. The area of the interfacial layer decreases with time by material transport from higher-curvature regions to lower-curvature regions. As the time progresses the configuration coarsens and the length scale, L, characterizing the interfacial pattern grows.

There are two parallel transport mechanisms. Material can be transported by diffusion, the relative motion of the two different species, through the bulk or by convection, the transport by the bulk flow. It turns out that each transport mechanism becomes dominant during certain time interval in the demixing process.

We will discuss how which mechanism dominates affects the rate of coarsening. In particular we will discuss how one can rigorously establish coarsening rates in form of weak upper bounds: the coarsening cannot proceed faster than $L \lesssim t^{1/3}$ for diffusion-mediated and subsequently $L \lesssim t$ for convection-mediated transport. These a rates re in agreement with the heuristically expected coarsening rates. (Received August 10, 2010)

1063-35-104 **Akif Ibragimov*** (akif.ibraguiomov@ttu.edu), Texas Tech University, Department of Mathemat, Broadway and Boston, Lubbock, TX, Lubbock, TX 79409-104, **Luan Hoang** (luan.hoang@ttu.edu,), Texas Tech University, Department of Mathemat, Broadway and Boston, Lubbock, TX, Lubbock, TX 79409-104, and **Eugenio Aulisa** (eugenio.aulisa@ttu.edu), Texas Tech University, Department of Mathemat, Broadway and Boston, Lubbock, TX, Lubbock, TX 79409-104. *On qualitative analyses of non-linear Forchheimer flows in porous media and application.*

Within frame work of the degenerate parabolic equation of second order we study the non-linear flows in porous media for compressible fluids Motivated by problems in the reservoir engineering we investigate Lyapunov type stability of the non-linear flows with respect to the Dirichlet and Neumann boundary data. Original system of hydrodynamic and state equations is reduced to non-linear parabolic equation of the second order with coefficients, degenerating as gradient of the pressure converges to infinity. Weighted monotonicity properties of the non-linear potential vector field associated with degenerating conductivity have been proved. Obtained monotonicity property used for long time comparison of the solutions with different boundary data. Accurate asymptotic estimate of the solution at infinity have been proved for so called boundary dominated regimes, corresponding to both Dirichlet and Neumann conditions. Some of the mathematical results are explicitly interpreted for class of traditional engineering problems. (Received August 12, 2010)

1063-35-109 **Zhen Lei**, Peoples Rep of China, and **Qi S. Zhang***, Math. Dept., Riverside, CA 92521. *Extra regularity for a linear parabolic equation with drift term.*

Extra regularity for a linear parabolic equation with drift term.

This is a joint work with Lei Zhen. We show that the solution of a linear parabolic equation with drift term has certain modulus of continuity, under a slightly supercritical condition. This equation arises from axially symmetric Navier-Stokes equations. (Received August 11, 2010)

1063-35-129 **Hongjie Dong*** (Hongjie_Dong@brown.edu), Division of Applied Mathematics, 182 George Street, Providence, RI 02912. *Some remarks on the aggregation equations.*

We study the multidimensional aggregation equations with power-law kernels K. We prove that with biological relevant potential $K(x) = |x|$, the equation is ill-posed in the critical Lebesgue space $L_{d/(d-1)}(\mathbb{R}^d)$. We then extend this result to more general power-law kernels $K(x) = |x|^\alpha$, $0 < \alpha < 2$ for $p = p_s := d/(d + \alpha - 2)$, and prove a conjecture of Bertozzi, Laurent and Rosado about an instantaneous-mass-concentration phenomenon. Finally, we classify all the "first kind" radially symmetric similarity solutions in dimension greater than two. (Received August 12, 2010)

1063-35-139 **Lincoln Chayes**, **Wilfrid Gangbo** and **Helen K Lei*** (glei@math.ucla.edu). *Inhomogeneous Continuity Equation with Application to Hamiltonian ODE.*

We consider a Hamiltonian $\mathcal{H}$ on $\mathcal{M}_2(\mathbb{R}^d)$, the set of (positive) Borel measures with bounded second moment on the phase space $\mathbb{R}^{2d}$: We study the initial value problem $\frac{d\mu_t}{dt} \nabla cdot(J_d v_t \mu_t) = 0$, where J_d is the canonical symplectic matrix, μ_0 is the prescribed initial measure, and v_t is a (time-dependent) velocity field growing polynomially at infinity. In contrast to the mass-conserved case, here we are particularly interested in dynamics where particles may reach infinity in finite time, thus leading to deficient meaures. We equip $\mathcal{M}_2$ with a suitable distance derived from the Wasserstein distance and first consider a regularized problem corresponding to the continuity equation with a nonzero right hand side. We construct solutions to the regularized problem and show that in a well-defined sense, as the regularization parameter tends to zero, the Hamiltonian is preserved. This is joint work with L. Chayes and W. Gangbo. (Received August 13, 2010)

1063-35-146 **Mihaela Ignatova Ignatova*** (ignatova@usc.edu) and **Igor Kukavica** (kukavica@usc.edu). *Strong Unique Continuation and Complexity of Solutions to Parabolic Partial Differential Equations with Gevrey Coefficients.*

We address the strong unique continuation problem for higher order parabolic partial differential equations with Gevrey coefficients. We provide a quantitative estimate of unique continuation (observability estimate) for

ranges of the Gevrey exponents strictly including non-analytic Gevrey classes. As an application, we obtain a new upper bound on the number of zeros for the solutions with a polynomial dependence on the coefficients. (Received August 13, 2010)

1063-35-168 **Anna L Mazzucato*** (alm24@psu.edu), McAllister Building, University Park, PA 16802, and **Xiaoming Wang** and **Dongjuan Niu**. *Boundary layer analysis for 3D plane-parallel channel flows.*

We study the boundary layer in a class of 3D plane-parallel channel flows using Prandtl-type effective equations for flow correctors. We establish optimal rates of convergence in the vanishing viscosity limit for various norms. (Received August 15, 2010)

1063-35-178 **Luan Thach Hoang*** (luan.hoang@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Box 41042, Lubbock, TX 79409, and **Akif Ibragimov** (akif.ibraguimov@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Box 41042, Lubbock, TX 79409. *Structural Stability of Nonlinear Flows in Porous Media.*

We study the generalized Forchheimer equations for slightly compressible fluids in porous media. The structural stability is established with respect to either the boundary data or the coefficients of the Forchheimer polynomials. A weighted Poincare-Sobolev inequality related to the non-linearity of the equation is used to study the asymptotic behavior of the solutions. Moreover, we prove a perturbed monotonicity property of the vector field associated with the resulting non-Darcy equation, where the correction is Lipschitz continuous in the coefficients of the Forchheimer polynomials. (Received August 15, 2010)

1063-35-182 **Igor Kukavica**, **Roger Temam**, **Mohammed Ziane** and **VIad C Vicol*** (vicol@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 S. University Avenue, Chicago, IL 60637. *Local Existence and Uniqueness for the Hydrostatic Euler Equations on a Bounded Domain.*

We address the question of well-posedness in spaces of analytic functions for the Cauchy problem for the hydrostatic incompressible Euler equations (inviscid primitive equations) on domains with boundary. By a suitable extension of the Cauchy-Kowalewski theorem we construct a locally in time, unique, real-analytic solution and give an explicit rate of decay of the radius of real-analyticity. (Received August 16, 2010)

1063-35-189 **Thomas Laurent*** (laurent@math.ucr.edu). *Instantaneous mass concentration in solutions of the aggregation equation.*

The aggregation equation is a continuum model for interacting particle systems with attractive/repulsive pairwise interaction potential K. It arises in a number of models for biological aggregation, materials science and granular media. The main phenomenon of interest is that, even with smooth initial data, the solutions can concentrate mass in finite time (i.e. a delta Dirac appears in the solution in finite time). We study how and under which circumstances these Dirac delta functions appear. (Received August 16, 2010)

1063-35-202 **Walter M. Rusin*** (rusin018@math.umn.edu), 3620 S Vermont Ave, KAP 108, Los Angeles, CA 90089. *Minimal initial data for potential Navier-Stokes singularities.*

Assuming some initial data lead to a singularity for the 3d Navier-Stokes equations, we show that there are also minimal initial data in the scale invariant homogenous Sobolev space which will produce a singularity. The talk is based upon joint work with Vladimir Sverak. (Received August 18, 2010)

1063-35-210 **Jerry L. Bona*** (bona@math.uic.edu), Department of Math, Statistics & Computer Sci, 851 S Morgan Street MC 249, Chicago, IL 60607, and **Jean-Claude Saut** (jean-claude.saut@math.u-psud.fr), Dépt. de Mathématiques, Université de Paris - Sud, Batiment 425, Orsay, France. *Dispersive Blow-up of Nonlinear Evolution Equations.*

Nonlinear evolution equations featuring strong dispersion may posess what the authors refer to as *dispersive blow-up*. This is related to the fact that such equations are often ill-posed in L^∞-spaces.

The lecture intends to quckly review dispersive blow-up results. It will then turn to potential application of these results to the genesis of oceanic rogue waves and to rogue wave formation in fiber optics cables. (Received August 16, 2010)

1063-35-220 **Thomas Y. Hou*** (hou@acm.caltech.edu), Applied and Comput. Math, 217-50, Caltech, Pasadena, CA 91125. *On dynamic stability and non-blow-up of a class of solutions of 3D incompressible Euler and surface QG equations.*

Whether the 3D incompressible Navier-Stokes equations can develop a finite time singularity from smooth initial data is one of the most challenging problems for both computation and analysis. We review some recent theoretical and computational studies of the 3D Euler equations which show that there is a subtle dynamic depletion of nonlinear vortex stretching due to local geometric regularity of vortex filaments. Our study reveals a surprising nonlinear stabilizing effect that the convection term plays in regularizing the solution. Finally, we present a new class of solutions for the 3D Euler and surface QG equation, which exhibit very interesting dynamic growth property. By exploiting the special structure of the solution and the dynamic balance between the vortex stretching term and the local geometric property of the solution, we prove nonlinear stability and the global regularity of this class of solutions. (Received August 16, 2010)

1063-35-231 **Alexey Cheskidov*** (acheskid@math.uic.edu), University of Illinois at Chicago, 322 Science and Engineering Offices, 851 S. Morgan Street, Chicago, IL 60607. *Beale-Kato-Majda type regularity criteria for the 3D Navier-Stokes equations.*

We present a new Beale-Kato-Majda type regularity criterion for the 3D Navier-Stokes equations. This criterion is weaker than every Ladyzhenskaya-Prodi-Serrin condition. (Received August 17, 2010)

1063-35-232 **Yanghong Huang*** (yhhuang@math.ucla.edu), Department of Mathematics, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada, and **Andrea L. Bertozzi**. *Self-Similar Blowup Solutions to an Aggregation Equation.*

Various self-similar blowup solutions of the aggregation equation is presented, depending on the power of the homogeneous kernel. As the power is large enough(>2), smooth solutions converge to a Delta-ring in space. Otherwise when the power is small, there are self-similar solutions of the second kind. These 2nd kind self-similar solutions are confirmed numerically. Though there is no explicit formula, the anomalous exponents characterizing these solutions can be calculated in a few special cases. (Received August 17, 2010)

1063-35-233 **Thomas Chen** and **Natasa Pavlovic*** (natasa@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 1 University Station, C 1200, Austin, TX 78712, and **Nikolaos Tzirakis**. *Energy conservation and blow-up of solutions for focusing Gross-Pitaevskii hierarchies.*

The Gross-Pitaevskii (GP) hierarchy is an infinite system of coupled linear non-homogeneous PDEs, which appear in the derivation of the nonlinear Schrödinger equation (NLS). Inspired by the PDE techniques that have turned out to be useful on the level of the NLS, we realized that, in some instances we can introduce analogous techniques at the level of the GP. In this talk we will discuss one of those techniques and present a sufficient condition for a finite-time blow-up. (Received August 17, 2010)

1063-35-236 **Maria Elena Schonbek*** (schonbek@ucsc.edu), 1156 High St., Math Dept., UCSC, Santa Cruz, Ca 95064, and **Mimi Dai** and **Jie Qing**. *Norm inflation for incompressible magneto-hydrodynamic system.*

Based on the construction of Bourgain and Pavlovic , I will show that the solutions to the Cauchy problem for the three dimensional different types of norm inflations in $\dot{B}_{\infty}^{-1,\infty}$. Particularly the magnetic field can develop norm inflation in short time even when the velocity remains small and vice verse. (Received August 17, 2010)

1063-35-237 **Louis F Rossi***, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, **Jennifer Miller**, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, **Allison Kolpas**, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, and **Plinio Juchem Neto**, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Continuum modeling and analysis of swarming with three interaction zones.*

In this project, we derive and analyze a continuum model for swarming with three interaction zones. The goal of this project is to develop a theoretical framework so that we can predict swarm phases such as parallel translation and milling from swarm parameters. We present a first order kinematic model and second order dynamic models for swarming. Linear analysis correctly predicts the stability of infinite, uniform translating states. Individual based simulations suggest that in certain regimes, patches evolve away from a uniform state toward an axisymmetric, variable density, coherent attractor. (Received August 17, 2010)

1063-35-244 **Andrew J. Bernoff*** (ajb@hmc.edu), Department of Mathematics, Harvey Mudd College, Claremont, CA 91711, and **Chad M. Topaz** (ctopaz@macalester.edu), Dept. of Mathematics, Statistics, and CS, Macalester College, St. Paul, MN 55105. *A Primer of Swarm Equilibria.*

We study equilibrium configurations of swarming biological organisms subject to exogenous and pairwise endogenous forces. Beginning with a discrete dynamical model, we derive a variational description of the continuum population density. Equilibrium solutions are extrema of an energy functional, and satisfy a Fredholm integral equation. We find conditions for the extrema to be local minimizers, global minimizers, and minimizers with respect to infinitesimal Lagrangian displacements of mass. In one spatial dimension, for a variety of exogenous forces, endogenous forces, and domain configurations, we find exact analytical expressions for the equilibria. These agree closely with numerical simulations of the underlying discrete model.The exact solutions provide a sampling of the wide variety of equilibrium configurations possible within our general swarm modeling framework. The equilibria typically are compactly supported and may contain δ-concentrations or jump discontinuities at the edge of the support. We apply our methods to a model of locust swarms, which are observed in nature to consist of a concentrated population on the ground separated from an airborne group. Our model can reproduce this configuration; quasi-two-dimensionality of the model plays a critical role. (Received August 17, 2010)

1063-35-247 **Inwon C Kim***, Math Science building, UCLA, LA, CA 90095. *A degenerate diffusion with nonlocal drift: behavior of radial solutions.*

We will discuss a diffusion-aggregation equation given by

$$(P) \qquad \rho_t - \Delta(\rho^m) + \nabla \cdot (\rho(\rho \nabla \Phi * \rho) = 0 \text{ in } R^n \times [0, \infty)$$

where $m > 1$ and $\Phi : R^n \to R$ is a radially decreasing function. We will discuss various properties on radial solutions of (P), based on comparison-principle type arguments.

This is joint work with Yao Yao. (Received August 17, 2010)

1063-35-271 **Juhi Jang***, Department of Mathematics, UC Riverside, Riverside, CA 92521, and **Hyungju Hwang**. *Initial boundary value problem for Vlasov-Poisson-Fokker-Plank system.* Preliminary report.

I'll discuss initial boundary value problem for Vlasov-Poisson-Fokker-Plank system. I'll present the global existence result of strong solutions to the system with reflecting, diffusive boundary conditions. (Received August 17, 2010)

1063-35-275 **Steve Shkoller*** (shkoller@math.ucdavis.edu), Department of Mathematics, Davis, CA 95616. *Well-posedness in smooth function spaces for the moving-boundary 3-D compressible Euler equations in physical vacuum.*

We prove well-posedness for the 3-D compressible Euler equations with moving *physical* vacuum boundary, with an equation of state given by $p(\rho) = C_\gamma \rho^\gamma$ for $\gamma > 1$. The physical vacuum singularity requires the sound speed c to go to zero as the square-root of the distance to the moving boundary, and thus creates a degenerate and characteristic hyperbolic *free-boundary* system. We establish the existence of unique solutions to this system on a short time-interval, which are smooth (in Sobolev spaces) all the way to the moving boundary, and our estimates have no derivative loss with respect to initial data. Our proof is founded on an approximation by a degenerate parabolic regularization obtained from a specific choice of a degenerate artificial viscosity term together with a new higher-order Hardy-type inequality. This is joint work with Daniel Coutand. (Received August 17, 2010)

1063-35-277 **Dong Li*** (dli@math.uiowa.edu), Department of Mathematics, University of Iowa, 14 MacLean Hall, Iowa City, IA 52242. *Recent results on aggregation equations.*

Recent results on aggregation equations (Received August 18, 2010)

37 ► Dynamical systems and ergodic theory

1063-37-6 **Annalisa Crannell*** (annalisa.crannell@fandm.edu), Department of Mathematics, Box 3003, Franklin & Marshall College, Lancaster, PA 17604-3003, and **Sohaib Alam** (malam@physics.utexas.edu). *Quasicontinuous functions with totally discontinuous iterates.*

Many theorems of topological dynamics apply beyond continuous functions to *quasicontinuous* functions, functions for which inverse images of open sets are semi-open. It is well known that every quasicontinuous function has a dense—indeed, residual—set of points of continuity. If we require of our quasicontinuous function f a mild extra condition (that the forward images of non-empty open sets contain non-empty open sets), then the same

is true of f^k for all $k > 0$. Indeed, we show that the set of points for which f is continuous at every point along the orbit of x is likewise residual. On the other hand, we show that iterates of general quasicontinuous functions are less well-behaved: in particular, we give examples of two quasicontinuous functions whose second iterates are discontinuous everywhere. (Received March 22, 2010)

1063-37-30 **Ami E. Radunskaya*** (aer04747@pomona.edu), Math Department, Pomona College, 610 N. College Ave., Claremont, CA 91711. *Stabilization Through Excitation.*

We consider the case of a first order, single-delay, differential equation with discontinuous, threshold control and periodic parametric excitation. The equation has the form:

$$\dot{x}(t) = (F(x(t-\tau)) + k\sin(2\pi f t))\, x(t)$$

where $k, f > 0$ and

$$F(x) = \begin{cases} a+b & x < \Theta \\ b & x >= \Theta \end{cases}$$

with $a > 0, b < 0, \Theta > 0$. It was discovered experimentally that solutions to this equation show that the "parametric excitation" modeled by the periodic term can have the effect of reducing the amplitude of the fluctuations caused by the "drift and act" control given by the function F. We explain this phenomenon and describe the parameter sets for which the amplitude damping occurs. (Received July 08, 2010)

1063-37-69 **Selenne H Garcia-Torres** and **Robert J Sacker*** (rsacker@usc.edu). *Concave Monotone Systems of Mappings in $\mathbb{R}^n$ and Periodic Difference Equations.* Preliminary report.

We consider a class $\mathcal{K}_n$ of mappings of $\mathbb{R}^n_+$ to $\mathbb{R}^n_+$ that are monotone increasing and concave with respect to an order cone K. $\mathcal{K}_n$ is a semigroup under composition and is closed under addition and positive scalar multiplication. Conditions are given guaranteeing a unique positive fixed point. Applications to periodic systems arising in the study of Mathematical Biology are discussed. (Received August 03, 2010)

1063-37-88 **Michel L Lapidus*** (lapidus@math.ucr.edu), Department of Mathematics, University of California, Riverside, CA 92521-0135. *Fractal Geometry and Dynamical Systems: From Fractal Drums and Strings to Fractal Billiards.* Preliminary report.

In this talk, we will attempt to discuss several points of contact between the theory of (continuous or discrete) dynamical systems and fractal geometry, particularly in connection with the vibrations of fractal strings and drums. This discussion may involve joint work with Machiel van Frankenhuisjen (for the general theory of fractal strings and their complex dimensions), John Rock as well as Katie Ellis and Michael Mackenzie (for multifractal zeta functions associated with iterated function systems), Hung Lu (for p-adic self-similar strings and dynamical systems), Nishu Lal (for multivariable complex dynamical systems associated with the spectra of Laplacians on fractals) and (for the still nascent theory of fractal billiards), Robert Niemeyer, in addition to work (in progress) of the author on continuous flows on moduli spaces of fractal membranes (cf., in particular, the author's book "In Search of the Riemann Zeros: Strings, Fractal Membranes and Noncommutative Spacetimes". Amer. Math. Soc., 2008) . (Received August 08, 2010)

1063-37-116 **Uri Bader**, **Alex Furman*** (furman@math.uic.edu) and **Roman Sauer**. *Rigidity of hyperbolic lattices in the framework of integrable measure equivalence.*

A restricted notion of measure equivalence between finitely generated groups is considered, one in which rearrangement cocycles are assumed to be integrable. In this framework of integrable measure equivalence new invariants and rigidity results are proven.

In particular for fundamental groups of negatively curved closed manifolds the dimension and the simplicial volume are shown to be invariants. For lattices in rank one groups SO(n,1) with n>2, and for surface groups, strong rigidity results are proven, analogous to those known for higher rank lattices.

The proofs use homological methods, a cocycle generalization of Mostow rigidity, and Milnor-Wood-Ghys phenomena for surface groups case. (Received August 11, 2010)

1063-37-122 **Nicolai T Haydn*** (nhaydn@usc.edu), Department of Mathematics, University of Southern California, Los Angeles, CA 90089. *Return times statistics for Markov towers.*

We show that for Lai-Sang Young's Markov towers the return times are in the limit Poisson distributed for sets that are countably infinite unions of cylinders. We use the decay of correlations for Hölder continuous functions paired up with L^∞ functions and the Chen-Stein method to obtain the approximate Poisson distribution for the return times distribution. Naturally, the return set has to satisfy a 'non-periodicity' condition to avoid very short, periodic like, returns. (Received August 12, 2010)

1063-37-188 **Alexander S. Kechris*** (kechris@caltech.edu), Department of Mathematics, 253-37, California Institute of Technology, Pasadena, CA 91125. *Brooks' Theorem for measure-preserving group actions.* Preliminary report.

Brooks' Theorem is a classical result in finite combinatorics asserting that, except for two obvious exceptions, the chromatic number of a finite graph is bounded by the maximum degree of the graph. As part of a larger project concerning the measurable combinatorics of graphs associated with measure-preserving actions of countable discrete groups, we study the extend to which Brooks' Theorem holds in this context. (This is joint work with Clinton Conley.) (Received August 16, 2010)

1063-37-200 **Yitwah Cheung**, **Arek Goetz** and **Anthony Quas***, Dept of Math and Stats, Victoria, BC V8W 3R4, Canada. *Lattices, Uniform Distribution and* $3\log 2 - \pi^2/8$. Preliminary report.

We consider a simple family of piecewise isometric dynamical systems. While there are few tools available for this class of systems, we use elementary techniques and derive some surprising conclusions. We also raise a number of open questions concerning the limiting density of quasi-periodic regions in the plane. (Received August 16, 2010)

1063-37-226 **Darren Creutz*** (dcreutz@math.ucla.edu). *A Normal Subgroup Theorem for (Dense) Commensurators of Lattices.*

We prove a statement akin to Margulis' Normal Subgroup Theorem for lattices in Lie groups, but our Theorem applies not to lattices but to commensurators of lattices. We show that any infinite normal subgroup of a (dense) commensurator of a lattice in a Lie group necessarily intersects the lattice in a finite index subgroup. We then develop this into a correspondence between normal subgroups of the commensurator and open normal subgroups of the relative profinite completion.

The approach, as in Margulis' Theorem, involves, on the one hand, using cohomology and rigidity theory to prove a certain group has property (T), and on the other hand, Furstenberg's Boundary Theory to prove this group is also amenable. We will focus more on the amenability half of the proof, in particular our new "Factor Theorem" which facilitates the proof (and which is of independent interest). (Received August 16, 2010)

1063-37-238 **Yoshikata Kida*** (kida@math.kyoto-u.ac.jp), Department of Mathematics, Kyoto University, Kyoto, 606-8502, Japan. *Measure equivalence rigidity of amalgamated free products.*

Measure equivalence is an equivalence relation between discrete countable groups, defined in measure-theoretic terms, and is closely related to the theory of orbit equivalence and von Neumann algebras. It is known that higher rank lattices and mapping class groups of compact orientable surfaces satisfy rigidity in the sense of measure equivalence. Particularly, the mapping class group G is ME rigid, that is, any group that is measure equivalent to G is virtually isomorphic to G. This talk presents a construction of ME rigid groups given as amalgamated free products of two rigid groups. (Received August 17, 2010)

1063-37-263 **Vitalii Ostrovskyi*** (ostrovsk@usc.edu) and **Paul Newton** (newton@usc.edu). *Stability of icosahedral configurations of point vortices on a sphere.*

Using icosahedron as the initial geometric distribution of point vortices on a sphere we show existence of icosahedral relative equilibrium configurations. To characterize these configurations we apply method based on finding the fixed points of the nonlinear dynamical system governing the $M = N(N-1)/2$ equations for interparticle distances. Obtained equations give sufficient conditions for the relative equilibria and lead to a problem of finding solutions to $A\Gamma = 0$, where $\Gamma \in R^N$ is the vector of vortex strengths, and $A \in R^{N\times M}$ is a rectangular, non-normal ($AA^T \neq A^TA$) 'configuration' matrix determined by the particle positions. Using singular value decomposition of A we prove that for icosahedron the Nullspace(A) is 7 dimensional. Vertex and edge stabilizers, as subgroups of icosahedral symmetry group, are used to build the set of symmetric icosahedral configurations with non-negative strengths. Energy-momentum method is used to study stability of discovered symmetric icosahedral relative equilibria. Using stability results we build an example of linear superposition of stable configurations which gives unstable configuration. (Received August 17, 2010)

39 ► Difference and functional equations

1063-39-11 **Yun Kang*** (yun.kang@asu.edu), Applied Sciences and Mathematics, Mesa, AZ 85212, and **Dieter Armbruster**, Math Department, Tempe, AZ 85297. *Dynamics of a discrete two-patch model on plant-insect interactions.*

We formulate and study a simple two-patch discrete time plant-insect model coupled through a dispersal of insect. Our objective is to understand how different intensities of dispersal impact both local and global population dynamics of the two-patch model, especially, we pay attention to two situations: when the single-patch model (i.e., in the absence of dispersal) is permanent and when the single-patch model exhibits Allee-like effects. First, we explore the existence and stability of synchronous and asynchronous dynamics between two patches. If the single-patch system is permanent, our analysis shows that the permanence of the system can be spoiled by large dispersals and large attacking rates of insect, thus, create multiple attractors; If the single-patch model exhibits Allee-like effects, the analytical and numerical results indicates that the small intensity of dispersals can generate source-sink dynamics between two patches, while the intermediate intensity of dispersals promote the extinction of insect in both patches, which may suggests a possible biology control strategy to stop the invasion of a pest by controlling its migration between patches. (Received August 10, 2010)

1063-39-16 **Hal Smith*** (halsmith@asu.edu), Tempe, AZ 85287, and **Paul Salceanu**. *Lyapunov Exponents and Persistence.*

The theory of Lyapunov exponents and methods from ergodic theory have been employed by several authors in order to study persistence properties of dynamical systems generated by ODEs or by maps. Here we derive sufficient conditions for uniform persistence, formulated in the language of Lyapunov exponents, for a large class of dissipative discrete-time dynamical systems on the positive orthant of R^n having the property that a nontrivial compact invariant set exists on a bounding hyperplane. We require that all so-called normal Lyapunov exponents be positive on such invariant sets. The results ensure the existence of a compact attractor in the interior of the orthant which attracts points of the interior. We apply the results to a plant-herbivore model, showing both plant and herbivore persist, and to a model of a fungal disease in a stage-structured host, showing that the host persists and the disease is endemic. (Received June 04, 2010)

1063-39-27 **Saber N Elaydi*** (selaydi@trinity.edu), One Trinity Place, San antonio, TX 78212. *Bifurcation and invariant manifolds of competition models.* Preliminary report.

The talk will focus on competition models. We will investigate stability and bifurcation of these models. In particular, we compute the invariant manifolds, including the important center manifolds, and study their bifurcation. Saddle-node and period doubling bifurcation route to chaos is exhibited via numerical simulations. (Received July 06, 2010)

1063-39-82 **J. M. Cushing*** (cushing@math.arizona.edu), University of Arizona, Department of Mathematics, 617 N Santa Rita, Tucson, AZ 85721. *A dynamic dichotomy for matrix equations with non-primitive projection matrices.* Preliminary report.

I will describe a dynamic dichotomy present in matrix difference equations with non-primitive projection matrices. These kinds of equations arise as (discrete time) models for the dynamics of biological populations that have a semelparous life history. The dichotomy is between stable positive equilibria versus attracting synchronous cycles. In biological applications this is a dichotomy between populations that equilibrate with overlapping generations and those with periodic oscillations with non-overlapping generations. I will focus on monotone and on hierarchical type of nonlinearities. As an application, I will show some experimental observations that, together with the well known LPA model, corroborate the theory. (Received August 06, 2010)

42 ► Fourier analysis

1063-42-39 **Steven C Hofmann*** (hofmanns@missouri.edu), Dept. of Mathematics, University of Missouri, Columbia, MO 65211. *Harmonic measure and uniform rectifiability.*

We discuss the interplay between harmonic measure estimates and rectifiability properties of the boundary of a domain. (Received July 19, 2010)

1063-42-49 **Andrei Lerner*** (lernera@math.biu.ac.il), Department of Mathematics, Bar-Ilan University, 52900 Ramat-Gan, Israel. *Sharp weighted norm inequalities for Littlewood-Paley operators.*

We prove sharp $L^p(w)$ norm inequalities for the intrinsic square function (introduced recently by M. Wilson) in terms of the A_p characteristic of w for all $1 < p < \infty$. This implies the same sharp inequalities for the classical Lusin area integral $S(f)$, the Littlewood-Paley g-function, and their continuous analogs S_ψ and g_ψ. (Received July 27, 2010)

1063-42-53 **Loukas Grafakos**, University of Missouri, Columbia, Missouri, **Liguang Liu**, Renmin University of China, Beijing, Peoples Rep of China, **Carlos Pérez**, Universidad de Sevilla, Seville, Spain, and **Rodolfo H. Torres*** (torres@math.ku.edu), Department of Mathematics, University of Kansas, 1460 Jayhawk Blvd, Lawrence, KS 66045-7594. *The multilinear strong maximal function.*

A multivariable version of the strong maximal function is introduced and a sharp distributional estimate for this operator in the spirit of the Jessen, Marcinkiewicz, and Zygmund theorem is obtained. Conditions that characterize the boundedness of this multivariable operator on products of weighted Lebesgue spaces equipped with multiple weights are obtained. Results for other multi(sub)linear maximal functions associated with bases of open sets are studied too. Bilinear interpolation results between distributional estimates, such as those satisfied by the multivariable strong maximal function, are also proved. (Received July 28, 2010)

1063-42-55 **Alexander L Volberg*** (sashavolberg@yahoo.com), Dept of Math., MSU, East Lansing, MI 48824. *A nonhomogeneous and bilinear outlook for sharp weighted estimates of singular operators.*

A nonhomogeneous and bilinear outlook for sharp weighted estimates of singular operators consists of applying the ideas that appeared in problems of nonhomogeneous analysis (random lattices, Tb theorems with partial data, etc) to much more homogeneous problems of one weight estimates of Calderón–Zygmund operators. The gain is then the sharp estimates in terms of weight. We also show how bilinear estimates appear absolutely naturally in dealing with these weighted sharp–and just linear—estimates. (Received July 29, 2010)

1063-42-72 **Steve Hofmann** (hofmanns@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, and **Jose Maria Martell*** (chema.martell@uam.es), Instituto de Ciencias Matematicas, CSIC-UAM-UC3M-UCM, 28049 Madrid, Madrid, Spain. *Extrapolation of Carleson measures and Muckenhoupt weights.*

We revisit the "extrapolation" method for Carleson measures, originally introduced by John Lewis to prove A_∞ estimates for certain caloric measures. We present a purely real variable version of the method suitable for deducing that a weight is in A_∞, given appropriate control by a Carleson measure. To illustrate the applicability of this criterion, we reprove a well known theorem of R. Fefferman, Kenig and Pipher concerning the solvability of the Dirichlet problem of second order divergence form elliptic operators with data in some L^p space. (Joint work with S. Hofmann) (Received August 04, 2010)

1063-42-81 **Fausto Ferrari** (ferrari@dm.unibo.it), Dipartimento di Matematica, Università di Bologna, Italy, **Bruno Franchi**, Dipartimento di Matematica, Università di Bologna, Italy, and **Igor Verbitsky*** (verbitskyi@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Hessian inequalities and the fractional Laplacian.*

Relations between the k-Hessian energy $\mathcal{E}_k[u] = \int_{\mathbb{R}^n} -u\, F_k[u]$ and the fractional Laplacian energy $E_k[u] = \int_{\mathbb{R}^n} |(-\Delta)^{\frac{k}{k+1}} u|^{k+1}\, dx$ will be discussed. Here F_k $(k = 1, \dots, n)$ is the k-Hessian operator, i.e., the sum of all the $k \times k$ principal minors of the Hessian matrix of u, and u is a k-convex function on $\mathbb{R}^n$ vanishing at ∞. (Received August 06, 2010)

1063-42-102 **Yen Do*** (yendo@math.gatech.edu), **Camil Muscalu** (camil@math.cornell.edu) and **Christoph Thiele** (thiele@math.ucla.edu). *A variational estimate for paraproducts.* Preliminary report.

We show variational estimates for paraproducts, which can be viewed as bilinear generalizations of Lépingle's variational estimates for martingale averages or scaled families of convolution operators. The heart of the matter is the case of low variation exponents. Joint work with Camil Muscalu and Christoph Thiele. (Received August 10, 2010)

1063-42-107 **Kabe Moen***, One Brookings Drive, St. Louis, MO 63130, and **David Cruz-Uribe**. *Sharp norm inequalities for commutators of classical operators.*

We will discuss sufficient conditions on pairs of weights (u, v) for commutators of classical operators to be bounded from $L^p(v)$ to $L^p(u)$. Our results are sharp and they demonstrate that commutators are more singular than the underlying operator. This work is based on a collaboration with David Cruz-Uribe. (Received August 10, 2010)

1063-42-147 **Michael Christ*** (mchrist@math.berkeley.edu), Department of Mathematics, UC Berkeley, Berkeley, CA 94720-3840. *On Random Multilinear Operators.* Preliminary report.

A venerable theme is the smallness of the Fourier transform of a measure, in the absence of linear structure. Prototypical examples include natural surface measures on curved submanifolds, and classes of random measures.

We investigate multilinear extensions of this theme, particularly in connection with two classes of matrices with random coefficients. Applications concerned with correlations, return times, and sparse subsequences in ergodic theory are given.

The techniques are elementary, relying on the humble TT^* method, allied with Fourier transformation, independence, large deviations, and entropy considerations. (Received August 14, 2010)

1063-42-179 **Ciprian Demeter** and **S. Zubin Gautam*** (sgautam@indiana.edu), Department of Mathematics, Indiana University, Rawles Hall, 831 East 3rd St., Bloomington, IN 47405. *On the finite linear independence of lattice Gabor systems.*

In the restricted setting of product phase space lattices, we give an alternate proof of P. Linnell's theorem on the finite linear independence of lattice Gabor systems in $L^2(\mathbb{R}^d)$. Our proof is based on a simple argument from the spectral theory of random Schrödinger operators; in the one-dimensional setting, we recover the full strength of Linnell's result for general lattices. (Received August 15, 2010)

1063-42-185 **Geoff Diestel*** (geoff_diestel@hotmail.com), 10405 NE 9th Ave, #D14, Vancouver, WA 98685. *A vector-valued embedding for Lebesgue spaces.* Preliminary report.

The space $\ell_\infty(L_{p,\infty}) \cap \ell_p(L_\infty)$ embeds into $L_{p,\infty}(\ell_\infty)$ for all $0 < p \leq \infty$. Combining this result with factorization theory allows one to obtain many square and maximal function estimates related to families of k-linear operators. With these results, many estimates can be obtained for a large class of vector-valued operators of the form $\vec{T} = (T_j)_j$. These estimates are particularly useful in conjunction with Littlewood-Paley theory to solve many new and old problems involving linear and multilinear Fourier multiplier operators. Applications for dyadic maximal operators and bilinear Calderón-Zygmund operators with rough kernels are included. Moreover, the above embedding leads to an extremely short and simple proof of the L_2 bounds for the Littlewood-Paley paraproduct P_b where $b \in BMO$. (Received August 16, 2010)

1063-42-201 **Carlos Perez*** (carlosperez@us.es), University of Seville, Seville, Spain. *Around the A2 conjecture for singular integral operators.*

Around the A_2 conjecture for singular integral operators.

We plan to give a brief survey on some recent results concerning the boundedness of singular integrals on weighted L^2 spaces with sharp operator bounds.

In the first part of this lecture (joint work with D. Cruz-Uribe and J. M. Martell) we will discuss a new proof of the linear sharp weighted L^2 estimate

$$\|T\|_{L^2(w)} \leq c_{n,T}\,[w]_{A_2}$$

where $w \in A_2$ and T is the Hilbert transform, a Riesz transform, the Beurling-Ahlfors operator or any operator that can be approximated by Haar shift operators which avoids the Bellman function technique and any two weight norm inequalities. The method can be applied to obtain similar sharp results for other important operators such as the dyadic square function, paraproducts or the vector-valued maximal function.

In the second part (joint work with S. Treil and A. Volberg) of the lecture we will discuss some recent progress of the A_2 conjecture for any Calderón-Zygmund operator. In particular we show that everything is reduced to consider the corresponding weighted weak L^2 estimate. (Received August 16, 2010)

1063-42-262 **Izabella Laba*** (ilaba@math.ubc.ca), Department of Mathematics, UBC, Vancouver, BC V6T1Z2, Canada. *Maximal operators and differentiation theorems for sparse sets.*

We study maximal averages associated with singular measures on $\mathbf{R}$. Our main result is a construction of singular Cantor-type measures in one dimension for which the corresponding maximal operators are bounded on L^p for all $p > 1$. As a consequence, we answer a question of Aversa and Preiss on density and differentiation theorems

in one dimension. Our proof combines probabilistic techniques with methods developed in multidimensional harmonic analysis. (Joint work with Malabika Pramanik.) (Received August 17, 2010)

43 ► Abstract harmonic analysis

1063-43-134 **Mario Bonk***, Department of Mathematics, University of California, Los Angeles, CA 90055. *Generalized Marcinkiewicz integrals.* Preliminary report.

The Marcinkiewicz integral is defined by

$$I(x) = \int_{|y|\le 1} \frac{\operatorname{dist}(x+y, A)}{|y|^{n+1}}\, dy,$$

where $A \subset \mathbb{R}^n$ is a closed set. Obviously, $I(x) = \infty$ for $x \in \mathbb{R}^n \setminus A$, but one can show that $I(x) < \infty$ for almost every $x \in A$. This is related to the fact that on average one can improve on the estimate

$$\operatorname{dist}(x+y, A) = o(|y|)$$

that holds for almost every $x \in A$. This observation leads to important applications of Marcinkiewicz integrals in harmonic analysis.

In my talk I will present a generalization of Marcinkiewicz integrals. This provides flexible tools for proving qualitatively sharp estimates in geometric analysis. (Received August 13, 2010)

1063-43-172 **Maria Carmen Reguera*** (mreguera@math.gatech.edu). *On Muckenhoupt-Wheeden conjecture.*

Let M denote the dyadic Maximal Function. We show that there is a weight w, and Haar multiplier T for which the following weak-type inequality fails.

$$\sup_{t>0} tw\{x \in \mathbb{R} \mid |Tf(x)| > t\} \le C \int_{\mathbb{R}} |f| Mw(x) dx.$$

This shows that a dyadic version of the so-called Muckenhoupt-Wheeden Conjecture is false. (Received August 15, 2010)

46 ► Functional analysis

1063-46-63 **Dietmar Bisch*** (dietmar.bisch@vanderbilt.edu), Vanderbilt University, Department of Mathematics, Nashville, TN 37240. *Composition of subfactors, and planar algebras.*

The technique of composing two subfactors, pioneered by Haagerup and myself, has led to a rich collection of standard invariants (or planar algebras) of subfactors. I will report on some recent constructions and new planar algebras obtained using this idea. (Received August 02, 2010)

1063-46-71 **Svitlana Mayboroda*** (svitlana@math.purdue.edu) and **Alexander Volberg**. *Square function, Riesz transform and rectifiability.*

We shall discuss connections between the analytic and geometric descriptions of sets. A celebrated 1991 theorem of David and Semmes ascertains that the L^2-boundedness of all Calderón-Zygmund operators with respect to a Hausdorff measure H^s on a set E implies that s is an integer and E is rectifiable ("contains big pieces of Lipschitz graphs"). In the present work the authors establish that it is, in fact, sufficient to assume pointwise boundedness of a single operator, namely, the square function associated to the Riesz transform, in order to arrive to the same conclusion. (Received August 04, 2010)

1063-46-96 **Benoit Collins** (bcollins@uottawa.ca), 585 King Edward, Ottawa, ON K1N 6N5, Canada, and **Todd Kemp*** (tkemp@math.ucsd.edu), 9500 Gilman Drive #0112, La Jolla, CA 92093-0112. *Free Liberation of Projections.*

Free liberation is a flow on pairs of operators, taking them toward freeness. It was introduced by Voiculescu in 1999 to be used in the analysis of free entropy and free Fisher information. It uses the free unitary Brownian motion to conjugate one operator so that, as time tends to infinity, a Haar unitary appears to produce freeness.

Let p and q be two projections, and let (p_t, q_t) be their free liberation. We use the free SDE for free unitary Brownian motion to construct a non-linear PDE that describes the flow of the law of $p_t q_t$, essentially characterizing the "principle angles" between the subspaces spanned by p_t and q_t. The arcsin law is a global attractor for this evolution, as expected.

We show that this PDE behaves like a non-linear heat flow, having conservation and smoothing properties. In the special case that p and q have trace $1/2$, the PDE miraculously can be converted into a functional equation,

introducing a new kind of subordination. This allows for very fine analysis of its local and global evolution. (Received August 09, 2010)

1063-46-100 **Vaughan Jones**, **Alice Guionnet** and **Dimitri Shlyakhtenko***, Department of Mathematics, UCLA, Los Angeles, CA 90095, and **Paul Zinn-Justin**. *Von Neumann algebras associated to planar algebras.* Preliminary report.

We discuss von Neumann algebras associated to a planar algebra using a construction involving random matrix theory. (Received August 09, 2010)

1063-46-105 **Zhe Dong** (dongzhe@zju.edu.cn), Department of Mathematics, Zhejiang University, Hangzhou, 310027, Peoples Rep of China, and **Zhong-Jin Ruan*** (ruan@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *A Hilbert module approach to coarse embedding of groups.*

In this talk, we first discuss some equivalent Schur multiplier conditions for exactness and coarse embedding of discrete groups. We then show that there is a natural Hilbert module approach to these properties. (Received August 10, 2010)

1063-46-110 **Feng Xu***, Dept. of Math, U.C.Riverside, Riverside, CA 92521. *On a subfactor generalization of Wall's conjecture.*

In this talk we discuss a conjecture on intermediate subfactors which is a generalization of Wall's conjecture from the theory of finite groups. We explore special cases of this conjecture and present supporting evidence. This talk is based on joint work with Robert Guralnick. (Received August 11, 2010)

1063-46-117 **Stefaan Vaes*** (stefaan.vaes@wis.kuleuven.be), Department of Mathematics, K.U.Leuven, Celestijnenlaan 200B, B-3001 Leuven, Belgium. *A class of group factors $L(G)$ that remember the group G.*

I will report on a recent joint work with Sorin Popa and Adrian Ioana in which we prove that for a fairly large class of generalized wreath product groups G, the associated von Neumann algebra $L(G)$ completely 'remembers' the group G. More precisely, if $L(G)$ is isomorphic to the von Neumann algebra $L(\Lambda)$ of an arbitrary countable group Λ, then Λ must be isomorphic to G. These represent the first superrigidity results pertaining to group von Neumann algebras. (Received August 11, 2010)

1063-46-120 **Marius Junge*** (junge@math.uiuc.edu), 1408 West Green Street, Urbana, IL 61801, and **Eric Ricard** and **Dimitri Shlyahktenko**. *Noncommutative diffusion semigroups.* Preliminary report.

In the theory of semigroups on commutative spaces diffusion semigroups are characterized by Bakry/Emry as those with local generator or equivalently with a solution of the martingale problem admitting almost everywhere continuous trajectories. We will show that for symmetric semigroups there always exists a Markov dilation. Moreover, assuming in additional a normal derivation the trajectories can be shown to have almost uniform continuous path. Therefore noncommutative diffusion groups provide tools such as an Ito formula way beyond the classical setting. (Received August 11, 2010)

1063-46-131 **Hans Wenzl*** (hwenzl@ucsd.edu), Dept of Math, UCSD, La Jolla, CA 92093. *A new q-Brauer algebra and subfactors.*

We construct subfactors which can be viewed as quantum analogs for the inclusion of the fixed point algebra under an outer SU(N) action contained in the fixed points of SO(N), for N odd. While we can take the familiar Hecke algebras for SU(N) fixed points, we need a new q-deformation of Brauer's centralizer algebra for the SO(N) fixed points. Unlike in the classical case, we get finite index finite depth subfactors. These subfactors are expected to be related to twisted loop groups. (Received August 12, 2010)

1063-46-135 **Stephen R Curran*** (curransr@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095. *Quantum symmetries in free probability.*

Beginning with the free de Finetti theorem of Kostler and Speicher in 2008, there have been a number of results which indicate that symmetries in free probability are described by certain universal compact quantum groups. We will survey some of these developments. (Received August 13, 2010)

1063-46-149 **J Owen Sizemore*** (sizemore@math.ucla.edu). *Rigidity for Actions of Wreath Product Groups.*

In this talk we will discuss recent W^* and Orbit Equivalence rigidity results for wreath product groups. This is joint work with Ionut Chifan and Sorin Popa. (Received August 14, 2010)

1063-46-153 **Edward G. Effros*** (ege@math.ucla.edu), Mathemaics Department, UCLA, Los Angeles, CA 90095, and **Lieven Vandenberghe** (vandenbe@ee.ucla.edu), Electrical Engineering Department, UCLA, Los Angeles, CA 90095. *On the Wittstock-Schmitt matricial Riesz interpolation property, and matrix convex optimization.* Preliminary report.

Matrix ordered and normed versions of the Hahn-Banach theorem provide the underpinning of "quantized" functional analysis. These results were proved by Arveson in 1969, and extended by Wittstock in 1981. Although the classical Hahn-Banach theorem was concerned with extending scalar valued linear functions, other "injective" range spaces could be used. In the ordered case, the dual injective spaces are the L^∞ spaces, the crucial property being the lattice property of the ordering. In fact the usual extension one dimension at a time only requires the weaker Riesz interpolation property, a key notion in the Choquet theory of convexity. The problem of finding matrix versions of the interpolation property that would "explain" matrix order injectivity was explored by Choi and Effros in 1977, and a more detailed analysis was given by Wittstock and Schmitt in the mid 1980's. Stimulated by the current interest in matricial orderings and corresponding tensor products and their applications in quantum information theory (e.g., Paulsen *et al*), we provide an elementary clarification of the Wittstock-Schmitt results based on methods of convex optimization. Other very recent and surprising developments in matrix convexity theory will also be mentioned. (Received August 14, 2010)

1063-46-155 **Dan-Virgil Voiculescu*** (dvv@math.berkeley.edu), Department of Mathematics UC Berkeley, Berkeley, CA 94720. *Aspects of the free Riemann sphere.* Preliminary report.

Passing from complex numbers to a non-commutative algebra of scalars, which also no longer commute with the variables, the appropriate extension of the Riemann sphere is the free Riemann sphere. This work is motivated by free probability and related spectral questions. (Received August 14, 2010)

1063-46-158 **Cyril Houdayer*** (cyril.houdayer@umpa.ens-lyon.fr), UMPA, ENS de Lyon (site Sciences), 46 allee d'Italie, 69364 Lyon, France. *Approximation properties and absence of Cartan subalgebra for free Araki-Woods factors.*

In this talk, we show that all the free Araki-Woods factors $\Gamma(H_{\mathbf{R}}, U_t)''$ have the complete metric approximation property. Using Ozawa-Popa's techniques, we then prove that every nonamenable subfactor $\mathcal{N} \subset \Gamma(H_{\mathbf{R}}, U_t)''$ which is the range of a normal conditional expectation has no Cartan subalgebra. We finally deduce that the type III_1 factors constructed by Connes in the '70s can never be isomorphic to any free Araki-Woods factor, which answers a question of Shlyakhtenko and Vaes. This is joint work with Éric Ricard. (Received August 15, 2010)

1063-46-159 **Ken Dykema*** (kjd@tamu.edu), Dept. of Mathematics, Texas A&M University, College Station, TX 77843-3368. *On free products related to the Guionnet-Jones-Shlyakhtenko construction for subfactors.*

We describe some amalgamted free products of von Neumann algebras over finite dimensional subalgebras. Special cases of these results are used to identify the type II_1 factors appearing in the construction of subfactors from planar algebras, due to Guionnet, Jones and Shlyakhtenko. (Received August 15, 2010)

1063-46-183 **Hiroki Sako*** (hiroki@ms.u-tokyo.ac.jp), Komaba 3-8-1, Meguro, Tokyo 191-0055, Japan. *Stone–Cech boundaries of discrete groups and measure equivalence theory.*

We get three types of results on measure equivalence theory: direct product groups of Ozawa's class S groups, wreath product groups and amalgamated free products. We prove measure equivalence factorization results on direct product groups of Ozawa's class S groups. As consequences, Monod–Shalom type orbit equivalence rigidity theorems follow. We prove that if two wreath product groups $A \wr G$, $B \wr \Gamma$ of non-amenable exact direct product groups G, Γ with amenable bases A, B are measure equivalent, then G and Γ are measure equivalent. Rigidity results on amalgamated free products of non-amenable exact direct product groups are also shown. We use the notion of biexactness of countable groups. We also prove that being in Ozawa's class S of countable discrete groups is invariant under measure equivalence. (Received August 16, 2010)

1063-46-196 **Yoann N. Dabrowski*** (yoann@math.ucla.edu). *A non-commutative Path Space approach to stationary free Stochastic Differential Equations.*

By defining tracial states on a non-commutative analog of a path space, we construct Markov dilations of certain conservative completely Markov semigroups on finite von Neumann algebras, including all symmetric semigroups. For well chosen semigroups, for instance with generator any divergence form operator associated to a derivation valued in the coarse correspondence, those dilations give rise to stationary solutions of certain free SDEs previously considered by D. Shlyakhtenko.

We explain two applications : a non-commutative Talagrand's inequality for non-microstate free entropy and the combination of our dilation results with techniques of Popa-Ozawa and Peterson giving the proof that the von Neumann algebra of any finitely generated group with complete metric approximation property and positive first L^2 betti number has no Cartan subalgebras. (Received August 16, 2010)

1063-46-199 **Alexander A. Katz** (katza@stjohns.edu), St. John's University, Department of Mathematics & Computer Science, 300 Howard Ave., DaSilva Academic Center 314, Staten Island, NY 10301, and **Roman Kushnir*** (kushnir_roman@yahoo.com), University of South Africa, Department of Mathematical Sciences, P.O. Box 392, Pretoria, 0003, South Africa. *On measurable bundles of real C*-algebras.*

We introduce and study real C*-algebras over $L_0(\Omega)$ (real *- Banach-Kantorovich algebras over the ring on all measurable functions whose norm satisfies conditions similar to those of real C*-algebras). It is shown that each such algebra admits a unique up to real *- isometry representation by means of a measurable bundle of real C*-algebras with vector-valued lifting. (Received August 16, 2010)

1063-46-242 **Jesse Peterson*** (jesse.d.peterson@vanderbilt.edu), Mathematics Department, Vanderbilt University, 1326 Stevenson Center, Nashville, TN 37240, and **Thomas Sinclair** (thomas.sinclair@vanderbilt.edu). *On cocycle superrigidity for Gaussian actions.*

I will present a general setting to investigate U_{fin}-cocycle superrigidity for Gaussian actions in terms of closable derivations on von Neumann algebras. In this setting I will describe some U_{fin}-cocycle superrigidity results of S. Popa and produce new examples of this phenomenon. I will also use a result of K. Schmidt to give a necessary cohomological condition on a group representation in order for the resulting Gaussian action to be U_{fin}-cocycle superrigid. (Received August 17, 2010)

1063-46-243 **Alexander A. Katz*** (katza@stjohns.edu), St. John's University, Department of Mathematics & Computer Science, 300 Howard Ave., DaSilva Academic Center 314, Staten Island, NY 10301. *On real $\mathbb{B}$-C^*-algebras.*

Let A be a real C^*-algebra, and $\mathbb{B}$ be a complete Boolean subalgebra of the Boolean algebra of all central projections of A. We call A a real $\mathbb{B}$-C^*-algebra, if for each partition of unity $(e_\lambda)_{\lambda\in\Lambda} \in \mathbb{B}$, and each family $(x_\lambda)_{\lambda\in\Lambda} \in A$, there exists a unique $\mathbb{B}$-mixing $mix_{\lambda\in\Lambda}(e_\lambda x_\lambda)$, i.e. a unique $x \in A$ such that $e_\lambda x_\lambda = e_\lambda x$ for all $\lambda \in \Lambda$. Let now $\mathbb{V}^{(\mathbb{B})}$ be a Boolean valued universe. Among other basic properties of real $\mathbb{B}$-C^*-algebras it is established that a bounded descent of a real C^*-algebra inside $\mathbb{V}^{(\mathbb{B})}$ is a real $\mathbb{B}$-C^*-algebra. Conversely, it is shown that for every real $\mathbb{B}$-C^*-algebra A there exists a unique (up to a real *-isomorphism) real C^*-algebra $\mathcal{A}$ inside $\mathbb{V}^{(\mathbb{B})}$ whose bounded descent is isometrically real *- $\mathbb{B}$-isomorphic to A. (Received August 17, 2010)

1063-46-256 **Adrian Ioana*** (adiioana@math.ucla.edu), UCLA Department of Mathematics, Los Angeles, CA 90095-1555. *W^*-superrigidity for Bernoulli actions of property (T) groups.*

I will present a recent result proving that if G on X^G is a Bernoulii action of an ICC property (T) group G, then its von Neumann algebra completely remembers the group and the action. (Received August 17, 2010)

1063-46-261 **Marta Asaeda*** (marta@math.ucr.edu). *The classification of finite depth subfactors—an overview and the recent developments.*

The classification of subfactors was started by V. Jones, and it developed dramatically, involving various other fields of mathematics. Existence of subfactors that do not come directly from other objects such as quantum groups was raised as question, and Haagerup gave the list of the candidates of graphs that might be invariants for such subfactors with index a little above 4. I would like to give an overview on the topic in this direction, including the most recent results by various people. (Received August 17, 2010)

47 ► Operator theory

1063-47-61 **Gilles Pisier***, pisier@math.tamu.edu. *Operator space structures on Lp-spaces.* Preliminary report.

We will describe a new operator space structure on L_p $(1 < p < \infty)$ and compare it with the one introduced in our previous work using complex interpolation. For the new structure, the Khintchine inequalities and Burkholder's martingale inequalities have a very natural form: the span of the Rademacher functions is completely isomorphic to the operator Hilbert space OH, and the square function of a martingale difference sequence d_n is $\Sigma\, d_n \otimes \bar{d}_n$. (Received August 02, 2010)

1063-47-108 **Maria Cristina Pereyra*** (crisp@math.unm.edu), Department of Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131, and **Carlos Perez** and **DaeWon Chung**. *Sharp weighted inequalities for commutators.*

The A_2 conjecture says that all Calderón-Zygmund singular integral operators must obey a linear bound in $L^2(w)$ with respect to the A_2-characteristic of the weight. Right now this is known to be true for convolution operators with sufficiently smooth kernel. This includes Hilbert, Riesz and Beurling transforms. However various groups are working on this conjecture and Tuomas Hytönen just posted in the arXiv what seems to be a proof of the conjecture.

The commutator $[b, T]$ of a BMO function b with a CZ SIO T is more singular than the operator T, for example it is not of weak-type (1,1). If the operator T obeys linear bounds in weighted $L^2(w)$ with respect to the A_2-characteristic of the weight w then the commutator $[b, T]$ obeys quadratic bounds in $L^2(w)$ with respect to the A_2-characteristic of the weight. Extrapolation gives results for $L^p(w)$. The proof follows the classical Coifman-Rochberg-Weiss argument. Same proof shows that for higher order commutators the power increases by one each time. The results are optimal for all $1 < p < \infty$, as examples involving the Hilbert, Riesz and Beurling transforms show. (Received August 16, 2010)

1063-47-239 **Thomas J Sinclair*** (thomas.sinclair@vanderbilt.edu), Mathematics Department, 1326 Stevenson Ctr, Vanderbilt University, Nashville, TN 37240. *Strong solidity of group factors from lattices in* $\mathrm{SO(n,1)}$ *and* $\mathrm{SU(n,1)}$.

Generalizing techniques found in Ozawa and Popa, "On a class of II_1 factors with at most one Cartan subalgebra, II" (Amer. J. Math., 2010), we show that the group factors of ICC lattices in $\mathrm{SO(n,1)}$ and $\mathrm{SU(n,1)}$, $n \geq 2$, are strongly solid. This strengthens a result of Ozawa and Popa showing that such group factors have no Cartan subalgebras. (Received August 17, 2010)

1063-47-240 **Ionut Chifan*** (ionut.chifan@vanderbilt.edu), 1420 Stevenson Center, Nashville, TN 37235, and **Jesse Peterson** (jesse.d.peterson@vanderbilt.edu), 1424 Stevenson Center, Nashville, TN 37235. *Von Neumann algebras with unique group measure space Cartan subalgebra.*

In this talk I will introduce a class of groups ($\mathcal{CR}$) satisfying the following property:

If $\Gamma \in \mathcal{CR}$ then any free, ergodic, measure preserving action of Γ on a probability space gives rise to a von Neumann algebra with unique group measure space Cartan subalgebra.

I will also discuss few applications of this result to W^*-rigidity. This is joint work with Jesse Peterson. (Received August 17, 2010)

49 ► Calculus of variations and optimal control; optimization

1063-49-197 **Ashley B. Pitcher*** (ashley.pitcher@balliol.oxon.org), CAMS-EHESS, 54 bd Raspail, 75270 Paris Cedex 06, France. *Optimal control of a model of offending and re-offending.* Preliminary report.

Whether or not to commit a crime is assumed to be based on the probability of punishment. If offenders are caught, they are subjected to a certain, immediate punishment. It is more costly to raise the probability of punishment for first-time offenders, because that would likely require an overall elevation in general policing. However, offenders known to police are easier/cheaper to apprehend because they can be watched more closely or because their DNA and fingerprints are in the system. A simple model is proposed for the cycle of offending and re-offending. Optimal control theory is used to minimize an objective functional representing the costs associated with raising the probability of punishment and the costs associated with the level of crime. The control variables are the probabilities of punishment for first-time offenders, known criminals and unknown criminals. The optimal strategy of course depends on the function used for how criminals react to a rise the probability of punishment. Different possibilities for this function are explored. (Received August 16, 2010)

51 ► Geometry

1063-51-268 **Facundo Memoli*** (memoli@math.stanford.edu), Department of Mathematics, Building 380, Stanford University, Stanford, CA 94305. *Metric Geometry in Shape Analysis.*

The problem of object matching under invariances can be studied using certain tools from Metric Geometry. The main idea is to regard objects as metric spaces (or measure metric spaces). The type of invariance one wishes to have in the matching is encoded in the choice of the metrics with which we endow the objects. The standard example is matching objects in Euclidean space under rigid isometries: in this situation one would endow the objects with the Euclidean metric. More general scenarios are possible in which the desired invariance cannot be reflected by the preservation of an ambient space metric. Several ideas due to M. Gromov are useful for approaching this problem. In this talk we discuss different adaptations of these, and in particular we construct an Lp version of the Gromov-Hausdorff distance using mass transportation ideas. (Received August 17, 2010)

1063-51-269 **Jen-Mei Chang*** (jchang9@csulb.edu), Department of Mathematics and Statistics, 1250 Bellflower Blvd, CSULB, Long Beach, CA 90840. *Classification on the Grassmannians: Theory and Applications.*

In this talk, we will introduce a novel geometric framework for the general classification problem and present empirical results obtained from applying the proposed method on a face recognition problem under varying illumination. The success of this geometric framework builds upon the fact that the geometry and statistics of the Grassmannians are well-understood and family of patterns with a common characterization possesses discriminatory variations that are useful for classification. Under the right conditions, these families of patterns can be viewed as points on the Grassmannian where distances are available for classification. An investigation in ways to further speed up the algorthm leads to two notions of compression on the Grassmann manifold, both of which will be discussed in the talk as well. (Received August 17, 2010)

52 ► Convex and discrete geometry

1063-52-166 **Daniel Champion**, **David Glickenstein** and **Andrea Young*** (ayoung@math.arizona.edu). *Regge's Einstein-Hilbert functional on the double tetrahedron.*

The double tetrahedron is the triangulation of the three-sphere gotten by gluing together two congruent tetrahedra along their boundaries. As a piecewise flat manifold, its geometry is determined by its six edge lengths, giving a notion of a metric on the double tetrahedron. Notions of Einstein metrics, constant scalar curvature metrics, and the Yamabe problem on the double tetrahedron will be discussed. The main tool is analysis of Regge's Einstein-Hilbert functional, a piecewise flat analogue of the Einstein-Hilbert (or total scalar curvature) functional on Riemannian manifolds. The behavior of the Einstein-Hilbert- Regge functional on the space of metrics and on discrete conformal classes of metrics will also be described. (Received August 15, 2010)

53 ► Differential geometry

1063-53-18 **Ovidiu Munteanu*** (omuntean@math.columbia.edu), Math Department, Columbia University, Room 509, MC 4406, 2990 Broadway, New York, NY 10027. *Gradient Ricci Solitons.*

We present some recent development in the study of gradient Ricci solitons. We will address some questions about their classification and about their geometric and topological structure. (Received June 21, 2010)

1063-53-68 **Dan Knopf*** (danknopf@math.utexas.edu). *Formal matched asymptotics for degenerate Ricci flow neckpinches.* Preliminary report.

Gu and Zhu have shown that Type-II Ricci flow singularities develop from non-generic rotationally symmetric Riemannian metrics on spheres. We derive and provide arguments for detailed asymptotic profiles and curvature blow-up rates of such solutions. In forthcoming work, we will provide rigorous proof that there exist solutions exhibiting the asymptotic behavior formally described here. This is joint work with Sigurd Angenent and James Isenberg. (Received August 03, 2010)

1063-53-73 **Kevin C Brighton*** (kcbrighton@math.ucsb.edu). *A Liouville-type Theorem for Smooth Metric Measure Spaces.*

For smooth metric measure spaces $(M, g, e^{-f} dvol)$ we prove a Liuoville-type theorem when the Bakry-Emery tensor is nonnegative and f is bounded. This generalizes a result of Yau, which is recovered in the case f is

constant. This result follows from a gradient estimate for f-harmonic functions on smooth metric measure spaces with Bakry-Emery tensor bounded from below and f bounded. (Received August 04, 2010)

1063-53-95 **Curtis Pro*** (pro@math.ucr.edu) and **Frederick Wilhelm**. *On The Rigidity of Riemannian Submersions of Nonnegatively Curved Manifolds.*

We show that any zero-curvature plane in the base space of a Riemannian submersion of a nonnegatively curved manifold exponentiates to a flat, provided that a single horizontal lift is tangent to a flat. (Received August 09, 2010)

1063-53-111 **James Isenberg*** (isenberg@uoregon.edu), Institute for Theoretical Science, University of Oregon, Eugene, OR 97403, and **Rafe Mazzeo** and **Natasa Sesum**. *Ricci Flow on Complete Surfaces.*

While the Ricci flow on closed surfaces is well-understood, much less is known about the Ricci flow on open surfaces. After briefly surveying what is generally known and what is still unresolved, we focus on our recent work concerning the behavior under Ricci flow of asymptotically Euclidean and asymptotically conical geometries with nontrivial topology. (Received August 11, 2010)

1063-53-115 **David Glickenstein*** (glickenstein@math.arizona.edu), 617 N Santa Rita, P.O. Box 210089, Tucson, AZ 85721. *Discrete conformal variations of piecewise flat manifolds.*

Discrete conformal variations are in the background of Thurston's formulation of circle packing approximations of Riemann mappings, combinatorial Ricci flow, and finite volume approximations of the Laplacian. We will give a formulation of discrete conformal variations of piecewise flat manifolds and draw connections with conformal variations in Riemannian geometry. (Received August 11, 2010)

1063-53-119 **Fred Wilhelm*** (fred@math.ucr.edu), Dept. of Math., Univ. of Calf., Riverside, CA , and **Barbara Herzog** (bherz001@student.ucr.edu), Dept. of Math., Univ. of Calf., Riverside, CA. *Toward a notion of index of critical points of distance functions.* Preliminary report.

I will describe some recent results that maybe the beginnings of a notion of index of critical points of distance functions. This is joint work with Barbara Herzog. (Received August 11, 2010)

1063-53-151 **Michael Jablonski*** (mjablonski@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019-0315. *Ricci soliton metrics on solvable Lie groups.*

By studying the moment map on the space of Lie brackets, we demonstrate how left-invariant Ricci solitons on solvable Lie groups may be obtained by consecutively following two natural curves of metrics.

Using these curves of metrics, we study the isometry groups of left-invariant metrics on completely solvable unimodular Lie groups (this includes nilpotent groups). Within this class of Lie groups, we show that Ricci soliton metrics (when they exist) have maximal isometry groups among all left-invariant metrics. (Received August 14, 2010)

1063-53-154 **Vincent Bonini*** (vbonini@calpoly.edu), Department of Mathematics, California Polytechnic State University, San Luis Obispo, CA 93407, and **José Espinar** and **Jie Qing**. *Correspondences of Hypersurfaces in Hyperbolic Poincaré Manifolds and Conformally Invariant PDEs.*

In this talk we focus on a preliminary result for hyperbolic Poincaré manifolds, which serve as prototypical models for asymptotically hyperbolic manifolds. We derive an explicit relationship between the eigenvalues of the Schouten tensor of a conformal representative of the conformal infinity of a hyperbolic Poincaré manifold and the principal curvatures on the level sets of its uniquely associated defining function. This work considerably simplifies the arguments and generalizes the results of Espinar, Gálvez and Mira on hypersurfaces in hyperbolic space $\mathbb{H}^{n+1}$ and gives a correspondence between Weingarten hypersurfaces in hyperbolic Poincaré manifolds and conformally invariant equations on the conformal infinity. In particular, we obtain an equivalence between Christoffel-type problems for hypersurfaces in hyperbolic Poincaré manifolds and scalar curvature problems on the conformal infinity. (Received August 14, 2010)

1063-53-160 **Robert E. Greene*** (greene@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095-1555. *Semi-continuity of Isometry and Automorphism Groups(joint work with K.T. Kim and S.G. Krantz).*

Symmetry of geometric objects can be diminished or eliminated by arbitrarily small perturbations, but increasing the amount of symmetry requires alteration of a definite size. This intuitive perception of the semi-continuity of symmetry groups can be given precise meaning in many cases. In this talk, we discuss a new proof of D. Ebin's well-known result on the semi-continuity of isometry groups of Riemannian metrics and present applications to

the semi-continuity of automorphism groups of domains in complex euclidean spaces and complex manifolds in general(joint with K.T.Kim and S.G.Krantz) (Received August 15, 2010)

1063-53-176 **Michael Usher*** (usher@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30606. *Deformations in Hamiltonian Floer theory and in Morse theory.*

Certain deformations of the usual algebraic structure of Hamiltonian Floer theory will be discussed, leading among other applications to the construction of Calabi quasimorphisms on the universal covers of the Hamiltonian diffeomorphism groups of a wide class of symplectic manifolds, including all toric manifolds and all point blowups. I will also discuss a similar construction in finite-dimensional Morse theory, which surprisingly is so far understood less well than its Floer-theoretic counterpart. (Received August 15, 2010)

1063-53-177 **Huai-Dong Cao*** (huc2@lehigh.edu), Department of Mathematics, Lehigh University, Bethlehem, PA 18015, and **Meng Zhu**, Department of Mathematics, Lehigh University, Bethlehem, PA 18015. *Second variation and stability for Ricci solitons.*

We will present the second variation formula for Perelman's shrinker entropy and discuss linear stability of Ricci solitons. (Received August 15, 2010)

1063-53-203 **Andrew Cotton-Clay*** (acotton@math.harvard.edu), Department of Mathematics, FAS, Harvard University, Cambridge, MA 02138. *Holomorphic Pairs of Pants in Mapping Tori.*

We reinterpret counts of holomorphic pairs of pants in $\mathbb{R}$ times a mapping torus for a symplectomorphism of a symplectic surface Σ as counts of index -1 triangles between Lagrangians in $\Sigma \times \Sigma$ for certain 1-parameter families of almost complex structures. We obtain a complete description of rigid holomorphic curves in the case $\Sigma = T^2$ and various pair-of-pants invariants for certain pseudo-Anosov symplectomorphisms on higher genus surfaces. We give applications to periodic Floer homology and to the symplectic field theory and contact homology of the natural stable Hamiltonian structure on the mapping torus. (Received August 16, 2010)

1063-53-204 **Christina Sormani** and **Guofang Wei***, Department of Math, UCSB, Santa Barbara, CA 93106. *The Covering Spectrum.*

We introduce the covering spectrum which measure the sizes of holes of a metric space or a Riemannian manifold. The spectrum is related to the length spectrum and Laplacian spectrum. We will study its behavior under Gromov-Hausdorff convergence. For non-compact space, we introduce the cut-off covering spectrum. (Received August 16, 2010)

1063-53-216 **Christopher T Woodward*** (ctw@math.rutgers.edu), 110 Frelinghuysen Rd, Piscataway, NJ 08904. *Gauged Lagrangian Floer theory.*

I will discuss the gauged Lagrangian Floer theory introduced by Frauenfelder, in the special case that the Lagrangians are inverse images of Lagrangians in the symplectic quotient. The special case of toric moment fibers will be discussed. (Received August 16, 2010)

1063-53-230 **Chadwick S Sprouse*** (chad.sprouse@csun.edu), Chad Sprouse, Dept. of Math., California State University, Northridge, CA 91330-8313. *Eigenvalue pinching and differential forms.*

We discuss pinching theorems for the eigenvalues of the Laplacian on manifolds with lower curvature bounds, in particular for the Hodge Laplacian on differential forms. (Received August 17, 2010)

1063-53-267 **Mario Micheli*** (mariomicheli@gmail.com), UCLA Mathematics Department, 520 Portola Plaza, Math Sciences Building 6363, Los Angeles, CA 90095. *A computable formulation of curvature for the Riemannian manifold of Landmarks.*

In the past few years there has been a growing interest, in diverse scientific communities, in endowing "shape spaces" with Riemannian metrics, so to be able to measure similarities between shapes and perform statistical analysis on data sets (e.g. for object recognition, target detection and tracking, classification, and automated medical diagnostics). The geometry of such spaces has started to emerge only very recently; in this talk we will explore the sectional curvature for the Riemannian manifold of landmark points (which is one of the simplest, in that it is finite-dimensional) and discuss its effects on applications. (Received August 17, 2010)

54 ► General topology

1063-54-191 **Aaron Kaestner*** (akaestne@math.uic.edu), University of Illinois at Chicago, Dept MSCS, 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60640. *On the Khovanov homology of virtual knots.*

We will discuss extensions of constructions arising from the Khovanov homology of classical knots to the Khovanov homology of virtual knots and the categorification of Arrow Polynomial. (Received August 16, 2010)

55 ► Algebraic topology

1063-55-14 **John E Harper*** (john.edward.harper@gmail.com), EPFL SB IGAT GR-HE, BCH 5115 (Batiment BCH), 1015 Lausanne, Switzerland. *On a Whitehead theorem for topological Quillen homology of algebras and modules over operads.*

In Haynes Miller's proof of the Sullivan conjecture on maps from classifying spaces, Quillen's derived functor notion of homology (in the case of commutative algebras) is a critical ingredient. This suggests that homology for the larger class of algebraic structures parametrized by an operad O will also provide interesting and useful invariants. Working in the context of symmetric spectra, we prove a Whitehead theorem for topological Quillen homology of algebras and modules over operads. This is part of a larger goal to attack the problem: how much of an O-algebra can be recovered from its topological Quillen homology? This talk is an introduction to these results (joint with K. Hess) with an emphasis on several of the motivating ideas. (Received June 02, 2010)

1063-55-84 **Philip Hackney*** (hackney@math.ucr.edu). *Operations in the Homology Spectral Sequence of a Cosimplicial Iterated Loop Space.*

We construct operations in the mod 2 homology spectral sequence associated to a cosimplicial E_{n+1}-space X. This spectral sequence abuts to the mod 2 homology of $\mathrm{Tot}(X)$, and our operations agree with the usual Araki-Kudo operations there. Jim Turner proved that operations exist in the spectral sequence of cosimplicial E_∞-spaces, but our construction is different than his and it is not known whether the operations agree. (Received August 06, 2010)

1063-55-190 **Kristine E. Bauer*** (kristine@math.ucalgary.ca), Department of Mathematics & Statistics, University of Calgary, 2500 University Dr., Calgary, AB T3L 2W9, Canada, **Brenda Johnson**, Schenectady, NY , and **Randy McCarthy**, , Canada. *A cotriple model for Goodwillie Calculus and DeRham cohomology.*

After Goodwillie introduced his now ubiquitous calculus for homotopy functors, Brenda Johnson and Randy McCarthy discovered a model for his theory using cotriples. Later, Andrew Mauer-Oats showed that the Johnson-McCarthy degree n approximations for a functor agree with Goodwillie's n-excisive approximations when they are defined. However, the Johnson-McCarthy model was limited: in particular, it only applies to functors whose source category has a basepoint. In this talk, I will describe a new cotriple model for calculus which is more general and explain how this model can be used to resolve two possible approaches to DeRham cohomology for ring spectra. (Received August 16, 2010)

57 ► Manifolds and cell complexes

1063-57-28 **Louis Hirsch Kauffman*** (kauffman@uic.edu), 5530 South Shore Drive, Apt 7C, Chicago, IL 60637-1946. *Categorifications of the Arrow Polynomial for Virtual Knots and Links.*

This talk will discuss ongoing work on categorifications of the arrow polynomial for virtual knots and links. The arrow polynomial is a construction of Dye and Kauffman that generalizes the Jones polynomial for virtual links to infinitely many variables, by using the oriented combinatorial structure of the link diagram. Dye, Kauffman and Manturov categorify the arrow polynomial by using new gradings associated with this extra structure. In this talk we discuss how these constructions are made, and we discuss joint work with Aaron Kaestner on examples of knots and links not detected by the arrow polynomial or by Khovanov homology that are detected by our categorification homology for the arrow polynomial. (Received July 07, 2010)

1063-57-43 **Yakov Eliashberg***, Department of Mathematics, Stanford University, Stanford, CA 94305. *Product formula for symplectic homology via Legendrain surgery.*

The pair-of-pants product on symplectic homology of a Weinstein manifold can be explicitly computed in terms of its handlebody (and, in particular, Lefschetz pencil) representation. This is a joint work with F. Bourgeois and T. Ekholm. (Received July 23, 2010)

1063-57-45 **Denis Auroux*** (auroux@math.berkeley.edu), UC Berkeley Department of Mathematics, 970 Evans Hall # 3840, Berkeley, CA 94720-3840. *Fukaya categories of symmetric products and bordered Heegaard-Floer homology.*

We outline an interpretation of Heegaard-Floer homology of 3-manifolds (closed or with boundary) in terms of the symplectic topology of symmetric products of Riemann surfaces, as suggested by recent work of Tim Perutz and Yanki Lekili. In particular we discuss the connection between the Fukaya category of the symmetric product and the bordered algebra introduced by Robert Lipshitz, Peter Ozsvath and Dylan Thurston, and recast bordered Heegaard-Floer homology in this language. (Received July 24, 2010)

1063-57-46 **Mohammed Abouzaid*** (abouzaid@math.mit.edu), 77 Massachusetts Ave, Building 2, Room 334, Cambridge, MA 02139. *Homotopy equivalence of nearby Lagrangians.*

Arnold conjectured that every exact Lagrangian in the cotangent bundle of a compact manifold is isotopic to the zero section. Fukaya-Seidel-Smith and Nadler proved, assuming the Maslov class vanishes and for a simply connected total space, that the inclusion induces an isomorphism on cohomology. Still assuming vanishing of the Maslov class, but for arbitrary fundamental groups, I will explain the proof that the inclusion is a homotopy equivalence. (Received July 25, 2010)

1063-57-47 **David A Clark*** (davidclark@rmc.edu), Randolph-Macon College, 204 Henry Street, Ashland, VA 23005. *An action of the symmetric group on* $\mathfrak{su}_3$ *Khovanov homology.* Preliminary report.

We demonstrate an action of the symmetric group on the $\mathfrak{su}_3$ Khovanov homology of a knot's n-cable, given by isotopies that permute cable strands. We will discuss implications of this action to an extension of the homology theory to higher irreducible representations of $\mathfrak{su}_3$. (Received July 26, 2010)

1063-57-58 **Uwe Kaiser*** (kaiser@math.boisestate.edu), Department of Mathematics, Boise State University, Boise, ID 83725-1555. *Curves on surfaces and Kauffman bracket state sums.* Preliminary report.

Given two simple closed curves on a surface we consider projections realizing their geometric intersection number. We discuss how partial Kauffman bracket state sums calculated from those projections give rise to invariants of the pair of isotopy classes of curves. We discuss the related calculus of tangles in the annulus, and the general problem of relating the geometry of curves on surfaces with Kauffman bracket state sums. (Received July 31, 2010)

1063-57-70 **Charles D Frohman*** (frohman@math.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Network Topological Field Theory and Representations of Web Groups.*

A web is a trivalent graph that is embedded in the three sphere, with its edges oriented and colored. A foam is a singular surface modeled with its faces oriented and colored embedded in a cylinder over the three sphere. We will discuss the connection between Topological Field Theories based on webs and foams, and the cohomology groups of spaces of representations of the fundamental group of the complement of the webs in the three sphere, and the representations of the fundamental group of the complements of foams embedded in a cylinder over the three sphere. (Received August 03, 2010)

1063-57-75 **Maciej Niebrzydowski** and **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, George Washington, Washington, DC 20052. *The second quandle homology of the Takasaki quandle of an even abelian groups.*

We complete the calculation of the second quandle homology of the Takasaki quandle of finitely generated abelian groups. (Received August 05, 2010)

1063-57-94 **Cagatay Kutluhan*** (kutluhan@math.columbia.edu), Department of Mathematics, Columbia University, 2990 Broadway, New York, NY 10027, **Yi-Jen Lee** (yjlee@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907, and **Clifford Henry Taubes** (chtaubes@math.harvard.edu), Department of Mathematics, Harvard University, Cambridge, MA 02138. *Heegaard Floer homology and Seiberg–Witten Floer homology.*

Let M be a closed, connected and oriented 3-manifold. We construct isomorphisms between the Heegaard Floer homology groups of M and the corresponding balanced versions of the Seiberg–Witten Floer homology groups of M. In this talk we give an overview of our construction and emphasize essential ingredients. This is joint work with Yi-Jen Lee and Clifford Henry Taubes. (Received August 09, 2010)

1063-57-121 **Tian-Jun Li** and **Weiyi Zhang*** (wyzhang@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Nakai-Moishezon Theorem and Donaldson's question for almost complex structures on rational surfaces.*

In this talk, our objectives are tamed and compatible almost complex structures. There are two interesting questions. The classical Nakai-Moishezon theorem (for surfaces) states the duality between ample divisor cone and curve cone for projective surfaces. Demailly-Paun, Buchdahl and Lamari generalized this duality to Kahler surfaces. It is natural to ask for such a duality for almost Kahler surfaces. Another interesting question is raised by Donaldson. He asked that if there is a J-tamed symplectic form, do we have a J-compatible symplectic form as well? We answered these two questions affirmatively for all tamed almost complex structures on spheres bundles over sphere. We also answer them in many interesting cases for other rational four manifolds, including the del Pezzo ones. (Received August 12, 2010)

1063-57-127 **Tye Lidman*** (tlid@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *Heegaard Floer Homology and Triple Cup Products.*

We give a complete calculation of $HF^\infty(Y, \mathfrak{s}_0; \mathbb{F}_2)$ for all three-manifolds, Y, and torsion Spin^c structures, $\mathfrak{s}_0$. It turns out that this is completely determined by the cup product structure on the cohomology of Y. This calculation agrees with predictions of Ozsváth-Szabó and thus establishes an isomorphism with Mark's cup homology, $HC^\infty(Y; \mathbb{F}_2)$. (Received August 12, 2010)

1063-57-137 **John Etnyre*** (etnyre@math.gatech.edu), School of Mathematics, 686 Cherry Street, Georgia Institute of Technology, Atlanta, GA 30332. *Non-loose Legendrian and transverse knots.*

Recently there have been several advances in our understanding of Legendrian and transverse knots in overtwisted contact manifolds. I will survey what we know about the structure of such knots and how they have features which do not have analogs for knots in tight contact manifolds. As time permits I will discuss relations with questions concerning Legendrian surgery and several open problems. (Received August 13, 2010)

1063-57-140 **Jason F McGibbon*** (mcgibbon@math.umass.edu), Department of Mathematics and Statistics, University of Massachusetts, Amherst, MA 01003-9305. *Monodromy invariants in the space of knots.*

Knot contact homology (KCH) is a combinatorially defined topological invariant of smooth knots introduced by Ng. Work of Ekholm, Etnyre, Ng and Sullivan shows that KCH is the contact homology of the unit conormal lift of the knot.

In this talk we describe a monodromy result for knot contact homology, namely that associated to a path of knots there is a connecting homomorphism which is invariant under homotopy. The proof of this result suggests a conjectural interpretation for KCH via open strings, which we will describe. (Received August 13, 2010)

1063-57-143 **J. Scott Carter**, **Alissa S. Crans**, **Mohamed Elhamdadi** and **Masahico Saito*** (saito@usf.edu). *Categorical quandles and knots, II – the fundamental* 2*-quandle and colorings.*

A categorical quandle, called a strict 2-quandle, is a category and also is a quandle satisfying certain conditions. We propose the fundamental strict 2-quandle, topologically defined generalizing the fundamental quandle. The elements are homotopy classes of arrows in the knot complement such that the end points are on the tubular neighborhood of a given knot, and are connected to a base point by arcs. To study its structure, we propose arrow systems defined on knot diagrams, and their colorings by finite strict 2-quandles. Examples are given, and relations to Fox colorings will be discussed. (Received August 13, 2010)

1063-57-144 **Eamonn Tweedy*** (eptweedy@math.ucla.edu). *On the $\mathcal{R}$-filtration for the Heegaard Floer chain complex of a branched double-cover.*

Seidel and Smith defined a knot invariant called symplectic Khovanov homology using braid closures. One can relate a set of generators for their complex to one for the hat-Heegaard Floer complex $\widehat{CF}$ for the branched double-cover, and the Seidel-Smith homological grading induces a filtration $\mathcal{R}$ on the $\widehat{CF}$ complex. We mention a proof that the $\mathcal{R}$-filtered chain homotopy type of $\widehat{CF}$ is a knot invariant. Further, we discuss the behavior of the $\mathcal{R}$-filtration with respect to connected sums of knots. The filtered $\widehat{CF}$ complex provides a spectral sequence computing $\widehat{HF}$, and one obtains an absolute Maslov grading on the homology group $\widehat{HF}$ when this spectral sequence collapses at the E_2-page (which occurs for all two-bridge knots, for example). We conclude with some speculation regarding the nature of this filtration. (Received August 13, 2010)

1063-57-169 **Lenhard Ng*** (ng@math.duke.edu), Mathematics Department, box 90320, Duke University, Durham, NC 27708. *Knot contact homology and transverse knots.*

This talk is an advertisement for a technique that uses contact topology to obtain invariants of smooth manifolds and submanifolds, via cotangent and conormal bundles. For knots, this technique produces a knot invariant called knot contact homology. I will survey some general properties of knot contact homology and present recent work that enhances it to produce a strong invariant of transverse knots. This is partly joint work with Tobias Ekholm, John Etnyre, and Michael Sullivan. (Received August 15, 2010)

1063-57-209 **J. Scott Carter*** (carter@jaguar1.usouthal.edu), Department of Mathematics and Statistics, ILB 325, Mobile, AL 3668, **Alissa S Crans** (acrans@lmu.edu), 1 LMU Drive, Loyola Marymount University, Los Angeles, CA 90045, **Mohamed Elhamdadi** (emohamed@mail.usf.edu), Department of Mathematics, University of South Florida, Tampa, FL 33620, and **Masahico Saito** (saito@usf.edu), Department of Mathematics, University of South Florida, Tampa, FL 33620. *Categorical quandles and knots, III – the fundamental 2-quandle and colorings.*

A *local arrow system of a classical knot diagram* is comprised of (a) a collection of arrows from an under-crossing arc to an over-crossing in a neighborhood of a crossing and (b) meridional arrows on each over-arc. A *coloring of a local arrow system by a strict* 2*-quandle* assigns objects to the arcs and morphisms to the arrows; the arrows must satisfy a collection of topologically natural conditions.

In this talk, we will examine the colorings of local arrow systems in the context of a presentation of the fundamental group that is obtained from the Dehn presentation by turning the associated handle-body decomposition upside-down. The tautological coloring (associated to a crossed module constructed from the fundamental group) is examined in this context. The Fox derivatives are applied to obtain a coloring by the Alexander 2-quandle. Finally, we will relate these constructions to the original definition of the Alexander polynomial that was given in Alexander and Briggs. (Received August 16, 2010)

1063-57-211 **Sam Nelson***, Department of Mathematical Sciences, 850 Columbia Ave, Claremont, CA 91711. *Rack modules and (t,s)-racks.*

Rack modules are representations of a certain algebra defined from a finite rack. These structures are related to a type of rack known as a (t,s)-rack. In this talk we will see new knot and link invariants defined via enhancement of the rack counting invariant using these rack module and (t,s)-rack structures. (Received August 16, 2010)

1063-57-223 **Paul H Drube*** (pdrube@math.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Which invariants of surfaces come from TQFT?*

Associated with every two-dimensional TQFT is a field-valued diffeomorphism invariant of closed, oriented two-manifolds, which we interpret as a map f whose domain is the counting numbers and whose range is the field over which the TQFT is defined. We precisely characterize which maps f may be realized as the diffeomorphism invariant of a 2-D TQFT Z. Intimately related to this characterization is the question of whether the Frobenius algebra A that a TQFT Z assigns the circle is equivalent to a quotient the algebra of all 2-D surfaces having the circle as their boundary, where the quotient is by the subspace of surfaces that "evaluate similarly". This nice property actually fails for a large class of TQFTs, including ones with both semisimple and non-semisimple associated Frobenius algebra. We precisely characterize the class of TQFTs satisfying this property, and demonstrate that the set of functions f arising from such TQFTs have a particularly succinct description. (Received August 16, 2010)

1063-57-241 **Carmen L Caprau*** (ccaprau@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue M/S PB 108, Fresno, CA 93740. *sl(n) link homology.* Preliminary report.
We will introduce and discuss some features of a topological construction giving rise to a new link homology categorifying the sl(n) link invariant. (Received August 17, 2010)

1063-57-249 **Heather M. Russell*** (hmrussellmath@gmail.com), **Moshe Cohen** and **Oliver Dasbach**. *A dimer model for the twisted Alexander polynomial.* Preliminary report.
A dimer is an edge in a bipartite graph, and a dimer covering is a perfect matching for that graph. We will revisit Kauffman's well-known state sum model for the Alexander polynomial using the language of dimers. By providing some additional structure we are able to extend this model to give a state sum formula for the twisted Alexander polynomial of a knot together with a representation of the knot group. This project is joint with Moshe Cohen (Bar-Ilan University) & Oliver Dasbach (LSU). (Received August 17, 2010)

1063-57-254 **Jeffrey Boerner*** (jeffboerner@gmail.com), 319 S. Market St., New Wilmington, PA 16172. *The Kauffman bracket skein module of T^3.*
The Kauffman bracket skein module of a 3-manifold is the module of isotopy classes of framed links embedded in the 3-manifold, subject to the Kauffman bracket skein relations. These skein modules are 3-manifold invariants, but can be difficult to compute. Dabkowski and Mroczkowski computed the Kauffman bracket skein module of the twice-punctured disk cross S^1. I will build on their notation and methods to explore the Kauffman bracket skein module of T^3. (Received August 17, 2010)

58 ► Global analysis, analysis on manifolds

1063-58-34 **Christina Sormani*** (sormanic@member.ams.org). *The Intrinsic Flat Distance between Riemannian Manifolds with Boundary.*
We define a new distance between oriented Riemannian manifolds with boundary that we call the intrinsic flat distance based upon Ambrosio-Kirchheim's theory of integral currents on metric spaces. Limits of sequences of manifolds, with a uniform upper bound on their volumes, the volumes of their boundaries and diameters are countably $\mathcal{H}^m$ rectifiable metric spaces with an orientation and multiplicity that we call integral current spaces. Collapsing sequences of manifolds converge to the 0 integral current space.

Recall that Greene-Petersen have proven that sequences of Riemannian manifolds with uniform geometric contractibility functions and a uniform upper bound on volume have a subsequence converging in the Gromov-Hausdorff sense to a metric space. We prove that when the geometric contractibility function is linear, the intrinsic flat limit agrees with the Gromov-Hausdorff limit revealing that the limit space is countably $\mathcal{H}^m$ rectifiable. When the function is not linear, the limit space need not have any rectifiability.

See http://comet.lehman.cuny.edu/sormani/research/intrinsicflat.html

This is joint work with S. Wenger and R. Schul. (Received July 14, 2010)

1063-58-161 **Joseph E Borzellino** and **Victor W Brunsden*** (vwb2@psu.edu), 3000 Ivyside Drive, Altoona, PA 16601. *A dictionary for translating between orbifolds and Lie groupoids.* Preliminary report.
We construct a dictionary that translates between the categorical approach to orbifolds via their description as Morita equivalence classes of proper etale Lie groupoids and the classical geometric approach of Satake and Thurston. As an application, we show that the Morita equivalence class of a proper etale Lie groupoid may be reconstructed from the group of complete orbifold diffeomorphisms of the corresponding orbifold. (Received August 15, 2010)

1063-58-173 **Christine M Guenther*** (guenther@pacificu.edu), Department of Mathematics and Computer Scienc, 2043 College Way, Pacific University, Forest Grove, OR 97116. *The second order renormalization group flow for locally homogeneous geometries on closed 3-manifolds.* Preliminary report.
The second order renormalization group flow of quantum field theory is the geometric evolution equation

$$\frac{\partial g}{\partial t} = -2Rc - \alpha Rm^2,$$

where g is a Riemannian metric, Rc is Ricci curvature, Rm is Riemannian curvature, and $0 < \alpha$ is a small parameter.

We investigate the behavior of the flow for locally homogeneous geometries on closed 3-manifolds, noting conditions under which it differs from the Ricci flow. (Received August 15, 2010)

1063-58-215 **Tedi Draghici** and **Tian-Jun Li*** (tjli@math.umn.edu), 206 Church Street, School of Math., University of Minnesota, Mpls, MN 55455, and **Adriano Tomassini** and **Weiyi Zhang**. *Geometry of almost complex four manifolds.*

In this talk I will survey my joint works with Tedi Draghici, Adriano Tomassini and Weiyi Zhang on the geometry of almost complex structures on four manifolds. (Received August 16, 2010)

60 ► Probability theory and stochastic processes

1063-60-17 **Jason Fulman*** (fulman@usc.edu). *Heat kernel and random matrices from compact Lie groups.*

We show how Stein's method can be combined with heat kernel techniques to study traces of powers of random elements of compact Lie groups. We also give an overview of some other applications of heat kernel techniques to random matrix problems. (Received June 09, 2010)

1063-60-23 **Barry C. Arnold*** (barry.arnold@ucr,edu). *Birthdays, Coupons, Hat-checks and Schur.*

The classical birthday, coupon collector and hatcheck problems are investigated with special reference to the effect of (1) eliminating exchangeability assumptions, and (2) introducing the possibility of imperfect recognition. The variability ordering of majorization is found to be useful in gauging the effect of inhomogeneity of the component probabilities in the three problems. (Received June 24, 2010)

1063-60-26 **Gerardo Rubino*** (gerardo.rubino@inria.fr), INRIA, 35042 Rennes, France. *On modeling and analysing P2P networks.*

Peer-to-peer (P2P) networks are omnipresent today, for many different kind of applications. They are large distributed systems, and their performance evaluation made appear new problems and new tools to analyze them. In this presentation, we will describe some of these performance problems, for which classical Markov models have been used, and for which different approaches based on deterministic techniques have been also used, basically leading to differential equations. We will make the link between them, using Mean Field analysis, and we will then use these models to analyze some improvements we propose for these networks. The main idea is to explore the implementation of priorities to optimize the system's behavior by giving more resources to more "cooperative" peers, but only when resources become rare. (Received July 04, 2010)

1063-60-31 **Mark Burgin** and **Gunter Meissner***, University of Hawaii, Shidler College of Business, 2404 Maile Way, Honolulu, HI 96822. *Mathematical Theory of Negative Probability and Models of Financial Processes.* Preliminary report.

Standard models of financial processes give only positive interest rates. However, negative nominal interest rates have occurred several times in the past in financial practice, as in the 2008/2009 global financial crisis, in Switzerland in the 1970s or in Japan in 2003. Negative probabilities allow economists to overcome shortcomings of standard models. However, in spite of numerous examples from physics and finance where negative probability has been successfully employed, there was no mathematical theory of negative probability taking values in classical number systems. In this work, a mathematical theory of probability that may take negative values is developed and studied in an axiomatic form, while its applications to financial problems in the context of the Black-Scholes-Merton framework are explained. Different properties of extended probability are obtained. Some of these properties are similar to properties of the classical probability, while other properties are essentially different. (Received July 09, 2010)

1063-60-35 **Mark Burgin** and **A. C. Krinik,***, Department of Mathematics and Statistics, California State Polytechnic University, 3801 W. Temple Ave., Pomona, CA 91768. *Conditional Hyperprobability.* Preliminary report.

Hyperprobability extends the concept of probability, allowing one to assign hyperprobability to events and processes that do not have probability, while preserving many properties of classical probability (Burgin, M. and Krinik, A.C. Probabilities and Hyperprobabilities, 8th Annual International Conference on Statistics, Mathematics and Related Fields, Honolulu, Hawaii, 2009, pp. 351-367). Here we define and study conditional hyperprobability. Many properties of conditional hyperprobability are similar to properties of conditional probability. In particular, Bayes Theorem for conditional hyperprobability is proved. This result allows essential extension of the Bayesian approach to statistics, inductive logic, and epistemology. At the same time, not all properties of conditional hyperprobability are similar to properties of conditional probability. (Received July 14, 2010)

1063-60-42 **Jason Schweinsberg*** (jschwein@math.ucsd.edu), Department of Mathematics, 0112, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0112, and **Julien Berestycki** and **Nathanael Berestycki**. *The genealogy of branching Brownian motion with absorption.*

We consider a system of particles which perform branching Brownian motion with negative drift and are killed upon reaching zero, in the near-critical regime where the total population stays roughly constant with approximately N particles. We show that the characteristic time scale for the evolution of this population is of the order $(\log N)^3$. Furthermore, the genealogy of the particles is then governed by a coalescent process known as the Bolthausen-Sznitman coalescent. This validates the non-rigorous predictions of Brunet, Derrida, Muller, and Munier for a closely related model. (Received July 22, 2010)

1063-60-44 **John Fricks*** (fricks@stat.psu.edu), 325 Thomas Bldg, University Park, PA 16802, and **John P Hughes** and **William O Hancock**. *Bridging Scales in Kinesin Motor Models.*

The kinesin molecular motor family takes a single 8 nanometer step forward for each ATP hydrolyzed except in rare cases. Recent experiments have demonstrated mulitiple steps including frequent back steps may be possible if the necklinker connecting the heads of the kinesin are extended. This talk will present a detailed intra-step model of kinesin stepping which allows for multiple steps and show that asymptotic quantities can be caclulated using a combination of limit theorems for semi-Markov processes and matrix analytic techniques for Markov chains. (Received July 24, 2010)

1063-60-48 **Yuval Peres*** (peres@microsoft.com), Microsoft Research, 1 Microsoft Way, Redmond, WA 98052, and **James R. Lee**. *Rate of escape for random walks on groups.*

Consider simple random walk on a finite Cayley graph of degree d. We show that the mean square distance from the starting point at time t is at least $t/(2d)$ for all t up to $1/gap$, the inverse spectral gap. It is an open question whether the bound holds (perhaps with another constant in front) for t less than the mixing time. For infinite Cayley graphs this bound holds for all t, as first noted by Anna Erschler. We can prove the following refinement for infinite groups: the probability that the walk is within distance $\epsilon t^{1/2}$ from the starting point is $O(\epsilon)$, provided $t > \epsilon^{-8}$. All the proofs are based on Lipschitz embeddings of the Cayley graph in Hilbert space. (Received July 27, 2010)

1063-60-52 **Brandi Bailes** and **Jenny Switkes*** (jmswitkes@csupomona.edu), Department of Mathematics and Statistics, 3801 W. Temple Ave., Pomona, CA 91768. *Optimization in Baseball Lineups.* Preliminary report.

In major league baseball there is great emphasis put on star performers - finding them, rating them, paying them millions of dollars, and filling the starting lineup with them - with almost no attention given to optimization, statistically or economically. Here, we use the plethora of available baseball statistics to help resolve baseball's optimization conundrum. By using the statistic "Runs Created," based off a combination of several non-fielding baseball statistics, we attempt to find the weakest players who still create a strong enough lineup to meet a desired minimum expected winning percentage against an opposing team. Our work is heavily based on the paper "Quasigeometric Distributions and Extra Inning Baseball Games" by Darren Glass and Philip Lowry. Our contribution is in applying their ideas to optimize starting lineups, and in creating a MATLAB-based routine and user interface that sabermetric-minded managers could use in putting together their starting lineups. (Received July 27, 2010)

1063-60-60 **Mark L Huber*** (mhuber@cmc.edu), 850 Columbia Ave., Claremont, CA 91711. *Near linear time perfect simulation of corrugated surfaces.*

Given a bipartite graph with n nodes, a corrugated surface can be viewed as a vector in $[0,1]^n$ such that all nodes in one partition are local maxima, and all the nodes in the other partition are local minima. In order to draw samples from this random landscape, Caracciolo, Rinaldi, and Sportiello (2008) constructed a Markov chain whose stationary distribution was uniform over the set of corrugated surfaces. They conjectured from experiments that the mixing time of the chain was $O(n \ln n)$ for the special case of a square lattice. Here a new Markov chain is presented that provably mixes in $O(n \ln n)$ time for all bipartite graphs. Like the Caraccilo, et al. chain, this new chain can also be used with coupling from the past to obtain samples drawn exactly from the desired distribution. Furthermore, this approach can then be combined with randomized cooling schedule methods in order to obtain a $1+\epsilon$ approximation (with probability at least $1-\delta$) of the corrugated surface volume in time $O(n^2(\ln n)\epsilon^{-2}\ln \delta^{-1})$. (Received August 01, 2010)

1063-60-66 **Cristian Tomasetti*** (cristian@math.umd.edu), 4146 CSIC Building #406, Paint Branch Drive, College Park, MD 20742, and **Doron Levy**. *The Role of Symmetric and Asymmetric Division of Cancer Cells in Developing Drug Resistance.*

Often, resistance to drugs is an obstacle to a successful treatment of cancer. Clearly, in order to understand drug resistance, it is imperative to have a good model of the underlying dynamics of cancer cells. One of the main ingredients that has been recently introduced into the rapidly growing pool of mathematical cancer models is stem cells. Surprisingly, this all-so- important subset of cells has not been fully integrated into existing mathematical models of drug resistance. In this work we incorporate the various possible ways in which a stem cell may divide into the study of drug resistance. We derive a new estimate of the probability of developing drug resistance by the time a tumor is detected, and calculate the expected number of resistant cancer stem cells at the time of tumor detection. To demonstrate the significance of this approach, we combine our new mathematical estimates with clinical data that is taken from a recent six-year follow-up of patients receiving imatinib for the first-line treatment of chronic myeloid leukemia. Based on our analysis we conclude that leukemia stem cells must tend to renew symmetrically as opposed to their healthy counterparts that predominantly divide asymmetrically. (Received August 03, 2010)

1063-60-67 **Edward C Waymire*** (waymire@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331, and **Thilanka A Appuhamillage**, **Vrushali A Bokil**, **Enrique A Thomann** and **Brian D Wood**. *Skew Diffusion in Highly Heterogeneous Environments.*

Skew diffusion models refer to stochastic processes whose infinitesimal generators are second order advection-dispersion elliptic operators having piecewise constant coefficients. Such processes arise naturally in connection with macroscopic mass balance and flux laws in highly heterogeneous environments. We shall present some applications of skew diffusion to explain some recent results of laboratory experiments and/or field observations pertaining to various types of interfacial behavior reported in the environmental and ecological sciences. (Received August 06, 2010)

1063-60-76 **Don Paul Rawlings*** (drawling@calpoly.edu), 1 Grand Avenue, Mathematics Department, California Polytechnic State University, San Luis Obispo, CA 93407. *Variations of the Absorption Process: Probabilistic Models for q-identities in Combinatorics and Number Theory.*

Several variations of Blomqvist's absorption process will be presented and used to provide probabilistic proofs of q-identities ranging from properties of the Gaussian polynomials to product expansions of basic hypergeometric series to extensions of Mahonian statistics. One of the variations of Blomqvist's absorption process to be discussed links the incomplete q-Eulerian polynomials to sequential search processes (which include proof reading and Russian roulette). Other variations to be considered involve q-Poisson distributions and provide probabilistic proofs for some of Euler's number theoretic (or partition) identities. (Received August 05, 2010)

1063-60-83 **Nicolas Lanchier*** (lanchier@math.asu.edu) and **Jared Neufer**. *Geometric properties of the majority rule model.*

Similarly to the voter model, the version of the majority rule model we introduce in this talk is an example of spin system, i.e., each vertex of the regular lattice is occupied by an individual either black or white. The population is further divided into overlapping groups, with all the individuals within the same group updating their color according to the majority within the group. In particular, the process can be seen as a natural extension of traditional interacting particle systems where dynamics depend upon a hypergraph structure rather than a connected graph. Whereas the voter model exhibits a diffusive clustering in two dimensions, numerical simulations suggest that stronger spatial correlations emerge for the majority rule model. We present analytical results in support of this picture. (Received August 06, 2010)

1063-60-89 **Sourav Chatterjee*** (sourav@cims.nyu.edu), 251 Mercer Street, Room 813, New York, NY 10012, and **Srinivasa Varadhan**. *The Large Deviation Principle for the Erdos-Renyi Random Graph.*

What does an Erdos-Renyi graph look like when a rare event happens? I will describe an answer to this question when p is fixed and n tends to infinity by establishing a large deviation principle under an appropriate topology. The formulation and proof of the main result uses the recent development of the theory of graph limits by Lovasz and coauthors and Szemeredi's regularity lemma from graph theory. As a basic application of the general principle, we work out large deviations for the number of triangles in G(n,p). Surprisingly, even this simple example yields an interesting double phase transition. This is based on joint work with S. R. S. Varadhan. (Received August 08, 2010)

1063-60-91 **Rinaldo B Schinazi*** (rschinaz@uccs.edu), Department of Mathematics, 1530 Austin Bluffs Parkway, Colorado Springs, CO 80933, and **Thomas M Liggett**. *A stochastic model for phylogenetic trees.*

We propose the following simple stochastic model for phylogenetic trees. New types are born and die according to a birth and death chain. At each birth we associate a fitness to the new type sampled from a fixed distribution. At each death the type with the smallest fitness is killed. We show that if the birth (i.e. mutation) rate is sub-critical we get a phylogenetic tree consistent with an influenza tree (few types at any given time and one dominating type lasting a long time). When the birth rate is super-critical we get a phylogenetic tree consistent with an HIV tree (many types at any given time, none dominating very long). (Received August 08, 2010)

1063-60-128 **Randall Swift*** (rjswift@csupomona.edu) and **Joe Gani**. *A PCR birth process subject to an enzyme death process.*

The PCR process is modelled as a birth process for DNA strands, subject to a death process for enzymes. The case of 1 DNA strand and 1 enzyme is considered first, and generalized to the n strand and b enzyme case. Finally an approximate process is considered which gives a good approximation for the expected number of DNA strands. (Received August 12, 2010)

1063-60-141 **Jorge Aarao** and **Mike O'Neill*** (moneill@cmc.edu), Department of Mathematics, Claremont McKenna College, Claremont, CA 91711. *Sharp inequalities of Zygmund type for Riesz transforms.*

The theory of stochastic integration for the Background Radiation process is used to obtain sharp constants in some endpoint inequalities of Zygmund type for the Riesz Transforms. Applications to estimates for Marcinkiewicz integrals will be discussed. The ideas come from works by Gundy-Varopoulos, Banuelos-Wang and Brian Cole. (Received August 13, 2010)

1063-60-150 **Elchanan Mossel*** (mossel@stat.berkeley.edu), Berkeley, CA 94720. *Probability, Social Choice and Social Networks.*

I will discuss some recent progress and problems involving stochastic models of voting and social interactions on graphs. (Received August 14, 2010)

1063-60-165 **Eyal Lubetzky*** (eyal@microsoft.com), Microsoft Research, 1 Microsoft Way, Redmond, WA 98052. *The cutoff phenomenon on explicit expanders.*

The cutoff phenomenon describes a sharp transition in the convergence of an ergodic finite Markov chain to equilibrium. Of particular interest is understanding this convergence for the simple random walk on a bounded-degree expander graph.

We will discuss the recent progress on this topic, focusing on two recent works joint with Allan Sly. In particular, we will present the first explicit construction of cubic expanders exhibiting total-variation cutoff from a worst case initial position, an explicit construction of cubic expanders without cutoff as well as cubic graphs with cutoff at any prescribed time-point. (Received August 15, 2010)

1063-60-171 **Rabi Bhattacharya*** (rabi@math.arizona.edu), Department of Mathematics, The University of Arizona, 617 N Santa Rita Avenue, Tucson, AZ 85750. *Speed of Convergence of Certain Markov Processes to Equilibrium.*

We consider several classes of Markov processes–irreducible as well as non-irreducible, and their approach to equilibrium. A splitting condition, generalizing a notion of Dubins and Freedman (1966),yields speeds of convergence in appropriate metrics for monotone Markov chains which are, in general, not irreducible. Examples include iterations of random quadratic maps, non-linear autoregressive models, and the Popp-Wilson algorithm for the Gibbs measure of the Ising model on a finite lattice. Conditions for exponential and polynmial rates of convergence to a steady state are derived for the Lindley process which is also monotone, but for which splitting does not occur. Multi-dimensional diffusions are another important class of Markov processes for which we explore new criteria for convergence to equilibrium at polynomial rates. (Received August 15, 2010)

1063-60-174 **David German*** (dgerman@cmc.edu), 850 Columbia Ave, Claremont, CA 91711-6420, and **Henry Schellhorn** (henry.schellhorn@cgu.edu), 150 E. 10th St., Claremont, CA 91711. *No-arbitrage conditions for limit-price orders.*

We consider a stock exchange model, operating with limit orders. When modelling the demand and supply rates, which are assumed to be driven by Brownian Sheets, we consider the limit price to be a variable (unlike the traditional approach). We base our model on the fundamental economic assumption that any moment the supply is equal to the demand, and then compute the clearing price at any given time. We derive the no-arbitrage

conditions on the drift and the volatility of supply and demand rates, so that the clearing price is a risk-neutral martingale. (Received August 15, 2010)

1063-60-180 **Andrea Montanari***, montanari@stanford.edu, and **Mohsen Bayati**, **David Donoho** and **Arian Maleki**. *Asymptotic behavior of high-dimensional random convex optimization problems.*

The problem of estimating a high-dimensional vector from a set of linear observations arises in a number of engineering disciplines. It becomes particularly challenging when the underlying signal has some non-linear structure that needs to be exploited. A common approach consists in solving a high-dimensional convex optimization problem. I will discuss an approach to study the asymptotic behavior of some families of such random convex problems. I will in particular focus on the mean square error for LASSO estimation in the context of compressed sensing problems. (Received August 15, 2010)

1063-60-186 **Allan Sly*** (allansly@microsoft.com), Theory Group, Microsoft Research, One Microsoft Way, Redmond, WA 98052. *Statistical physics and computational phase transitions of the hardcore model.*

The hardcore model is a model of lattice gas systems which has received much attention in statistical physics, probability theory and theoretical computer science. It is the probability distribution over independent sets I of a graph weighted proportionally to $\lambda^{|I|}$ with fugacity parameter λ. We prove that at the uniqueness threshold of the hardcore model on the d-regular tree, approximating the partition function becomes computationally hard on graphs of maximum degree d.

Specifically, we show that unless NP=RP there is no polynomial time approximation scheme for the partition function (the sum of such weighted independent sets) on graphs of maximum degree d for fugacity $\lambda_c(d) < \lambda < \lambda_c(d) + \epsilon(d)$ where

$$\lambda_c = \frac{(d-1)^{d-1}}{(d-2)^d}$$

is the uniqueness threshold on the d-regular tree. Weitz produced an FPTAS for approximating the partition function when $0 < \lambda < \lambda_c(d)$ so this result demonstrates that the computational threshold exactly coincides with the statistical physics phase transition thus confirming a conjecture of Mossel, Weitz and Wormald. Our proof is based on an analysis of the hardcore model on random bi-partite graphs which act as gadgets in a reduction to MAX-CUT. (Received August 16, 2010)

1063-60-194 **Nayantara Bhatnagar*** (nayantara.bhatnagar@gmail.com), School of Computer Science and Engineering, Hebrew University of Jerusalem, 91904 Jerusalem, Israel. *Reconstruction in the Potts and Hardcore models.*

I will talk about some recent results on the reconstruction problem on trees for the Potts and hardcore models.

The talk is based on joint works with Elitza Maneva and Allan Sly and Prasad Tetali. (Received August 16, 2010)

1063-60-195 **Firas Rassoul-Agha*** (firas@math.utah.edu), 155 South 1400 East, Salt Lake City, UT 84109, and **Timo Seppalainen**. *Almost sure process-level large deviations for random walk in random environment.*

Random walk in random environment is a generalization of classical random walk. It accounts for the disordered medium in which the particle travels and with which it interacts. The usual limit theorems become more subtle and much harder to prove. We prove a level-3 large deviation principle, for almost every realization of the environment, with rate function related to an entropy. This is joint work with Timo Seppalainen. (Received August 16, 2010)

1063-60-205 **Sheldon Ross*** (smross@usc.edu), Dept. Of Industrial and Systems Eng, Univ. of Southern California, Los Angeles, CA. *Systems of Dependent Components.*

We consider a system composed of n components, each of which works for a random time and then fails. Two general models that result in dependent component lifetimes are presented. The first supposes that there is a random process of environmental shocks. Attached to each shock is an n-vector, with result that the instantaneous failure rates of the components increase by the amounts specified by this vector. The second model supposes that the failure of component i causes the instantaneous failure rate of component j to increase by a specified amount c(i,j). We present results related to life distributions, component life dependency properties, and efficient simulation. (Received August 16, 2010)

1063-60-208 **Perla Sousi*** (p.sousi@statslab.cam.ac.uk), Selwyn College, Grange Road, Cambridge, CB3 9DQ, England, and **Yuval Peres**. *Brownian motion with variable drift: 0-1 laws, hitting probabilities and multiple points.*

By the Cameron Martin theorem, if a function f is in the Dirichlet space, then $B+f$ has the same a.s. properties as standard Brownian motion, B. In this talk I will present some properties of $B+f$ when f is a deterministic function not in this space. First I will show a 0-1 law, which in particular implies that the Hausdorff dimension of the image and the graph of $B+f$ are constants a.s. I will also present some results on hitting probabilities and multiple points for $B+f$ when the function f is Hölder(α), for $\alpha \leq 1/2$. I will conclude the talk by giving lower bounds on the Hausdorff dimension of the image of $B+f$, for any continuous deterministic function f. (Received August 16, 2010)

1063-60-212 **Amber L Puha*** (apuha@csusm.edu), 333 S. Twin Oaks Valley Road, San Marcos, CA 92096-0001, and **H Chrsitian Gromoll** and **Douglas G Down**. *Fluid Limits for Shortest Remaining Processing Time Queues.*

We consider a single server queue with renewal arrivals and i.i.d. service times, in which the server employs the shortest remaining processing time policy. To describe the evolution of this queue, we use a measure-valued process that keeps track of the residual service times of all buffered jobs. We propose a fluid model (or formal law of large numbers approximation) for this system. Under mild assumptions, prove existence and uniqueness of fluid model solutions. In addition, we prove a scaling limit theorem that justifies the fluid model as a first-order approximation of the stochastic model. The fluid model state descriptor is a measure-valued function whose dynamics are governed by certain inequalities together with the standard workload equation. These dynamics determine the evolution of the left edge (infimum) of the state descriptor's support, which in turn yields conclusions about response times. In particular, we are able to determine the exact manner in which the growth rate of the left edge depends on the service time distribution. By considering various examples, it is shown that this rate can vary from logarithmic to polynomial. This suggests that for heavier tailed service time distributions, shortest remaining processing time is not as unfair to the large jobs. (Received August 16, 2010)

1063-60-222 **Yuval Peres**, **Alistair Sinclair**, **Perla Sousi** and **Alexandre Stauffer*** (stauffer@cs.berkeley.edu). *Detection and Percolation on Mobile Geometric Graphs.*

We consider the following dynamic Boolean model introduced by van den Berg, Meester and White (1997). At time 0, let the nodes of the graph be a Poisson point process in $\mathbb{R}^d$ with constant intensity and let each node move independently according to Brownian motion. At any time t, we put an edge between every pair of nodes if their distance is at most r. We study two features in this model: detection (the time until a target point—fixed or moving—is within distance r from some node of the graph) and percolation (the time until a given node belongs to the infinite connected component of the graph). We obtain asymptotics for these features by combining ideas from stochastic geometry, coupling and multi-scale analysis. (Received August 16, 2010)

1063-60-224 **Jian Ding*** (jding@stat.berkeley.edu), Department of Statistics, UC Berkeley, Berkeley, CA 94720, **James Lee** (jrl@cs.washington.edu), Department of Computer Science, University of Washington, Seattle, WA 98195, and **Yuval Peres** (peres@microsoft.com), Microsoft Research, One Microsoft Way, Redmond, WA 98052. *Cover times, blanket times, and majorizing measures.* Preliminary report.

We exhibit a strong connection between cover times of graphs, Gaussian processes, and Talagrand's theory of majorizing measures. In particular, we show that the cover time of any graph G is equivalent, up to universal constants, to the square of the expected maximum of the Gaussian free field on G, scaled by the number of edges in G. This allows us to resolve a number of open questions. We give a deterministic polynomial-time algorithm that computes the cover time to within an O(1) factor for any graph, answering a question of Aldous and Fill (1994). We also positively resolve the blanket time conjectures of Winkler and Zuckerman (1996), showing that for any graph, the blanket and cover times are within an O(1) factor. The best previous approximation factor for both these problems was $O((\log\log n)^2)$ for n-vertex graphs, due to Kahn, Kim, Lovasz, and Vu (2000). (Received August 16, 2010)

1063-60-228 **Lea Popovic*** (lpopovic@mathstat.concordia.ca), 1455 de Maisonneuve Blvd W, Montreal, QC H3G 1M8, Canada. *Spatial aspects of multiscale reaction networks.*

In modeling interactions between different types of molecular species (or individuals) in a population one often makes the assumption that the system is "well mixed". This is reflected in the fact that the rate at which reactions between species occur is proportional the overall number of each of the species types that are needed as inputs for the reaction. Intuitively this assumption is correct if molecular transport (or individual movement) is

"much faster" than the interactions. When molecular transport is not fast enough to insure spatial homogeneity of the system, one needs to address the role of space in the evolution of the total amount of each species (individual type) in the system. I will present a model for a spatially inhomogeneous system. By making different assumptions on how fast the molecular transport (individual movement) is relative to the interactions, I will derive results for the evolution of the total amount of each species in the system, and discuss how they differ from results in a homogeneous system. This is joint work with Peter Pfaffelhuber (Freiburg). (Received August 16, 2010)

1063-60-229 **Joseph C Watkins*** (jwatkins@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85716, **Xavier Didelot** (xavier.didelot@gmail.com), Oxford Centre for Gene Function, University of Oxford, 1 South Parks Road, Oxford, OX1 3TG, and **Jesse E Taylor** (jtaylor@math.asu.edu), Department of Mathematics, Arizona State University, tempe, AZ 85287. *The Wright-Fisher Diffusion Process and an Application to Queues and Bacterial Recombination.*

In this talk, we will develop, using a duality argument, an identity stating that the Laplace transform of the length of a contiguous bacterial recombination region equals the probability of choosing a given allele in a stationary population evolving according to the one-dimensional Wright-Fisher diffusion model. Beyond giving us an improved inferential strategy for parameter estimation in bacterial recombination, the matching of the selection and recombination parameters in the identity also suggests the existence of an intriguing connection between ancestral recombination graphs and ancestral selection graphs. (Received August 17, 2010)

1063-60-234 **Martin T. Barlow**, **Jian Ding**, **Asaf Nachmias** and **Yuval Peres*** (peres@microsoft.com), Microsoft Research, 1 Microsoft Way, Redmond, WA 98052. *The evolution of the cover time.*

The cover time of a graph is a celebrated example of a parameter that is easy to approximate using a randomized algorithm, but for which no constant factor deterministic polynomial time approximation was known. A breakthrough due to Kahn, Kim, Lovasz and Vu yielded a $(\log\log n)^2$ polynomial time approximation. We refine this upper bound, and show that the resulting bound is sharp and explicitly computable in random graphs. Cooper and Frieze showed that the cover time of the largest component of the Erdos-Renyi random graph $G(n, c/n)$ in the supercritical regime with $c > 1$ fixed, is asymptotic to $f(c)n\log^2 n$, where $f(c)$ tends to 1 as c tends to 1. However, our new bound implies that the cover time for the critical Erdos-Renyi random graph $G(n, 1/n)$ has order n, and shows how the cover time evolves from the critical window to the supercritical phase. Our general estimate also yields the order of the cover time for a variety of other concrete graphs, including critical percolation clusters on the Hamming hypercube $\{0, 1\}^n$, on high-girth expanders, and on tori Z_n^d for fixed large d. For the graphs we consider, our results show that the blanket time, introduced by Winkler and Zuckerman, is within a constant factor of the cover time. (Received August 17, 2010)

1063-60-235 **Persi Diaconis**, **Laurent Miclo** and **Jessica Zuniga*** (jzuniga@math.stanford.edu), Stanford University, Department of Mathematics, Building 380, Stanford, CA 94305. *On the spectral analysis of second-order Markov chains.*

In this talk we consider second-order finite Markov chains that are trajectorially reversible, a property that is a generalization of the notion of reversibility for usual Markov chains. Specifically, we study spectral properties of second-order Markov chains that have a tendency to not return to their previous state. We confirm that resorting to second-order chains can be an option to improve the speed of convergence to equilibrium. This is joint work with Persi Diaconis and Laurent Miclo. (Received August 17, 2010)

1063-60-248 **Todd Kemp*** (tkemp@math.ucsd.edu), La Jolla, CA, **Ivan Nourdin** (inourdin@gmail.com), Nancy, France, **Giovanni Peccati** (giovanni.peccati@gmail.com), Kirchberg, Luxembourg, and **Roland Speicher** (speicher@mast.queensu.ca), Saarbrucken, Germany. *Chaos and the Fourth Moment.*

The Wiener chaos is a natural orthogonal decomposition of the L^2 space of a Brownian motion; it is the backbone upon which more sophisticated tools like Malliavin calculus are built. In 2005, Nualart and Peccati proved a remarkable Central Limit Theorem: in a fixed order of chaos, convergence to a normal law is equivelent to convergence of the fourth moment.

In this talk, I will briefly describe the analogue of the Wiener chaos in free probability (the probability theory that governs the density of eigenvalues of large random matrices). The very same central limit theorem holds true, but the techniques required for the proof are very combinatorial. Time permitting, I will also discuss applications of this central limit theorem and further refined results using free Malliavin calculus. (Received August 17, 2010)

1063-60-265 **Jason P Miller*** (jmiller@math.stanford.edu), CA , and **Yuval Peres** (peres@microsoft.com). *Uniformity of the Uncovered Set of Random Walk and Cutoff for Lamplighter Chains.*

We show that the measure on markings of $\mathbb{Z}_n^d$, $d \geq 3$, with elements of $\{0,1\}$ given by iid fair coin flips on the range $\mathcal{R}$ of a random walk X run until time T and 0 otherwise becomes indistinguishable from the uniform measure on such markings at the threshold $T = \frac{1}{2}T_{\text{cov}}(\mathbb{Z}_n^d)$. As a consequence of our methods, we show that the total variation mixing time of the random walk on the lamplighter graph $\mathbb{Z}_2 \wr \mathbb{Z}_n^d$, $d \geq 3$, has a cutoff with threshold $\frac{1}{2}T_{\text{cov}}(\mathbb{Z}_n^d)$. We give a general criterion under which both of these results hold; other examples for which this applies include bounded degree expander families, the intersection of an infinite supercritical percolation cluster with an increasing family of balls, the hypercube, and the Caley graph of the symmetric group generated by transpositions. The proof also yields precise asymptotics for the decay of correlation in the uncovered set. (Received August 17, 2010)

62 ► Statistics

1063-62-24 **Erik Lewis*** (ealewis@gmail.com), **George Mohler**, **P. Jeffrey Brantingham** and **Andrea Bertozzi**. *Self-Exciting Point Process Models of Civilian Deaths in Iraq.*

Our goal in this paper is to analyze temporal patterns of civilian death reports in Iraq. For this purpose we employ a branching point process model similar to those used in earthquake analysis. Here the rate of events is partitioned into the sum of a Poisson background rate and a self-exciting component in which events trigger an increase in the rate of the process. More specifically, each event generated by the process in turn generates a sequence of offspring events according to a Poisson distribution. Whereas the background rate is typically assumed to be stationary for seismic activity, such an assumption is not valid in the context of civilian deaths in Iraq. We propose three simple adjustments to account for background rate variation and compare the effectiveness of each model using Iraq Body Count data from 2003 to 2007. Our results indicate that branching point processes are well suited for modeling the temporal dynamics of violence in Iraq. (Received June 30, 2010)

1063-62-57 **Judy X. Li** (xli006@student.ucr.edu) and **Daniel R. Jeske*** (daniel.jeske@ucr.edu), Room 2605 STAT-COMP Building, Department of Statistics, University of California, Riverside, CA 92506, and **Jesus Lara** (jlara007@ucr.edu) and **Mark Hoddle** (mhoddle@ucr.edu). *Sequential Hypothesis Testing for Pest Count Spatial GLMM Models.*

It is well known that sequential hypothesis test plans can have appreciable cost savings compared to fixed sample size test plans. The first sequential hypothesis test plan was developed by Wald for one-parameter families of distributions and later extended by Bartlett to handle the case of nuisance parameters. However, Bartlett's hypothesis test plan requires independent and identically distributed observations. In pest management applications, it is common for count data to exhibit spatial correlations. We illustrate the existence of spatial correlations in pest count data by analyzing the spatial structure in a data set for a foliar-feeding mite pest. Spatial correlations should be accounted for when designing a sequential hypothesis test plan to decide if the density of the pest is above an economic threshold. We extend Bartlett's method to contexts where spatial generalized linear mixed models are appropriate for the data and we illustrate its implementation. (Received July 30, 2010)

1063-62-221 **Michael D. Porter*** (mike.porter@spadac.com), 7921 Jones Branch Dr, McLean, VA 22102, and **Gentry White**. *Self-exciting Hurdle Models for Terrorism.*

The contagiousness of terrorism is investigated by studying the influence that a terrorist attack has on the likelihood of future incidents. Examination of terrorism data from Indonesia, which has been subjected to 454 terrorist attacks between 1977 and 2007, reveals evidence that terrorist activity does indeed increase following successful attacks.

Our analysis employs a shot noise process to explain the self-exciting nature of the terrorist activities. This model estimates the probability of future attacks as a function of the times since the past events. In addition, the possibility of multiple coordinated attacks on the same day compelled the use of hurdle models to jointly model the probability of an attack day with the number of attacks per day. Interpretation of the model parameters and the suitability of these models for Indonesian terrorism is discussed. (Received August 16, 2010)

1063-62-252 **George O Mohler***, Santa Clara University, San Jose, CA 95126. *Point process modeling and estimation of near-repeat effects in crime data.*

Highly clustered event sequences are observed in crime data due to various patterns of criminal behavior. We show how these "near-repeat" effects can be incorporated into macroscopic models of crime using self-exciting point processes similar to models of earthquake aftershock sequences. We discuss both parametric and nonparametric approaches, illustrated with burglary and gang data provided by the Los Angeles Police Department. (Received August 17, 2010)

68 ► Computer science

1063-68-2 **Cristopher Moore*** (moore@santafe.edu), University of New Mexico and the Santa Fe Institute, 1399 Hyde Park Rd., Santa Fe, NM 87501. *Phase Transitions in NP-Complete Problems: A Challenge for Probability, Combinatorics, and Computer Science.*

Classic NP-complete problems like Graph Coloring and Satisfiability seem to undergo phase transitions when the density of the problem crosses a critical threshold. For instance, the probability that an Erdos-Renyi random graph is 3-colorable seems to jump from 1 to 0 when the average degree crosses 4.69 or so. This phenomenon has created a lively interaction between computer scientists, mathematicians, and statistical physicists. I will describe to what extent this transition is understood rigorously, and some exciting challenges that lie ahead. (Received June 23, 2010)

1063-68-270 **Shantanu Joshi*** (sjoshi@loni.ucla.edu), Laboratory of Neuro Imaging, Dept. of Neurology, UCLA School of Medicine, 635 Charles Young Drive South, Suite 225, Los Angeles, CA 90095. *Diffeomorphic Shape Analysis of Continuous Curves.*

The talk will focus on a Riemannian framework for shape analysis of both open and closed, parameterized curves. Shapes are treated as elements of an infinite-dimensional, non-linear, quotient space, and statistics of shapes are defined and computed intrinsically using differential geometry of this shape space. Due to a special square-root velocity parameterization, the shape space turns out to be a infinite-dimensional sphere, and geodesics can be analytically specified. Additionally, the geodesics will also be computed in a parameterization-invariant manner. This enables elastic matching of shapes with interesting results. Finally, I'll present some results of curve-based shape analysis applied to a brain morphometry. (Received August 17, 2010)

1063-68-272 **Yalin Wang*** (ylwang@math.ucla.edu), Department of Mathematics, 520 Portola Plaza, Math Sciences Building 6363, Los Angeles, CA 90095. *Human Brain Mapping with Conformal Geometry and Multivariate Tensor-based Morphometry.*

Historically, biology and medicine have been primarily descriptive science. The rapid advance of information and medical technology will accelerate the trend towards more quantitative science and help achieve an integrated understanding of anatomy, genetics and illness prevention and treatment. For human brain mapping research, we aim to apply computational methods to track the emergence of disease in the living brain, and understand clinical and genetic correlates of changes in brain scans. In this talk, I will introduce how to apply conformal geometry and multivariate tensor-based morphometry (MTBM) to analyze brain structures effectively. With harmonic energy minimization, holomorphic 1-form and discrete curvature flow (Ricci/Yamabe flow) methods, we can parameterize brain surfaces onto various canonical domains such as sphere, Euclidean plane, and the Poincaré disk. The resulting surface subdivision and the parameterizations of the components are intrinsic and stable. It provides a rigorous framework for representing, matching and measuring brain structure surfaces. The obtained conformal grids are beneficial for PDE are stable shape indices for statistical analysis. (Received August 17, 2010)

1063-68-278 **Yongning Zhu*** (yzhu@math.ucla.edu), University of California Los Angeles. *An efficient multigrid method for the simulation of high resolution elastic solids.*

We present a multigrid framework for the simulation of high resolution elastic deformable models, designed to facilitate scalability on shared memory multiprocessors. We incorporate several state-of-the-art techniques from multigrid theory, while adapting them to the specific requirements of graph- ics and animation applications, such as the ability to handle elaborate geometry and complex boundary conditions. Our method supports simulation of linear elasticity and co-rotational linear elasticity. The efficiency of our solver is practically independent of material parameters, even for near- incompressible materials. We achieve simulation rates as high as 6 frames per second for test models with 256K vertices on an 8-core SMP, and 1.6 frames per second for a 2M vertex object on a 16-core SMP. (Received August 18, 2010)

1063-68-279 **Rasmus Tamstorf*** (Rasmus.Tamstorf@disneyanimation.com), Walt Disney Animation.
Asynchronous variational contact mechanics.

An asynchronous, variational method for simulating elastica in complex contact and impact scenarios is developed. Asynchronous Variational Integrators (AVIs) are extended to handle contact forces by associating different time steps to forces instead of to spatial elements. By discretizing a barrier potential by an infinite sum of nested quadratic potentials, these extended AVIs are used to resolve contact while obeying momentum- and energy-conservation laws. A series of two- and three-dimensional examples illustrate the robustness and good energy behavior of the method. (Received August 18, 2010)

1063-68-280 **Eftychios Sifakis*** (sifakis@math.ucla.edu), University of California Los Angeles.
Dynamic digital faces and bodies: Challenges, applications and broader impact of biomechanical modeling and simulation technology.

Digital doubles have not only evolved into prevalent elements of motion pictures and entertainment-oriented computing, but are also finding an ever growing application base including medical diagnostics, surgical planning and design of vehicles and crafts. At the same time, current and developing applications demand improved photorealism, enhanced biomechanical accuracy, better subject-specificity and faster simulation algorithms. As these demands often outgrow the evolution of computer hardware, new algorithms for biomechanical modeling and simulation are necessary to ensure that upcoming computational platforms are utilized to the best of their capacity. Additionally, biomechanical simulation has provided a great opportunity for transformative advances in medical practice using virtual models of the human body for disease prevention and treatment. These emerging applications mandate an increased level of attention to the unique demands of subject-specificity and anatomical accuracy for clinical uses of biomechanical modeling and simulation. This talk will outline a number of numerical algorithms and computational techniques that were designed to facilitate modeling and simulation of digital doubles with high fidelity and efficiency. Finally, I will discuss the cross-cutting impact of such advances on character animation, scientific computing and virtual surgery. (Received August 18, 2010)

1063-68-281 **Aleka McAdams*** (amcadams@math.ucla.edu), UCLA/Walt Disney Animation/WETA.
Crashing waves, awesome explosions, turbulent smoke and beyond: applied mathematics and scientific computing in the visual effects industry.

Whether it's an exploding fireball in "Star Wars: Episode 3", a swirling maelstrom in "Pirates of the Caribbean: At World's End", or beguiling rats turning out gourmet food in "Ratatouille", computer-generated effects have opened a whole new world of enchantment in cinema. All such effects are ultimately grounded in mathematics, which provides a critical translation from the physical world to computer simulations. We will describe some of the most compelling applications of applied math and scientific computing in the visual effects industry. Furthermore, we will discuss some of the ways in which physical simulation techniques for special effects differ from those developed for more classical applications in physics and engineering. Particularly, there are many cases where the artistic vision of a scene requires a high level of controllability in the outcome of a simulation. To this end, special effects simulation tools, while physically based, must be able to be dynamically controlled in an intuitive manner in order to ensure both believability as well as the quality of the effect. We will highlight techniques from computational fluid dynamics, computational solid dynamics, rigid body simulation, and collision detection and resolution. (Received August 18, 2010)

1063-68-282 **Andrew Selle*** (Andrew.Selle@disneyanimation.com), Walt Disney Animation.
Numerical simulation in film production.

Film production increasingly depends on the use of computers. Numerical simulation of physical phenomena such as light transport and dynamics form an important part of modern story telling. I will discuss the challenges of uniting technology and artistry at Walt Disney Animation Studios. Examples given will be liquid, smoke and fire simulation. A few lessons about what makes research technology appealing and transferable to artists will be discussed. (Received August 18, 2010)

1063-68-283 **Joseph Teran*** (jteran@math.ucla.edu), UCLA/Walt Disney Animation. *A parallel multigrid Poisson solver for fluids simulation on large grids.*

We present a highly efficient numerical solver for the Poisson equation on irregular voxelized domains supporting an arbitrary mix of Neumann and Dirichlet boundary conditions. Our approach employs a multigrid cycle as a preconditioner for the conjugate gradient method, which enables the use of a lightweight, purely geometric multigrid scheme while drastically improving convergence and robustness on irregular domains. Our method is designed for parallel execution on shared-memory platforms and poses modest requirements in terms of bandwidth and memory footprint. Our solver will accommodate as many as 768X1152 voxels with a memory footprint

less than 16GB, while a full smoke simulation at this resolution fits in 32GB of RAM. Our preconditioned conjugate gradient solver typically reduces the residual by one order of magnitude every 2 iterations, while each PCG iteration requires approximately 6.1 sec on a 16-core SMP at 768^3 resolution. We demonstrate the efficacy of our method on animations of smoke flow past solid objects and free surface water animations using Poisson pressure projection at unprecedented resolutions. (Received August 18, 2010)

70 ► Mechanics of particles and systems

1063-70-19 **F. J. Lin*** (fjlin@usc.edu), University of Southern California, Department of Mathematics, KAP 108, 3620 S. Vermont Avenue, Los Angeles, CA 90089-2532. *Quantum and classical geometric phases in N-body molecular dynamics each describe the motion of a moving frame corresponding to internal angular momentum.* Preliminary report.

In differential geometric terms, a geometric phase is the holonomy of a connection. In N-body molecular dynamics, for example, a geometric phase arises in the solution of differential equations: (1) the time-dependent Schrodinger equation for a wavefunction in quantum mechanics and (2) Hamilton's equations for a trajectory in phase space in classical mechanics. In quantum dynamics, a geometric phase in the wavefunction is a phase shift corresponding to the expected value of the internal/vibrational angular momentum of the N-body system within its moving frame. In classical dynamics, a geometric phase of a moving frame is its net rotation corresponding to the internal/vibrational momentum of the N-body system within its moving frame. The geometric phase is also called a Berry phase and arises in further situations in both quantum and classical mechanics. (Received June 22, 2010)

1063-70-273 **Alethea Barbaro*** (alethea@math.ucla.edu), UCLA Mathematics Department, Los Angeles, CA 90095, and **Lincoln Chayes** and **Maria R. D'Orsogna**. *A statistical mechanics approach to gang territoriality.* Preliminary report.

We study the problem of gang territory formation by simulating an interacting particle system on a lattice. Our basic hypothesis is that territory formation occurs through territorial marking. We show that gang territories can develop in reaction to graffiti. We study a two–gang model in which there are agents from two different groups, red and blue, and each agent is identical aside from its affiliation. Red agents create red graffiti, blue agents create blue graffiti, and all graffiti decays in time. Using methods from statistical mechanics, we prove a phase transition occurs in this system and thus when the number of gang members is conserved, red agents and blue agents segregate themselves and distinct territories are formed. (Received August 17, 2010)

1063-70-274 **Alethea Barbaro*** (alethea@math.ucla.edu), UCLA Mathematics Department, Los Angeles, CA 90095. *Limiting PDEs for flocking models.* Preliminary report.

Interacting particle models have been shown to be effective at modeling the collective dynamics of large groups of social animals and insects. However, simulation of such systems becomes computationally intractable as the number of particles increases. Here, we formally derive a limiting PDE for one model of socially interacting particles. (Received August 17, 2010)

74 ► Mechanics of deformable solids

1063-74-142 **Emine Yasemen Kaya*** (yasemen.kaya@ttu.edu), 6302 Elgin Ave #276, Lubbock, TX 79413, and **Eugenio Aulisa** and **Akif Ibraguimov**. *Dynamics and stability of the non-linear model for fluid coupling with 1-D beam of changing thickness and 2-D plate.*

In this work we consider the dynamical response of a non-linear beam with viscous damping, perturbed in both the vertical and axial directions interacting with a potential flow.The system is modeled using non-linear momentum equations for the axial and transverse displacements coupled with the fluid flow subjected to the potential law. In particular we show that for a class of boundary conditions (beam clamped at the extremes and specifi ed velocity inlet for the fluid flow) there exists an appropriate energy norm depending on the beam displacements and the potential flow, which is bounded by the incoming boundary condition in the liquid region. Some preliminary results for dynamics of non-linear plate oscillation in the presence of damping coefficients will be also presented. (Received August 14, 2010)

76 ► Fluid mechanics

1063-76-13 **Fathi M Allan*** (f.allan@uaeu.ac.ae), Department of Mathematical Sciences, POBx 17551, Al Ain, United Arab Emirates, and **James H Curry** (James.H.Curry@colorado.edu), Program of Applied Mathematics, University of Colorado at Boulder, Boulder, CO 80302. *The dynamics of instability of the fluid flow over a flat plate.*

The fluid flow over a flat plate is of primary interest as prototypical nonlinear system. The highly disturbed flow and transition are governed by a nonlinear process. Previous studies have found that the transition to chaos observed experimentally or numerically depends on the system under consideration. For example, quasiperiodic motion arises in a Taylor-Couette system, period doubling occurs in the surface waves and the flow in a rotating annulus with topography. Therefore, our study of the transition in the boundary layer of a flat plate provides an opportunity to understand the effect of nonlinear disturbances on the transition and then to investigate the road to chaos. The goal is achieved by directly solving the time dependent Navier-Stokes equations that describe the flow phenomena under a suitable choice of boundary and initial conditions. The nonlinear theory of dynamical systems is then used to analyze the results. (Received May 14, 2010)

1063-76-29 **Ahmed Ahmed kaffel*** (kaffel07@gmail.com), 1404 J university city blvd, Blacksburg, VA 24060, and **Michael Renardy**. *Linear instability of plane parallel viscoelastic shear flows in the limit of infinite Weissenberg and Reynolds numbers.*

Elastic effects on the hydrodynamic instability of inviscid parallel shear flows are investigated through a linear stability analysis. We focus on the upper convected Maxwell model in the limit of infinite Weissenberg and Reynolds numbers. Specifically, we study the effects of elasticity on the instability of a few classes of simple parallel flows, specifically plane Poiseuille and Couette flows, the hyperbolic-tangent shear layer and the Bickley jet. The equation for stability is derived and solved numerically using the spectral Chebyshev collocation method. This algorithm is computationally efficient and accurate in reproducing the eigenvalues. We consider flows bounded by walls as well as flows bounded by free surfaces. In the inviscid, nonelastic case all the flows we study are unstable for free surfaces. In the case of wall bounded flow, there are instabilities in the shear layer and Bickley jet flows. In all cases, the effect of elasticity is to reduce and ultimately suppress the inviscid instability. (Received July 08, 2010)

1063-76-32 **Nebojsa Murisic*** (nebo@math.ucla.edu), Mathematics Department, University of California, Los Angles, Los Angeles, CA 90095-1555, and **Andrea Bertozzi**. *Particle-laden viscous thin-film flows.*

In this work we carry out a study of settling regimes for particle-laden thin films flows on an incline over a range of particle sizes and liquid viscosities. The three regimes we observe are: settled (low inclination angle and bulk particle volume fraction - particles settled out of the flow); ridged (high inclination angle and bulk particle volume fraction - particles aggregate at the front); and well-mixed. Through comparison between our experimental results and the predictions of equilibrium theory, we uncover the transient nature of the well-mixed regime, where bifurcation to either of the remaining regimes eventually occurs. Next, an equilibrium theoretical model is derived, where hindered settling balances the shear-induced migration of particles. Model's predictions and our experimental results are shown to be in excellent agreement over all ranges of viscosities and particle sizes; they also provide additional evidence for transiency of well-mixed regime. Finally, a dynamic model guiding evolution of film thickness and particle volume fraction is derived. It is based on a system of scalar hyperbolic conservation laws and it uses the equilibrium predictions for suspension and particle fluxes. Predictions of this PDE model are compared with the experimental data. (Received July 13, 2010)

1063-76-126 **Jeff D. Eldredge*** (eldredge@seas.ucla.edu), Mechanical and Aerospace Engineering, University of California, Los Angeles, Los Angeles, CA 90095, and **Chengjie Wang** (chengjie@seas.ucla.edu). *High-fidelity simulations and low-order modeling of vortex–body interactions in biomorphic locomotion.*

A prevailing challenge in understanding biological mechanisms for locomotion in fluids is describing, in a simplified manner, the important role of the unsteady nonlinear fluid dynamics in determining the forces on the control surfaces. Reduced-order modeling of these fluid–body interactions – for example, for use in vehicle control strategies – is therefore an important objective. Since the force generation in these bio-inspired mechanics is strongly coupled to the dynamics of the vortical structures, it is paramount for models to embody these dynamics. In this talk, we present techniques for high-fidelity simulation and low-order modeling of the Navier–Stokes equations in the context of these problems. In particular, we highlight the common basis of these techniques – the generation

and transport of vorticity – and demonstrate their use on a canonical problem motivated by bird perching. This problem consists of a thin flat plate undergoing a rapid pitch-up maneuver in a steady free stream at Reynolds number 1000. The forces predicted by the low-order model are compared with the high-fidelity results, and good agreement is found. The forces are decomposed into inertial reaction and circulatory components, and their relative contributions are inspected. (Received August 12, 2010)

1063-76-138 **Lidia Bloshanskaya*** (lidia.bloshanskaya@ttu.edu), Texas Tech University, Department of Mathemathematics & Statistics, Broadway and Boston, Lubbock, TX 79409. *Longterm dynamics for well Productivity Index for nonlinear flows in porous media.*

Motivated by the reservoir engineering concept of the well Productivity Index (PI) we study a time dependent functional for general non-linear Forchheimer equation. This equation is widely used by physicists and engineers for modeling of non-Darcy flows in porous media. PI of the well characterizes the well capacity with respect to drainage areas of the well. Unlike the linear case for which this concept is well developed, there are only a few recent publications dedicated to non-linear PI. In this paper non-linear PI is comprehensively studied from mathematical point of view. The impact of the non-linearity on the value of the PI for Forchheimer flows is analyzed. In particular, an explicit estimate of the difference between PI for linear and non-linear case is obtained. For quasi-1D model exact formula for so called "skin factor" case is derived. This formula enables calculation of the nonlinear PI provided information on linear PI and geometrical parameters ! only. Longterm dynamics of the PI with arbitrary initial pressure is studied for the certain class of boundary data. Its convergence to the specific value of steady state PI is justified. (Received August 15, 2010)

1063-76-162 **Hui Sun*** (huiprobable@math.ucla.edu), UCLA Math Department, CA 90095, **David Uminsky**, UCLA, Mathematics Department, Los Angeles, CA 90095, and **Andrea Bertozzi**, UCLA Mathematics Department, Los Angeles, CA 90095. *A generalized Birkhoff-Rott equation for the 2D active scalar problems.*

In this talk we derive new evolution equations for the active scalar problem in 2D for the case when all scalars lie on a 1D curve, analogous to the Birkhoff-Rott equation for 2D vorticity. The new equations are Lagrangian and valid for nonlocal kernels K that may include both a gradient and an incompressible term. We develop a numerical method for implementing the model which achieves second order convergence in space and fourth order in time. We simulate classic active scalar problems such as the vortex sheet problem (in the case of purely incompressible flow) and the collapse of delta ring solutions (in the case of pure aggregation) and find excellent agreement. We also include news examples that contain both incompressible and gradient flows. (Received August 15, 2010)

1063-76-181 **Jon Wilkening*** (wilken@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *Computation of time-periodic water waves.*

We develop a quasi-Newton trust-region shooting algorithm for solving two-point boundary value problems governed by nonlinear partial differential equations. We use our method to compute families of (time-periodic) standing water waves in two and three dimensions. To evolve the water wave in time, we use a spectrally accurate boundary integral collocation method in 2D, and a 5th order finite element method in 3D. As a starting guess, we use analytically determined time-periodic solutions of the linearized problem about a flat surface. We then use our numerical method to continue these solutions beyond the realm of linear theory to explore their behavior. Preliminary results suggest that if limiting wave profiles exist in the two-dimensional case, they have more complicated singularities than the 90 degree angles previously conjectured. (Received August 16, 2010)

1063-76-214 **Matthew R Mata*** (matthewmata@math.ucla.edu), 520 Portola Plaza, Los Angeles, CA 90095-1555, and **Andrea L Bertozzi**. *A Numerical Scheme for Particle-Laden Thin Film Flow in 2-D.*

Currently, the physics of particle-laden thin film flow are not fully understood, and recent experiments have raised questions with current theory. There is a need for fully 2-D simulations to compare with experimental data. To this end, a numerical scheme is presented for a lubrication model derived for particle-laden thin film flow in two dimensions with surface tension. The scheme relies on an ADI process to handle the higher-order terms, and an iterative procedure to improve the solution at each timestep. This is the first paper to simulate the 2-D particle-laden thin film lubrication model. Several aspects of the scheme are examined for a test problem, such as the timestep, runtime, and number of iterations. The results from the scheme are compared to experimental data. The simulation agrees qualitatively with experiments, but could be quantitatively improved. (Received August 17, 2010)

1063-76-245 **Fangxu Jing*** (fjing@usc.edu), 854 Downey Way, RRB101, Los Angeles, CA 90089, and **Eva Kanso** and **Paul K. Newton**. *Viscous evolution of point vortex equilibria: The collinear state.*

When point vortex equilibria of the 2D Euler equations are used as initial conditions for the corresponding Navier-Stokes equations (viscous), typically an interesting dynamical process unfolds at short and intermediate time scales, before the long time single peaked, self-similar Oseen vortex state dominates. In this paper, we describe the viscous evolution of a collinear three vortex structure that corresponds to an inviscid point vortex fixed equilibrium. Using a multi-Gaussian 'core-growth' type of model, we show that the system immediately begins to rotate unsteadily, a mechanism we attribute to a 'viscously induced' instability. We then examine in detail the qualitative and quantitative evolution of the system as it evolves toward the long-time asymptotic Lamb-Oseen state, showing the sequence of topological bifurcations that occur both in a fixed reference frame, and in an appropriately chosen rotating reference frame. The evolution of passive particles in this viscously evolving flow is shown and interpreted in relation to these evolving streamline patterns. (Received August 17, 2010)

1063-76-250 **James P Kelliher*** (kelliher@math.ucr.edu), University of California Riverside, 900 University Ave., Surge 202, Riverside, CA 92521, and **Roger M Temam** and **Xiaoming Wang**. *Boundary layer associated with the Darcy-Brinkman-Boussinesq model for convection in porous media.*

We study the asymptotic behavior of the infinite Darcy-Prandtl number Darcy-Brinkman-Boussinesq system for convection in porous media at small Brinkman-Darcy number. The existence of a boundary layer with thickness proportional to the square root of the Brinkman-Darcy number for the velocity field is established in both the $L^\infty(H^1)$ norm (2 and 3 d) and the $L^\infty(L^\infty)$ norm (2d only). This improves an earlier result of Payne and Straughan (1998) where the vanishing Brinkman-Darcy number limit is studied without resolving the boundary layer. (Received August 17, 2010)

1063-76-251 **James P Kelliher*** (kelliher@math.ucr.edu), University of California Riverside, 900 University Ave., Surge 202, Riverside, CA 92521. *An inverse problem associated with flow maps.*

It is classical that given a vector field whose modulus of continuity (MOC), μ, satisfies the Osgood condition there exists a unique flow map with an explicit bound, Γ_t, on its MOC at time $t \geq 0$. We examine the inverse problem: given a MOC, f, find a MOC, μ, such that $f = \Gamma_1$. For many applications, linear or nonlinear, both μ and Γ_t are naturally constrained to be concave functions. We show that under such constraints the inverse problem is equivalent to an open problem in the theory of iterative functional equations. Our motivation for studying this inverse problem is to try to construct an initial velocity field for which the associated flow for a solution to the Euler equations has an arbitrarily poor MOC. (Received August 17, 2010)

1063-76-259 **David T Uminsky*** (duminsky@math.ucla.edu), 520 Portola Plaza, Box 951555, Los Angeles, CA 90095-1555, and **Gene Wayne** (cew@math.bu.edu), **Alethea Barbaro** (alethea@math.ucla.edu) and **Vitalii Ostrovskyi** (ostrovsk@usc.edu). *A multi-moment vortex method for 2D viscous fluids.*

In this talk we introduce a new vortex method for 2D incompressible viscous fluids which incorporates Hermite moment corrections to radially symmetric Gaussian basis functions. Convergence of the Hermite expansion is proven and the higher order Hermite moments allow for each particle to deform under convection. We analyze the case of a single particle with many Hermite moments in the context of a shear diffusion example and discuss the improved spatial accuracy of the method. Time permitting, we will provide some examples of a large number of particles with fewer Hermite moments and discuss the trade off between computational efficiency and spatial accuracy. (Received August 17, 2010)

81 ► Quantum theory

1063-81-112 **Michael George Dombroski*** (dombroskiSTM11@verizon.net), Los Angeles City College. *A Catalog of **IJK** and **InJnKn** Matrix Base States with **TriKets**©.* Preliminary report.

In a previous paper (1054-81-8, Abstracts, Volume 30, Issue 4), the 48 **IJK** and **InJnKn Matrices** were introduced. The object of deriving these matrices was to eliminate imaginary numbers. These 48 4×4 matrices have unique symmetry properties. In this paper the matrices are empirically derived. They are analyzed, and Dirac Bra-Ket analogs, here called **TriKets**, are introduced. **TriKets** are sets-of-three matrix pair combinations.

There are 384 **TriKets** in this catalog. Separate, complete, **BosonFermion (BF)** pair catalogs for each of the **IJK** and **InJnKn** matrices are presented. The multitude of fine, precise, detailed, phase interactions of Matrix Base States are then shown. The non-commutative (**BF**–**FB**) reveals two distinct orders. TriKets have complementary pairs. Exchange of Permutation Numbers (**PN**) over these pairs, shows the Signs, States, and combinations that change. A fundamental result is the existence of a *10-dimensional matrix space*. The data is organized by using quantum-amplitude analogs. The wealth and variety of $\frac{1}{3}$ and $\frac{2}{3}$ phase function combinations may provide a natural, unitless, basis for charge, spin, mass, quarks and supersymmetry at the Plank level. This work also answers the question posed by John Archibald Wheeler: *"What line of thought could ever be imagined as leading to four dimensions–or any dimensionality at all–out of more primitive considerations?"* `http://dombroskiSTM.org`

© Copyright 2009–2010 by Michael George Dombroski, Jr., All Rights Reserved. (Received August 11, 2010)

85 ► Astronomy and astrophysics

1063-85-1 **Terence Tao***, Department of Mathematics, University of California Los Angeles. *The cosmic distance ladder.*

How do we know the distances from the earth to the sun and moon, from the sun to the other planets, and from the sun to other stars and distant galaxies? Clearly we cannot measure these directly. Nevertheless there are many indirect methods of measurement, combined with basic high-school mathematics, which can allow one to get quite convincing and accurate results without the need for advanced technology (for instance, even the ancient Greeks could compute the distances from the earth to the sun and moon to moderate accuracy). These methods rely on climbing a "cosmic distance ladder", using measurements of nearby distances to then deduce estimates on distances slightly further away; we shall discuss several of the rungs in this ladder in this lecture. (Received April 03, 2009)

90 ► Operations research, mathematical programming

1063-90-41 **Susan E. Martonosi*** (`martonosi@math.hmc.edu`), Harvey Mudd College, 301 Platt Blvd., Claremont, CA 91711, and **Douglas Altner**, U.S. Naval Academy, Annapolis, MD. *Disrupting Terrorist Networks.*

We present a new network disruption technique that tries to make otherwise secretive members of a terrorist group more visible. Through vertex deletion, this technique forces the secretive members to increase their participation in network communication. This talk will illustrate our disruption metric based on network flows, address graph-theoretic characteristics of promising vertices to target and discuss some computational challenges. (Received July 20, 2010)

91 ► Game theory, economics, social and behavioral sciences

1063-91-85 **Judea Pearl***, Department of Computer Science, 4732 Boelter Hall, UCLA, Los Angeles, CA 90095. *The Mathematics of Cause and Effect.*

I will review concepts, principles, and mathematical tools that were found useful in applications involving causal relationships (J. Pearl, Causality, Cambridge University Press, 2nd edition, 2009). The principles are based on structural-model semantics, in which functional (or counterfactual) relations represent autonomous physical processes. This semantical framework, enriched with a few ideas from logic and graph theory, gives rise to a complete, coherent, and friendly calculus that resolves long-standing problems involving causal and counterfactual relationships. These include questions of policy analysis, responsibility assignment and mapping the data-generating mechanisms. (Received August 06, 2010)

1063-91-114 **Laura M. Smith*** (lsmith@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555. *Simulating Gang Rivalries in Hollenbeck: An Agent-Based Approach.* Preliminary report.

We propose an interacting particle model to simulate the creation of gang rivalries in the Hollenbeck policing district of eastern Los Angeles. Our model integrates data from the Los Angeles Police Department, geographic information, and behavioral dynamics suggested by the LAPD and the criminology community. The movement dynamics of agents are coupled to an evolving complex network of gang rivalries, which is determined by previous interactions among agents in the system. The knowledge of major highways, the Los Angeles River, and the locations of gangs' centers of activity influences the agents' motion. The number of agents in each gang reflects historical information from the LAPD. We use common metrics from graph theory to compare networks produced by our simulations to the network existing in the criminology literature. (Received August 11, 2010)

1063-91-133 **Maria R D'Orsogna*** (dorsogna@csun.edu), Department of Mathematics, 18111 Nordhoff Avenue, Northridge, Los Angeles, CA 91330, and **Martin Short** and **Jeff Brantingham**. *Tolerating crime to reduce crime.* Preliminary report.

Citizens that actively engage in civic life usually give rise to low crime communities. Law enforcement officials are trusted, are crimes are reported and punished. In certain areas however, the presence of organized drug trafficking, mafia associations or war insurgencies, citizen involvement may not be the norm. Fears of retaliation or of ostracism may stop individuals from collaborating with the law enforcement system. We use an evolutionary game model to study a society where players display different attitiudes towards committing and reporting crimes, and study the conditions under which greater collaboration with law enforcement may be promoted. We find that encouraging informant figures, that while committing crimes are also exchanging information with autorities, may be key in transforming societal attitudes towards crimes. (Received August 13, 2010)

1063-91-227 **Mike O'Leary*** (moleary@towson.edu), Department of Mathematics, Towson University, 8000 York Road, Towson, MD 21252. *Patterns in Offender Distance Decay and the Geographic Profiling Problem.*

The geographic profiling problem in criminology is the problem of estimating the location of the home base of a serial offender based on the known locations of the criminal's offense sites. This is an operational problem of some importance for law enforcement agencies throughout the country.

Fundamental to any mathematical approach to this problem is an understanding of how offenders select targets, and one important component is the *distance decay* behavior of the offender. This curve gives the fraction of offenses that occur at a given distance from the offender's home base. Despite being well studied, there is no consensus as to the best mathematical form of the distance decay curve.

By appropriately rescaling the problem, we shall show that a simple *a priori* argument lead to a predicted distance decay curve that is a close match for the observed distance decay curves. We shall discuss these results and explain their significance for the geographic profiling problem. (Received August 16, 2010)

1063-91-257 **Mohsen Bayati**, **Christian Borgs** and **Jennifer Chayes*** (jchayes@microsoft.com), 1 Memorial Drive, Cambridge, MA 02142, and **Yashodhan Kanoria** and **Andrea Montanari**. *Nash Bargaining Exchange Networks: Fast Convergence of Natural Dynamics.*

Bargaining networks model the behavior of a set of players who need to reach pairwise agreements for making profits. Nash bargaining solutions in this context correspond to solutions which are stable and balanced. Prior work showed that if such solutions exist, then they can be calculated in polynomial time, but left open the question of whether there exists a local dynamics modeling the behavior of real-world players which can converge quickly to the Nash bargaining solution. In this work, we introduce a natural single-stage local dynamics, and prove that this dynamics converges quickly in a precise sense. Our proof introduces techniques from functional analysis which we believe should be useful in a variety of related problems. (Received August 17, 2010)

92 ► Biology and other natural sciences

1063-92-92 **Azmy S Ackleh*** (ackleh@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, **Baoling Ma**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, and **Paul Salceanu**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *Persistence and Global Stability in a Size-Structured Model with Selection and Mutation.*

We analyze a selection-mutation size-structured model with n ecotypes competing for common resources. Uniform persistence and robust uniform persistence are established, when the selection-mutation matrix Γ is irreducible, i.e., individuals of one ecotype may contribute directly or indirectly to individuals of other ecotypes. In the case of pure selection in which offspring of one ecotype belongs to the same ecotype (i.e., $\Gamma = I$, the identity matrix) we prove that the boundary equilibrium that describes competitive exclusion, with the fittest being the winner ecotype, is globally asymptotically stable. We show that small perturbations of the pure selection matrix lead to the existence of globally asymptotically stable interior equilibria. For the case when the selection-mutation matrix is reducible, we establish presistence for a special case and for other cases we discuss the outcome a of numerical simulations (Received August 08, 2010)

1063-92-97 **Lisette dePillis*** (depillis@hmc.edu), Department of Mathematics, Harvey Mudd College, 301 Platt Blvd, Claremont, CA 91711. *Mathematical Approaches to Modeling Immune-Cancer Dynamics.*

The critical importance of the immune system in combating cancer has been verified both clinically and through mathematical models. In this talk, we will discuss the components of the immune system that have been shown to play an important role in the progression and control of cancer, along with our approaches to modeling tumor-immune interactions and treatment approaches that harness the power of the immune system. (Received August 09, 2010)

1063-92-192 **Jia Li*** (li@math.uah.edu), Department of Mathematical Sciences, University of Alabama in Huntsville, Huntsville, AL 35899. *Transgenic Mosquitoes and the Impact on Malaria Transmission.*

To prevent malaria transmission, genetically-altered (transgenic) mosquitoes, that are resistant to malaria infection, become an effective weapon. To study the impact of releasing transgenic mosquitoes into the field of wild mosquitoes, we formulate mathematical models of interactive wild and transgenic mosquitoes. We consider both dominant and recessive transgenes, and include density-dependent vital rates. With fundamental analysis of the dynamics of the interactive mosquitoes, we then introduce them into simple compartmental malaria transmission models. We study the dynamics of the simple malaria model and the models with the transgenic mosquitoes, and investigate the impact of transgenic mosquitoes on the malaria transmission. (Received August 16, 2010)

1063-92-213 **Joe Latulippe***, Department of Mathematics and Statistics, Cal Poly Pomona, 3801 West Temple Ave., Pomona, CA 91768. *A Mathematical Model for Stimuli Dependent Neuron Responses.*

The transmission of information between neurons typically occurs at synaptic junctions. At these junctions, a pre-synaptic potential initiates the release of neurotransmitters that bind to channels on the post-synaptic cell. These channels open and close allowing the flow of ions across the post-synaptic cell membrane. Although pre- and post-synaptic processes control how and when neuronal information is transmitted, generally speaking, synaptic transmission is a random process. In order to get a better idea of how neurons are affected by stochastic inputs, we present a simple integrate-and-fire neuron model that incorporates random post-synaptic inputs. We investigate how in vivo-like stochastic inputs affects the response of the single cell model. By controlling both an excitatory and inhibitory conductance, the model can reproduce in vivo-like behavior due to random firing of pre-synaptic neurons. (Received August 16, 2010)

94 ► Information and communication, circuits

1063-94-5 **Stanley J Osher*** (sjo@math.ucla.edu), Mathematics, UCLA, 520 Portola Plaza, Los Angeles, CA 90272. *New algorithms in information science.*

The past few years have seen an incredible explosion of new (or revival of old) fast an effective algorithms for various imaging and information science applications. These include: nonlocal means, compressive sensing, sparse reconstruction, L1 and TV minimization, as well as relatively old favorites such as the level set method

and PDE based image restoration. I'll give my view of where we are and where we are going, hopefully giving credit to all the people involved. (Received August 09, 2010)

1063-94-59 **Yuichiro Kakihara*** (ykakihar@csusb.edu), 5500 University Parkway, San Bernardino, CA 92407. *Information channels and channel operators.* Preliminary report.

Define the pointwise weak* topology on the set $\mathcal{O}$ of all channel operators with some input and output. The set $\mathcal{C}$ of all information channels is regarded as a subset of $\mathcal{O}$. Then, an approximation of an operator in $\mathcal{O}$ by a sequence of channels in $\mathcal{C}$ with respect to the pointwise weak* topology is considered. (Received August 01, 2010)

00 ► General

1064-00-60 **Joseph A. Gallian*** (jgallian@d.umn.edu), Department of Mathematics and Statistics, 1117 University of Minnesota Duluth, Duluth, MN 55812. *Research in mathematics by undergraduates: past, present and future.*

Although involving undergraduates in research has been a long standing practice in the experimental sciences, it has only been recently that undergraduates have been involved in research in mathematics in significant numbers. In this talk I will trace the evolution of research by undergraduates over the past 25 years and the reasons for it. I will give my opinion on what lies ahead over the next ten years. (Received August 25, 2010)

1064-00-152 **Adel Ardalan*** (ardalan@wisc.edu), **Hesam Dashti**, **James Driver**, **Larry Rolen** and **Amir Assadi**. *Hyperbolic Invariants for Collective Dynamics of Massive Data Sets of Time-Series.* Preliminary report.

Networks offer a general framework for simultaneous study of an ensemble of structures (the nodes) that have pairwise relationships (the edges). In some applications, (e.g. biology/economics), the nodes are represented by a massive ensemble X(t) of n-dimensional real vectors varying with time t (e.g. all gene expressions of a genome, or stock prices in a market), and the edges by very large incidence matrices A(t). We report on preliminary progress in construction of a family of quantitative invariants for exploring global dynamic behavior of X(t) in short term and asymptotically. We demonstrate their use in answering challenging questions in systems biology and social networks, such as if two networks would have time evolutions to closely related networks, or diverge to networks with different probabilistic behavior. Further, we derive numerical estimates for the average rate of convergence to a common network or divergence to different ones. The arguments are based on a synthesis of methods from hyperbolic geometry, probability theory and computational mathematics. Concrete applications to biology and economics are also mentioned. (Received September 06, 2010)

1064-00-389 **Paige E. Rinker***, 6188 Kemeny Hall, Hanover, NH 03755. *Cluster Analysis of Heterogeneous Data on Rankings and Flags.* Preliminary report.

In 2007, Busse, Orbanz and Buhmann devised an efficient method for performing cluster analysis of particular kinds of ranking data. Their work focuses on data comprised of a mixture of complete rankings and "top-t" partial rankings, where t is allowed to vary. Here, we extend their method to partial rankings of arbitrary type and go on to describe a similar approach for cluster analysis of data on the flag variety for $GL_n(\mathbb{F}_q)$. (Received September 14, 2010)

1064-00-405 **Aparna W. Higgins*** (Aparna.Higgins@notes.udayton.edu), Department of Mathematics, University of Dayton, 300 College Park, Dayton, OH 45469-2316. *Contributions made by the Project NExT community to undergraduate mathematics education.*

Project NExT (New Experiences in Teaching) is a professional development program of the Mathematical Association of America, designed for new PhDs in the mathematical sciences who are interested in improving the teaching and learning of undergraduate mathematics. Seventy or so recent PhDs in mathematics are selected annually for participation in this year-long program that addresses the full range of faculty responsibilities in teaching, research and service. Members of a cohort of Project NExT Fellows benefit by networking with each other and with more experienced members of the profession through an electronic listserv. Project NExT Fellows are introduced to national issues, trends, challenges and opportunities in undergraduate mathematics education early in their careers. Now in its seventeenth year, Project NExT has helped integrate over one thousand two hundred faculty into the mathematics community. We will examine the impact that Project NExT Fellows have had in their departments and MAA Sections, and we will consider the influence that they are having as educators and administrators at their institutions and as officers of professional organizations in the mathematics community. (Received September 15, 2010)

03 ► Mathematical logic and foundations

1064-03-61 **Barbara F. Csima**, **Johanna N.Y Franklin** and **Richard A. Shore*** (shore@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell UInversity, Ithaca, NY 14853. *Degrees of Categoricity.* Preliminary report.

Fokina, Kalimullin and Miller (Degrees of Categoricity of Computable Structures) defined the degree of categoricity of a recursive structure $\mathcal{A}$ to be the least degree $\mathbf{d}$ (if there is one) such that for every recursive structure $\mathcal{B}$ isomorphic to $\mathcal{A}$ there is an isomorphism recursive in $\mathbf{d}$. We strengthen their results and answer a number of their questions as follows:

Theorem: *Every degree which is d-r.e. in and above $0^{(\alpha)}$ for any recursive ordinal α is the degree of categoricity of some recursive structure.*

Theorem: *Every degree of categoricity is hyperarithmetic.*

A simple calculation shows that the index set of the e such that the eth recursive structure has a degree of categoricity is Σ^1_2. As an application of our results and the methods used to prove them, we show that this index set is actually Π^1_1 complete. (Received August 25, 2010)

1064-03-77 **Robert Irving Soare*** (soare@uchicago.edu), Department of Mathematics, 5734 University Avenue, Chicago, IL 60637-1546. *Games in Computability Theory.* Preliminary report.

This comes from Chapter 17 on games in Soare's new book, *Computability Theory and Applications: The Art of Classical Computability.* It includes Banach-Mazur games, Gale-Stewart games, and especially *Lachlan games.* Lachlan games are useful for contructing computably enumerable (c.e.) sets and degrees and for studying *classical computability theory.* We discuss their relation to *art* in mathematics. Here "art" refers first to a method for solving problems, and second to an esthetic sense which reveals the beauty of the underlying mathematics. Lachlan games have been used by a few senior reseachers such as Harrington, Lachlan, and Soare, and their associates, but have not been widely used. Recently, Lachlan games have solved a complex problem which resisted standard approaches. Games appeal to the imagination and help achieve Harrington's "mountaintop" view. (Received August 29, 2010)

1064-03-78 **Antonio Montalban*** (antonio@math.uchicago.edu), 5734 S University ave., Eckhart Hall - University of Chicago, Chicago, IL 60657. *The non-hyperarithmetic degrees form a spectrum.*

We prove that there is a structure, that can be taken to be a linear ordering, such that a set can compute a presentation of it if and only if the set is not hyperarithmetic.

This is joint work with Noam Greenberg and Ted Slaman. (Received August 29, 2010)

1064-03-120 **Denis R. Hirschfeldt*** (drh@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 S. University Ave., Chicago, IL 60637, and **Russell Miller** and **Alexandra Shlapentokh**. *Computable Categoricity for Algebraic Fields.* Preliminary report.

We examine the computable dimension of computable algebraic fields. (Received September 02, 2010)

1064-03-166 **Carl Jockusch*** (jockusch@math.uiuc.edu), Department of Mathematics, 250 Altgeld Hall, University of Illinois, 1409 W. Green St., Urbana, IL 61801, and **Paul Schupp** (schupp@math.uiuc.edu), Department of Mathematics, 250 Altgeld Hall, University of Illinois, 1409 W. Green St., Urbana, IL 61801. *Generic computability, Turing degrees, and asymptotic density.*

Many authors have studied generic decidability in group theory and other areas, and we now study it in the context of classical computability theory. A set A of natural numbers is called *generically computable* if there is a partial computable function which agrees with the characteristic function of A on its domain D, and furthermore D has density 1, i.e. $\lim_{n\to\infty} |\{k < n \ : \ k \in D\}|/n = 1$. A set A is called *coarsely computable* if there is a computable set R such that the symmetric difference of A and R has density 0. We prove that there is a set which is generically computable but not coarsely computable and vice versa. We show that every nonzero Turing degree contains a set which is not generically computable and also a set which is not coarsely computable. We prove that there is a c.e. set of density 1 which has no computable subset of density 1. In further work, joint with Rod Downey, we show that the Turing degrees of such sets are precisely the nonlow c.e. degrees. (Received September 07, 2010)

1064-03-177 **David Diamondstone*** (ded@math.uchicago.edu), Dept. of Mathematics, 5734 S. University Avenue, Chicago, IL 60637. *Low LR upper bounds.*

We say that $A \leq_{LR} B$ if every B-random real is A-random—in other words, if B has at least as much derandomization power as A. This is what is called a "weak reducibility": it is implied by Turing reducibility, but does not imply Turing reducibility. Even calling it a "reducibility" may be misleading, as LR-lower cones can be uncountable; an example is the cone $\{A : A \leq_{LR} 0'\}$ below $0'$. However, the LR reducibility is a natural one for studying randomness. The K-trivials form the bottom LR degree, just as the computable reals form the bottom Turing degree, and K-trivials often play the role of computable sets from the point of view of randomness.

Much remains mysterious about the LR degrees. It is not even known whether they form a semilattice. (It is known that if a join exists, it cannot be the same as the join in the Turing degrees.) So there are many open structural questions. We show that given two (or even finitely many) low sets, there is a low c.e. set which lies LR above both. This is very different from the situation in the Turing degrees. Indeed, the Sacks splitting theorem gives us two low sets whose Turing degrees join to $0'$, so the fact that any two low sets have a low c.e. upper bound in the LR degrees is quite surprising. (Received September 07, 2010)

1064-03-183 **Rachel Epstein*** (repstein@math.harvard.edu), Department of Mathematics, FAS Harvard University, 1 Oxford St, Cambridge, MA 02138. *Definability and Automorphisms of the C.E. Sets.*

The computably enumerable (c.e.) sets form a lattice under set inclusion. Determining which classes of sets and degrees are definable in the lattice has been an important topic of study. Automorphisms can help us to determine which classes are not definable. We will discuss the history of definability and automorphism problems, as well as recent results and open questions. The focus of the talk will be on the recently-solved problem of determining which jump classes of degrees are definable. All upward-closed jump classes are definable except for the nonlow degrees. (Received September 08, 2010)

1064-03-202 **Johanna N.Y. Franklin*** (johannaf@gauss.dartmouth.edu), Department of Mathematics, 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755. *Martin-Löf randomness and Birkhoff's ergodic theorem.*

We characterize Martin-Löf randomness using Birkhoff's ergodic theorem. We show that in a computable probability space, given any computable measure-preserving map, any point that is Poincaré for this map with respect to effectively closed sets must be Birkhoff for this map with respect to effectively closed sets as well. When combined with a result of Bienvenu, Hoyrup, and Shen, this shows that a point in a computable probability space is Martin-Löf random precisely when it is Birkhoff for any computable ergodic map with respect to effectively closed sets.

This work is joint with Noam Greenberg, Joseph S. Miller, and Keng Meng Ng. (Received September 09, 2010)

1064-03-210 **Rebecca Weber***, Department of Mathematics, Dartmouth College, 6188 Kemeny Hall, Hanover, NH 03755. *Sets automorphic to low sets.*

We survey recent joint work with Peter Cholak on c.e. sets automorphic to low sets. (Received September 09, 2010)

1064-03-215 **Peter Cholak**, **David Galvin** and **Reed Solomon*** (solomon@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269-3009. *Reverse mathematics and infinite traceable graphs.*

We will give a reverse mathematics analysis of two theorems in graph theory concerning infinite traceable graphs and one application of these results in lattice theory. The graph theoretic statements are of interest in reverse mathematics because the classical proofs use Ramsey's theorem for four tuples. (Received September 09, 2010)

1064-03-219 **Joseph S. Miller*** (jmiller@math.wisc.edu), Madison, WI. *Revisiting Cooper's jump inversion theorem.* Preliminary report.

Cooper showed that every degree above $\mathbf{0'}$ is the jump of a minimal degree. We give a fairly easy proof of this result, using a simple method to force the jump on partial trees. The method allows us to extend Cooper's result by showing that every $S \geq_{tt} \emptyset'$ is actually truth-table equivalent to the jump of a minimal (Turing) degree. In particular, there is a superhigh minimal degree. The method also allows us to construct a minimal GL_1 degree that is not weakly jump traceable, giving a new proof that downward GL_1 does not imply weak jump traceability.

These results are joint with Steffen Lempp, Keng Meng Ng and Liang Yu. (Received September 09, 2010)

1064-03-230 **Jan S Reimann*** (reimann@math.psu.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802. *Effective geometric measure theory.*

We study two central results of geometric measure theory - Frostman's Lemma and the existence of subsets of finite measure - from a computability theoretic view. We use computability theoretic methods to give a new proof of Frostman's Lemma and use it to prove a collapse of randomness notions. Furthermore, we will study the Muchnik degrees related to subsets of finite Hausdorff measure of a given Borel set. (Received September 09, 2010)

1064-03-238 **Noam Greenberg**, **Asher M. Kach** and **Steffen Lempp*** (lempp@math.wisc.edu), Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706, and **Daniel D. Turetsky**. *Computability and uncountable linear orders.* Preliminary report.

We will present some computability-theoretic results on uncountable computable linear orders of size $\aleph_1$ (under the Axiom of Constructibility). In particular, we will completely characterize all such linear orders which are computably categorical. (Received September 10, 2010)

1064-03-239 **Barbara F. Csima*** (csima@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, and **Bernard A. Anderson**. *A bounded jump for the bounded Turing degrees.*

We define the *bounded jump*, a jump operator on the bounded Turing (bT) degrees (also known as the weak truth-table degrees). We let A^{nb} denote the n-th bounded jump of a set A. We demonstrate several properties of the bounded jump, including that it is strictly increasing and order preserving on the bounded Turing (bT) degrees. We show that the bounded jump is related to the Ershov hierarchy. Indeed, for $n \geq 2$ we have $X \leq_{bT} \emptyset^{nb} \iff X$ is ω^n-c.e. $\iff X \leq_1 \emptyset^{nb}$, extending the classical result that $X \leq_{bT} \emptyset' \iff X$ is ω-c.e.. Finally, we prove that the analogue of Shoenfield inversion holds for the bounded jump on the bounded Turing degrees. That is, for every X such that $\emptyset^b \leq_{bT} X \leq_{bT} \emptyset^{2b}$, there is a $Y \leq_{bT} \emptyset^b$ such that $Y^b \equiv_{bT} X$. (Received September 10, 2010)

1064-03-241 **Brooke M. Andersen**, **Asher M. Kach*** (asher.kach@uconn.edu), **Bakhadyr Khoussainov**, **Alexander G. Melnikov** and **D. Reed Solomon**. *Jump Degrees of Countable Structures.*

After introducing/reviewing the notion of (proper) α^{th} jump degree, we will discuss the existence or nonexistence of structures within a fixed class with a prescribed (proper) α^{th} jump degree. In particular, we will consider the class of torsion-free abelian groups and the class of $\aleph_0$-categorical structures.

This is joint work with Brooke Andersen, Alexander Melnikov, and Reed Solomon; and Bakhadyr Khoussainov and Alexander Melnikov. (Received September 10, 2010)

1064-03-243 **Stephen G. Simpson*** (simpson@math.psu.edu), Department of Mathematics, McAllister Building, Pollock Road, Pennsylvania State University, State College, PA 16802. *Symbolic dynamics: entropy = Hausdorff dimension = Kolmogorov complexity.*

This talk will be self-contained for both logicians and dynamicists. Let X be a d-dimensional symbolic dynamical system over a finite set of symbols. Note that we impose no computability hypothesis on X. We prove that, with respect to the standard metric on X, the Hausdorff dimension of X coincides with the effective Hausdorff dimension of X and with the topological entropy of X. We obtain a sharp characterization of the Hausdorff dimension of X in terms of the Kolmogorov complexity of the finite configurations of symbols which occur in the orbits of X. (Received September 10, 2010)

1064-03-261 **Damir D Dzhafarov*** (damir@math.uchicago.edu), 5734 South University Avenue, Chicago, IL 60637. *Reverse mathematics and the finite intersection principle.*

The finite intersection principle (FIP) states that every family of sets has a maximal subfamily such that the intersection of any finite number of its members is nonempty. Over ZF, FIP is equivalent to the axiom of choice. I discuss a countable analogue of this principle, and its proof-theoretic strength as measured using the tools of reverse mathematics. It turns out that FIP lies below ACA_0 and is incomparable with WKL_0, and as such is very weak by comparison with (countable analogues) of many other choice principles studied in the literature. More specifically, modulo Σ^0_2 induction, it is implied over RCA_0 by the atomic model theorem principle (AMT) studied by Hirschfeldt, Shore, and Slaman (2009), and implies the omitting partial types principle (OPT). This gives a surprising connection between the reverse mathematical content of set-theoretic principles on the one hand, and model-theoreitc ones on the other. This is part of joint work with Carl Mummert. (Received September 12, 2010)

1064-03-265 **Mingzhong Cai*** (yiyang@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *A direct construction of a hyperimmune minimal degree.*

The existence of minimal Turing degrees was first proved by Spector, and the minimal degree constructed by Spector's method is hyperimmune-free. Sacks later gave a construction of a minimal degree below $\mathbf{0}'$, and all nonrecursive degrees below $\mathbf{0}'$ are automatically hyperimmune. Based on these facts, Miller and Martin then raised the question whether there is a hyperimmune minimal degree not below $\mathbf{0}'$.

Cooper answered Miller and Martin's question by using an indirect argument. He proved a jump inversion theorem for minimal degrees and used a result by Jockusch that if $\mathbf{d}' \geq \mathbf{0}''$ then $\mathbf{d}$ is hyperimmune. Therefore any minimal degree whose jump is high enough is then hyperimmune and not below $\mathbf{0}'$.

We revisited Miller and Martin's question after studying Lerman's question asking whether every $\overline{\mathbf{GL_2}}$ degree fails to have the finite maximal chain property. In fact we can show that a relativized version of Miller and Martin's problem is necessary in giving a negative answer to Lerman's question. We will present a direct construction of a hyperimmune minimal degree. The coding idea in this direct construction turns out to be an essential ingredient in our solution to Lerman's problem. (Received September 12, 2010)

1064-03-270 **Bjørn Kjos-Hanssen*** (bjoern@math.hawaii.edu), Department of Mathematics, University of Hawai'i–Mānoa, 2565 McCarthy Mall, Honolulu, HI 96822. *Recovering randomness from an asymptotic Hamming distance.*

A notion of asymptotic Hamming distance suitable for the study of algorithmic randomness of infinite binary sequences is developed. As an application, it is shown that there is no fixed procedure that computes a Mises-Wald-Church stochastic sequence from a complex sequence. Here a sequence is complex if its prefixes have Kolmogorov complexity bounded below by an unbounded, nondecreasing computable function. (Received September 12, 2010)

1064-03-272 **Paul Shafer*** (pshafer@math.cornell.edu), Department of Mathematics, 310 Malott Hall, Cornell University, Ithaca, NY 14853. *Birkhoff's theorem and reverse mathematics.* Preliminary report.

Three key theorems of finite matching theory are Hall's theorem determining when a bipartite graph has a perfect matching, König's duality theorem equating the maximum cardinality of a matching in a bipartite graph to the minimum cardinality of a cover in that graph, and Birkhoff's theorem decomposing an $n \times n$ doubly stochastic matrix (i.e., a matrix in which every row and column sums to one) into a convex combination of permutation matrices. In the finite case, Hall's theorem and König's duality theorem each have an easy proof from the other, and both theorems easily imply Birkhoff's theorem. The relations among these theorems are more colorful when generalized to countable cases and put in the context of reverse mathematics. Hirst proved that one countable version of Hall's theorem is equivalent to the system WKL_0 and that another is equivalent to the stronger system ACA_0. Aharoni, Magidor, Shore, and Simpson proved that a countable version of König's duality theorem is equivalent to the even stronger system ATR_0. We continue this program by analyzing, in the context of reverse mathematics, a countable version of Birkhoff's theorem originally due to Isbell. (Received September 12, 2010)

1064-03-298 **Andrew Edwin Marcus Lewis*** (andy@aemlewis.co.uk), Department of mathematics, Leeds, LS29JT, England. *The search for natural definability in the Turing degrees.*

While the definability of all jump classes other than low has been established by Nies, Shore and Slaman through coding techniques, there remains a conspicuous lack of any natural definability results in the Turing degrees – I shall detail the state of affairs in a program which looks to address this issue by systematically analyzing the order theoretic properties satisfied by the degrees in the various jump classes. (Received September 13, 2010)

1064-03-303 **Theodore A. Slaman*** (slaman@math.berkeley.edu), Department of Mathematics, The University of California Berkeley, Berkeley, CA 94720-3840, and **Antonio Montalban** and **Noam Greenberg**. *Structural Characteristics of Recursion Theoretic Properties.*

We investigate whether recursion theoretic properties of real numbers are indicated by the isomorphism types of the structures that they compute. (Received September 13, 2010)

1064-03-315 **Chris J. Conidis*** (cconidis@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Canada. *A hyperimmune-low basis theorem for infinitely branching trees.*

We will define a class of infinitely branching trees for which there is a hyperimmune-low basis theorem, showing that it is possible to prove low basis theorems in a noncompact setting. (Received September 13, 2010)

1064-03-325 **Keng Meng Ng*** (selwynng@math.wisc.edu), Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706-1388, Madison, WI 53706. *Degrees of members of Π^0_1 classes.*

Given a Turing degree **a** we say that **a** is realized in a Π^0_1 class P if P contains a path of degree **a**. In this talk we will give a selection of results regarding the possible classes of Turing degrees which can be realized in Π^0_1 classes. We discuss some recent joint work with various authors (Barbara Csima, Rod Downey, Liang Yu, Yue Yang). We show that given any c.e. degree **a** there is a perfect Π^0_1 class P which realizes **a** and no other c.e. degree. We also discuss the complexity of index sets which can be realized in this way. We show that there is an uncountable Π^0_1 class where every path has hyperimmune-free degree. (Received September 13, 2010)

05 ► Combinatorics

1064-05-19 **Amin Bahmanian*** (mzb0004@auburn.edu), Department of Mathematics, Auburn University, Auburn, AL 36849. *Detachments of Amalgamated 3-uniform Hypergraphs.*

In this paper we use Nash-Williams lemma on laminar families to prove a detachment theorem for amalgamated 3-uniform hypergraphs, which yields a substantial generalization of previous amalgamation theorems by Hilton, Rodger and Nash-Williams.

To demonstrate the power of our detachment theorem, we show that the complete 3-uniform n-partite multi-hypergraph $\lambda K^3_{m_1,\ldots,m_n}$ can be expressed as the union $\mathcal{G}_1 \cup \ldots \cup \mathcal{G}_k$ of k edge-disjoint factors, where for $i = 1, \ldots, k$, $\mathcal{G}_i$ is r_i-regular if and only if:

(i) $m_i = m_j := m$ for all $1 \leq i, j \leq k$,

(ii) $3 \mid r_i mn$ for each i, $1 \leq i \leq k$, and

(iii) $\sum_{i=1}^{k} r_i = \lambda\binom{n-1}{2}m^2$,

which yields a generalization of Baranyai theorems for 3-uniform hypergraphs. Our result in particular leads to a polynomial time algorithm for parallelisms, while all other known constructions are of exponential complexity. (Received July 28, 2010)

1064-05-56 **Suil O**, **Douglas West** and **Hehui Wu*** (hehuiwu2@illinois.edu). *Longest cycles in k-connected graphs with given independence number.*

The Chvátal–Erdős Theorem states that every graph whose connectivity is at least its independence number has a spanning cycle. In 1976, Fouquet and Jolivet conjectured an extension: If G is an n-vertex k-connected graph with independence number a, and $a \geq k$, then G has a cycle of length at least $\frac{k(n+a-k)}{a}$. We prove this conjecture. (Received August 23, 2010)

1064-05-58 **Christine T. Cheng*** (ccheng@uwm.edu). *A poset-based approach to embedding median graphs in hypercubes and lattices.*

A *median graph* G is a graph where, for any three vertices u, v and w, there is a unique node that lies on a shortest path from u to v, from u to w, and from v to w. While not obvious from the definition, median graphs are *partial cubes*; that is, they can be isometrically embedded in hypercubes and, consequently, in integer lattices. The *isometric* and *lattice dimensions* of G, denoted as $dim_I(G)$ and $dim_Z(G)$, are the smallest integers k and r so that G can be isometrically embedded in the k-dimensional hypercube and the r-dimensional lattice respectively. Motivated by recent results on the cover graphs of distributive lattices, we study these parameters through *median semilattices*, a class of ordered structures related to median graphs. We show that not only does this approach provide new combinatorial characterizations for $dim_I(G)$ and $dim_Z(G)$, they also have nice algorithmic consequences. (Received August 24, 2010)

1064-05-69 **SuHo Oh*** (suhooh@gmail.com), 70 Pacific 446B, Cambridge, MA 02139. *Generalized permutohedra, h-vector of cotransversal matroids and pure O-sequences.*

Stanley has conjectured that the h-vector of a matroid complex is a pure O-sequence. We will prove this for cotransversal matroids by using generalized permutohedra. We construct a bijection between lattice points inside a r-dimensional convex polytope and bases of a rank r transversal matroid. (Received August 25, 2010)

1064-05-72 **Dan Roberts*** (dpr0003@auburn.edu), Dept. of Mathematics and Statistics, Auburn University, Auburn, AL 36849-5310, Auburn, AL 36849, and **Amin Bahmanian**. *On Hyperstar Decompositions of Hypergraphs.*

A hypergraph $G = (X, \mathcal{E})$ is a *hyperstar* with center C if $C \subseteq \bigcap_{E \in \mathcal{E}} E$. The *size* of G is $|\mathcal{E}|$ and we say that G has *center size* $|C|$. We find necessary and sufficient conditions for complete uniform hypergraphs and

complete hypergraphs to be decomposed into $S_{m_1}, \ldots, S_{m_\ell}$ where S_{m_i} is a hyperstar of size m_i with center size 1. (Received September 01, 2010)

1064-05-79 **Art Duval*** (artduval@math.utep.edu), Department of Mathematical Sciences, 500 W. University Ave., El Paso, TX 79968-0514, and **Caroline Klivans** and **Jeremy Martin**. *The Critical group of a simplicial complex.*

In previous work, we had extended the concept of a spanning tree from graphs to simplicial complexes. We now do the same for the critical group of a graph, sometimes called the "sandpile group", related to the "chip-firing" game. As in the graphical case, the critical group of a simplicial complex (if its codimension 1 skeleton has a suitably nice spanning tree) can be computed directly from the reduced Laplacian, and its order is given by a weighted count of the simplicial spanning trees. (Received August 29, 2010)

1064-05-95 **Andrew Crites*** (acrites@uw.edu), Department of Mathematics, University of Washington, Box 354350, Seattle, WA 98195-4350, and **Sara Billey** (billey@uw.edu), Department of Mathematics, University of Washington, Box 354350, Seattle, WA 98195-4350. *Pattern characterization of rationally smooth affine Schubert varieties of type A.*

Schubert varieties in finite dimensional flag manifolds G/P are a well-studied family of projective varieties indexed by elements of the corresponding Weyl group W. In particular, there are many tests for smoothness and rational smoothness of these varieties. One key result due to Lakshmibai-Sandhya is that in type A the smooth Schubert varieties are precisely those that are indexed by permutations that avoid the patterns 4231 and 3412. Recently, there has been a flurry of research related to the infinite dimensional analogs of flag manifolds corresponding with G being a Kac-Moody group and W being an affine Weyl group or parabolic quotient. In this paper we study the case when W is the affine Weyl group of type A or the affine permutations. We develop the notion of pattern avoidance for affine permutations. Our main result is a characterization of the rationally smooth Schubert varieties corresponding to affine permutations in terms of the patterns 4231 and 3412 and the twisted spiral permutations. (Received August 31, 2010)

1064-05-102 **Seog-Jin Kim** and **Alexandr Kostochka*** (kostochk@math.uiuc.edu), Department of Mathematics, University of Illinois, 1409 W. Green St., Urbana, IL 61801, and **Douglas B. West**, **Hehui Wu** and **Xuding Zhu**. *Each sparse graph decomposes into a forest and a graph with bounded degree.* Preliminary report.

A (k, d)-decomposition of a graph G is a partition of its edges into k forests and a graph with maximum degree at most d. A recent series of papers on $(1, d)$-decompositions of planar graphs with a given girth was inspired by the observation of X. Zhu that the game chromatic number and the game coloring number of every $(1, d)$-decomposable graph is at most $4 + d$. We prove that every graph G with *maximum average degree*, $mad(G)$, less than $4 - \frac{4}{d+2}$ is $(1, d)$-decomposable. The result is sharp (since for every $d \geq 1$ there are graphs G_d with $mad(G_d) = 4 - \frac{4}{d+2}$ that are not $(1, d)$-decomposable) and implies several recent results on planar graphs with given girth. We also give a sharp sparseness condition for a graph to be (k, d)-decomposable when $k < d$. (Received September 01, 2010)

1064-05-115 **Isabella Novik*** (novik@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350, and **Ed Swartz** (ebs@math.cornell.edu), Cornell University, Department of Mathematics, Ithaca, NY 14853-4201. *Face numbers of pseudomanifolds with isolated singularities.*

We discuss several results on the face numbers of pseudomanifolds with isolated singularities. This includes (i) a version of the Dehn-Sommerville relations, (ii) a strengthening of the lower bound theorem when the singularities are homologically isolated, and (iii) a complete characterizaiton of possible face vectors of all triangulations for three particular pseudomanifolds. (Received September 02, 2010)

1064-05-117 **Pawel Pralat*** (pralat@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506. *Modular orientations of random regular graphs.*

Extending an old conjecture of Tutte, Jaeger conjectured in 1988 that for any fixed integer $p \geq 1$, the edges of any $4p$-edge connected graph can be oriented so that the difference between the outdegree and the indegree of each vertex is divisible by $2p + 1$. It is known that it suffices to prove this conjecture for $(4p + 1)$-regular, $4p$-edge connected graphs. Here we show that there exists a finite p_0 so that for every $p > p_0$ the assertion of the conjecture holds asymptotically almost surely for random $(4p + 1)$-regular graphs. The proof is based on the spectral properties of these graphs, and applies to (appropriately defined) pseudo-random $(4p + 1)$-regular

graphs as well.
(Joint work with Noga Alon.) (Received September 02, 2010)

1064-05-119 **Suil O*** (suilo2@math.uiuc.edu), 409 W. Green Street, Urbana, IL 61801, and **Sebastian Cioaba** and **Douglas B West**. *Edge-connectivity, eigenvalues, and matchings in regular graphs.*

We prove a lower bound for the minimum size of a maximum matching in an l-edge-connected k-regular graph with n vertices, for $l \geq 2$ and $k \geq 4$. Again it is sharp for infinitely many n, and we characterize when equality holds in the bound. We also study the relationship between eigenvalues and the existence of certain subgraphs in regular graphs. We give a condition on an appropriate eigenvalue that guarantees a lower bound for the matching number of a t-edge-connected d-regular graph, when $t \leq d - 2$. This work extends some classical results of von Baebler and Berge and more recent work of Cioab a, Gregory, and Haemers. (Received September 12, 2010)

1064-05-131 **Benjamin J Braun*** (benjamin.braun@uky.edu), 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **Matthew Zeckner**. *Deformation Retracts of Neighborhood Complexes of Stable Kneser Graphs.* Preliminary report.

In 2003, Anders Björner and Mark De Longueville proved that the neighborhood complex of the stable Kneser graph $SG_{n,k}$ is homotopy equivalent to a k-sphere. Further, for $n = 2$, they showed that the complex deformation retracts to a subcomplex isomorphic to the associahedron. They went on to ask whether or not, for all n and k, the neighborhood complex of $SG_{n,k}$ contains as a deformation retract the boundary complex of a simplicial polytope.

We give a positive answer to this question in the case $k = 2$. We also find in this case that, after partially subdividing the neighborhood complex, the resulting complex deformation retracts onto a spherical subcomplex that is invariant under the action induced by the automorphism group of $SG_{n,2}$. (Received September 03, 2010)

1064-05-139 **Edward Swartz*** (ebs22@cornell.edu), Malott Hall, Cornell University, Ithaca, NY 14852. *Thirty years and counting.*

It has been over 30 years since Stanley proved that face numbers of simplicial polytopes satisfy McMullen's g-conditions. We will survey various attempts to extend this result to more general spaces. Along the way we will see that if Stanley's idea holds for PL-spheres, then there are strong implications for face numbers of PL-manifolds. Alternatively, if his idea does not hold for PL-spheres, then it must fail in an 'interesting' way. (Received September 04, 2010)

1064-05-145 **Kari Ragnarsson*** (kragnars@math.depaul.edu), 2320 N Kenmore Avenue, Chicago, IL 60614, and **Bridget E. Tenner**. *The boolean complex of a Coxeter system.*

In joint work with Bridget Tenner we have investigated the topological and combinatorial properties of the boolean complex of a Coxeter system. The boolean complex of a Coxeter system is a regular cell complex which can be constructed using just the (unlabeled) Coxeter graph. We show that the complex is homotopy equivalent to a wedge of spheres, each of dimension one less than the Coxeter system. The number of spheres can be calculated recursively using edge operations on the Coxeter graph and can be regarded as a graph invariant, called the boolean number. We obtain a bijective correspondence between a basis for the homology of the boolean complex and a certain set of derangements of the generators in the Coxeter system. This gives a combinatorial meaning to the spheres in the wedge sum representing the homotopy type of the Boolean complex and explains an enumerative result previously obtained by Reiner and Webb. (Received September 05, 2010)

1064-05-150 **Michael Ferrara*** (michael.ferrara@ucdenver.edu), **Michael Jacobson** and **Florian Pfender**. *Degree Conditions for H-Linked Digraphs.*

Given a digraph H, an *H-subdivision* is any simple graph obtained by replacing each arc uv of H with a (directed) $u - v$ path of arbitrary length. A directed graph D is *H-linked* if every injective function $f : V(H) \to V(D)$ extends to an H-subdivision in G. The H-linkage property has been well-studied in undirected graphs, and in both the directed and undirected case generalizes the notions of k-linked and k-ordered (di)graphs. Here, we give sharp degree-sum and minimum semi-degree conditions that assure a digraph D is H-linked for arbitrary H. This extends recent results of Kuhn and Osthus on k-linked and k-ordered graphs. (Received September 06, 2010)

1064-05-159 **Tao Jiang**, **Oleg Pikhurko** and **Zelealem B Yilma*** (zyilma@andrew.cmu.edu), Dept. of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *Set systems without a strong simples.*

A *d-simplex* is a collection of $d+1$ sets such that every d of them have non-empty intersection and the intersection of all of them is empty. A *strong d-simplex* is a collection of $d+2$ sets $A, A_1, \ldots, A_{d+1}$ such that $\{A_1, \ldots, A_{d+1}\}$ is a d-simplex, while A contains an element of $\cap_{j \neq i} A_j$ for each i, $1 \leq i \leq d+1$.

Mubayi and Ramadurai [*Combin. Probab. Comput.,* 18 (2009), pp. 441-454] conjectured that if $k \geq d+1 \geq 3$, $n > k(d+1)/d$, and $\mathcal{F}$ is a family of k-element subsets of an n-element set that contains no strong d-simplex, then $|\mathcal{F}| \leq \binom{n-1}{k-1}$ with equality only when $\mathcal{F}$ is a star. We prove their conjecture when $k \geq d+2$ and n is large. The case $k = d+1$ was solved in [M. Feng and X. J. Liu, *Discrete Math.,* 310 (2010), pp. 1645-1647]. Our result also yields a new proof of a result of Frankl and Füredi [*J. Combin. Theory Ser.* A, 45 (1987), pp. 226-262] when $k \geq d+2$ and n is large. (Received September 07, 2010)

1064-05-161 **Jonathan Cutler*** (cutlerjo@mail.montclair.edu), Department of Mathematical Sciences, Montclair State University, One Normal Avenue, Montclair, NJ 07043, and **A. J. Radcliffe**. *Hypergraph independent sets.*

The study of extremal problems related to independent sets in hypergraphs is a problem that has generated much interest. While independent sets in graphs are defined as sets of vertices containing no edges, hypergraphs have different types of independent sets depending on the number of vertices from an independent set allowed in an edge. We say that a subset of vertices is *j-independent* if its intersection with any edge has size strictly less than j. The Kruskal-Katona theorem shows that in an r-uniform hypergraph with a fixed size and order, the hypergraph with the most r-independent sets is the lexicographic hypergraph. In this talk, we use a hypergraph regularity lemma, along with a technique developed by Loh, Pikhurko, and Sudakov, to give an asymptotically best possible upper bound on the number of j-independent sets in an r-uniform hypergraph. (Received September 07, 2010)

1064-05-162 **Jeremy L Martin*** (jmartin@math.ku.edu), 405 Snow Hall, 1460 Jayhawk Boulevard, Lawrence, KS 66045-7523, and **Jennifer D Wagner** (jennifer.wagner1@washburn.edu). *Updown numbers and the initial monomials of the slope variety.*

Let I_n be the ideal of all algebraic relations on the slopes of the $\binom{n}{2}$ lines formed by placing n points in a plane and connecting each pair of points with a line. Under each of two natural term orders, the initial ideal of I_n is generated by monomials corresponding to permutations satisfying a certain pattern-avoidance condition. We show bijectively that these permutations are enumerated by the updown (or Euler) numbers, thereby obtaining a formula for the number of generators of the initial ideal in every degree. (Received September 07, 2010)

1064-05-164 **Thomas Lam** and **Pavlo Pylyavskyy*** (pylyavskyy@gmail.com). *Crystals and total positivity on orientable surfaces.*

We develop a combinatorial model of networks on orientable surfaces, and study weight and homology generating functions of paths and cycles in these networks. Network transformations preserving these generating functions are investigated. We describe in terms of our model the crystal structure and R-matrix of the affine geometric crystal of products of symmetric and dual symmetric powers of type A. Local realizations of the R-matrix and crystal actions are used to construct a double affine geometric crystal on a torus, generalizing the commutation result of Kajiwara-Noumi-Yamada and an observation of Berenstein-Kazhdan. We show that our model on a cylinder gives a decomposition and parametrization of the totally nonnegative part of the rational unipotent loop group of GL_n. (Received September 07, 2010)

1064-05-172 **Jacob Anthony White*** (jawhite@msri.org), Mathematical Sciences Research Institute, 17 Gauss Way, Berkeley, CA 94707, **Helene Barcelo** (hbarcelo@msri.org), Mathematical Sciences Research Institute, 17 Gauss Way, Berkeley, CA 94707, and **Christopher Severs** (csevers@msri.org), Mathematical Sciences Research Institute, 17 Gauss Way, Berkeley, CA 94707. *Homology of the k-Parabolic Arrangement and Discrete Morse Theory.*

The k-parabolic arrangement, introduced by the authors, is a generalization of the well known k-equal arrangement of type A and B. We construct a cell complex with the same homotopy type as the complement. Then we use discrete Morse theory to create a minimal cell complex for the complement. We obtain a combinatorial description of the Betti numbers, generalizing the work of Björner and Welker for the k-equal arrangement. (Received September 07, 2010)

1064-05-178 **Brendon Stanton*** (bstanton@iastate.edu), Iowa State University, Department of Mathematics, 396 Carver Hall, Ames, IA 50010. *Vertex Identifying Codes on The Hexagonal Grid.* Preliminary report.

An r-identifying code on a graph G is a set $C \subset V(G)$ such that for every vertex in $V(G)$, the intersection of the radius-r closed neighborhood with C is nonempty and unique. On a finite graph, the density of a code is $|C|/|V(G)|$, which naturally extends to a definition of density in certain infinite graphs which are locally finite. We present improved bounds for the minimum density of a code on the infinite hexagonal and square grids. (Received September 07, 2010)

1064-05-182 **Jozsef Balogh** and **Dhruv Mubayi*** (mubayi@math.uic.edu). *The Structure of Typical Hypergraphs with Local Constraints.*

We prove hypergraph versions of the Erdos-Kleitman-Rothschild theorem, which states that almost all triangle-free graphs with vertex set [n] are bipartite. (Received September 08, 2010)

1064-05-186 **Jozsef Balogh*** (jobal@math.uiuc.edu) and **Wojtek Samotij**. *On the Chvatal-Erdos triangle game.* Preliminary report.

Given a graph G and positive integers n and q, let $G(G; n, q)$ be the game played on the edges of the complete graph K_n in which the two players, Maker and Breaker, alternately claim 1 and q edges, respectively. Maker's goal is to occupy all edges in some copy of G; Breaker tries to prevent it. In their seminal paper on positional games, Chvátal and Erdős proved that in the game $G(K_3; n, q)$, Maker has a winning strategy if $q < \sqrt{2n+2} - 5/2$, and if $q \geq 2\sqrt{n}$, then Breaker has a winning strategy. In this note, we improve the latter of these bounds by describing a randomized strategy that allows Breaker to win the game $G(K_3; n, q)$ whenever $q \geq (2 - 1/24)\sqrt{n}$. Moreover, we provide additional evidence supporting the belief that this bound can be further improved to $(\sqrt{2} + o(1))\sqrt{n}$. (Received September 08, 2010)

1064-05-189 **Jonathan Browder*** (browder@math.washington.edu), Department of Mathematics, University of Washington, Box 354350, Seattle, WA 98195. *Face Numbers of Cohen-Macaulay Flag Complexes.*

A simplicial complex Δ is *flag* if whenever τ is a subset of the vertices of Δ such that any two elements of τ form an edge in Δ then τ is itself a face of Δ. In other words, flag complexes are simplicial complexes that are completely determined by their edges. It was conjectured by Kalai and proved by Frohmader that if Δ is a d-dimensional flag complex, then there is another d-dimensional simplicial complex, Γ, which has the same number of faces as Δ in each dimension and is *balanced* (that is, properly d-colorable). Kalai further conjectured that if Δ is in addition Cohen-Macaulay, we may take Γ to be Cohen-Macaulay as well.

In this talk I will exhibit a large class of complexes for which Kalai's conjecture holds, and explain the methods of the proof, which involves finding an appriate isomorphic image of the Stanley-Reisner ring. I will also note how our class contains the class of Cohen-Macaulay complexes arising as independence complexes of graphs of sufficient girth. (Received September 08, 2010)

1064-05-194 **Drew Armstrong** and **Brendon Rhoades***, brhoades@math.mit.edu. *The Shi arrangement and the Ish arrangement.*

The Shi arrangement is a hyperplane arrangement introduced by Shi in 1985 in his study of the Kazhdan-Lusztig cellular structure of the affine type A Weyl group. The Ish arrangement was introduced last year by Armstrong and can be used to define a q,t-Catalan bistatistic on the dominant Shi regions. We show that the Shi and Ish arrangements share many combinatorial properties including characteristic polynomials and the joint distribution of (number of ceilings, degrees of freedom) on their regions. We show that our results hold in the more general context of 'deleted' Shi and Ish arrangements. We give a refinement of a product formula of Kreweras which counts noncrossing partitions of [n] by 'type' which was predicted from the study of the Ish arrangement. This is mostly joint work with Drew Armstrong at the University of Miami. (Received September 08, 2010)

1064-05-197 **John Engbers*** (jengbers@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556, and **David Galvin**. *The typical structure of H-colorings of the Hamming cube.*

The d-dimensional discrete hypercube Q_d is the graph on $\{0,1\}^d$ with two strings adjacent if they differ on one coordinate. For a graph H (possibly with loops), an H-coloring of Q_d is a function from $\{0,1\}^d$ to $V(H)$ which preserves adjacency. With appropriate choices of H, H-colorings can encode independent sets and proper colorings of Q_d.

We are interested in the following question: In a uniformly chosen H-coloring of Q_d, what proportion of vertices of Q_d get mapped to each vertex of H? We obtain a quite precise answer to this question. For example,

we can say that in a uniformly chosen proper $2k$-coloring of Q_d, asymptotically almost surely each color class has size very close to $2^d/(2k)$, and in a uniformly chosen proper $(2k+1)$-coloring, asymptotically almost surely there are k color classes with size very close to $2^d/(2k)$ and $k+1$ class with size very close to $2^d/(2(k+1))$. In both cases, each color class is contained almost exclusively in a single bipartition class of Q_d.

The results generalize to the discrete torus with fixed even side length. The approach is through entropy, and extends results obtained by Jeff Kahn (who had considered the case when H is a doubly infinite path). (Received September 08, 2010)

1064-05-198 **Julianna Tymoczko***, Department of Mathematics, 14 MacLean Hall, University of Iowa, Iowa City, IA 52242. *Poset pinball and cohomology rings.*

Instead of thinking of a poset as a directed acyclic graph, we think of it as a collection of paths and chutes on a tilted board—just like a pinball machine. In poset pinball, we place traps on the poset and then drop balls from various points, letting the balls roll down the poset until they're captured by the traps. This talk will show how to play poset pinball and will describe what pinball says about equivariant cohomology rings. Then we'll identify cohomology rings for some interesting varieties, including Peterson varieties. This work is joint with M. Harada (McMaster University). (Received September 09, 2010)

1064-05-214 **Jane V. Butterfield*** (jbutter2@illinois.edu), Department of Mathematics, University of Illinois, 1409 W. Green Street, Urbana, IL 61801, and **József Balogh**. *Online Ramsey Games for Triangles in Random Graphs.*

In the online F-avoidance edge-coloring game with r colors, a graph on n vertices is generated by at each stage randomly adding a new edge. The player must color each new edge as it appears; his goal is to avoid a monochromatic copy of F. Let $N_0(F,r,n)$ be the threshold function for the number of edges that the player is asymptotically almost surely able to paint before he loses. Even when $F = K_3$, the order of magnitude of $N_0(F,r,n)$ is unknown for $r \geq 3$. In particular, the only known upper bound is the threshold function for the number of edges in the offline version of the problem, in which an entire random graph on n vertices with m edges is presented to the player to be r edge-colored. We improve the upper bound for the online triangle-avoidance game with r colors, providing the first result that separates the online threshold function from the offline bound for $r \geq 3$. This supports a conjecture of Marciniszyn, Spöhel, and Steger that the known lower bound is tight for cliques and cycles for all r. (Received September 09, 2010)

1064-05-216 **Florian Block*** (blockf@umich.edu), University of Michigan, 530 Church St, Ann Arbor, MI 48109. *Computing Node Polynomials for Plane Curves.*

Enumeration of plane algebraic curves has a 150-year-old history. A combinatorial approach to this problem, inspired by tropical geometry, was recently suggested by Brugalle, Fomin, and Mikhalkin. I will explain this approach and its applications to computing Gromov-Witten invariants (or Severi degrees) of the complex projective plane, and their various generalizations.

According to Goettsche's conjecture (now a theorem), these invariants are given by polynomials in the degree d of the curves being counted, provided that d is sufficiently large. I will discuss how to compute these "node polynomials," and how large d needs to be. (Received September 09, 2010)

1064-05-223 **Liviu Ilinca*** (ilinca@indiana.edu) and **Jeff Kahn**. *The Number of Matchings of a Given Size.*

We use entropy methods to prove upper bounds for the number $\Phi_l(G)$ of matchings of a given size l in a graph G with a given degree sequence. In particular, for a d-regular, N-vertex graph G, our bound is best possible up to an error factor that is $e^{o(N)}$ provided $d \to \infty$. This represents the best progress to date on the "Upper Matching Conjecture" of Friedland, Krop, Lundow and Markström. (Received September 09, 2010)

1064-05-233 **Andrew J Radcliffe*** (aradcliffe1@math.unl.edu), Department of Mathematics, 205 Avery Hall, University of Nebraska-Lincoln, Lincoln, NE 68502, and **Andrew Ray**, University of Nebraska-Lincoln. *Extremal Trees for Homomorphism Enumeration.*

For a certain class of image graphs H, we determine the trees with fixed size and maximum degree having the largest number of homomorphisms into H. Our proof technique also allows us to determine extremal trees for a range of other enumeration problems on the same class of trees. One class of extremal trees is somewhat unexpected, and deserves to be better known. These are the festoons. We give a new, and more tractable characterization of festoons. (Received September 10, 2010)

1064-05-249 **Marcus Schaefer*** (mschaefer@cdm.depaul.edu), DePaul University, 243 South Wabash, Ste 401, Chicago, IL 60604. *Realizability of Graphs and Linkages.*

Given a weighted graph, how hard is it to determine whether there is a straight-line drawing of the graph in the plane in which each edge has the length prescribed by its weight? This problem is known to be NP-hard, as shown by Saxe and Yemini in the seventies, but it turns out that it is much harder: even for the special case of unit distance graphs (all edges have unit length), the problem has the same complexity as deciding the truth of sentences in the existential theory of the reals. It turns out that this is not an isolated phenomenon: the complexity of many problems in geometry, graph drawing and other areas is captured precisely by the existential theory of the reals, including the rectilinear crossing number, the Steinitz problem and several families of intersection graphs. We will also look at some related problems on linkages and their rigidity. (Received September 10, 2010)

1064-05-268 **Lale Ozkahya*** (ozkahya@iastate.edu) and **Yury Person** (person@informatik.hu-berlin.de). *Minimum H-decompositions of graphs: edge-critical case.*

For a given graph H, let $\phi_H(n)$ be the maximum number of parts that are needed to partition the edge set of any graph on n vertices such that every member of the partition is either an edge or it is isomorphic to H. Bollobás showed that when $H = K_r$, $r \geq 3$, $\phi_H(n)$ is equal to $t_{r-1}(n)$, the size of the $(r-1)$-partite Turán graph. Pikhurko and Sousa extended this result to any graph H, with chromatic number $\chi(H) = r \geq 3$, and proved that $\phi_H(n)$ is at most $t_{r-1}(n) + o(n^2)$. Pikhurko and Sousa conjectured that $\phi_H(n) = \mathrm{ex}(n, H)$ when $\chi(H) \geq 3$ and n is sufficiently large, where $\mathrm{ex}(n, H)$ denotes the maximum size of a graph on n vertices that does not contain H as a subgraph. We verify their conjecture for any edge-critical graph H and show that the graphs maximizing $\phi_H(n)$ for such H are $(\chi(H)-1)$-partite Turán graphs. This is joint work with Yury Person. (Received September 12, 2010)

1064-05-274 **Jeong Ok Choi*** (jeong.choi@trincoll.edu), 300 Summit Street, Department of Mathematics, Hartford, CT 06106, and **John P. Georges** and **David W. Mauro**. *Classification of Z_2^k-magic graphs.*

Let $G = (V, E)$ be a graph (loopless and not necessarily simple). Let $(A, +)$ be an abelian group with identity 0, and let $A^* = A - \{0\}$. Then an *A-magic labeling of G* is a function ϕ from E into A^* such for some $c \in A$, $\sum_{e \in E(v)} \phi(e) = c$ for every $v \in V$, where $E(v)$ is the set of edges incident to v. If ϕ exists such that $c = 0$, then G is *zero-sum A-magic*. In this talk, the properties of Z_2^k-magic graphs in terms of chromatic index, even edge-coverings, and factorability will be discussed. Also, it will be discussed that for every bridgeless graph G, the minimum k such that G is zero-sum Z_2^k-magic is equal to the minimum number of even subgraphs that cover G, and that $k \leq 3$. Finally, equivalent conditions for graphs of even order with bridges to be Z_2^k-magic for all $k \geq 4$ will be mentioned. This is joint work with John P. Georges and David W. Mauro. (Received September 12, 2010)

1064-05-276 **Sami Assaf***, MIT Department of Mathematics, 77 Massachusetts Ave, Cambridge, MA 02139. *Towards a kicking basis for Garsia-Haiman modules.*

We give a combinatorial construction of an explicit basis for Garsia-Haiman modules indexed by any partition not containing the partition (3,3,2) and from it derive a seven term recurrence relation for the corresponding Hilbert Series. (Received September 12, 2010)

1064-05-279 **Todd Kemp**, **Karl Mahlburg**, **Amarpreet Rattan** and **Clifford Smyth*** (cdsmyth@uncg.edu). *The number of non-crossing perfect matchings compatible with a 2-coloring.*

Let the vertices V of a convex $2n$-gon be labeled 1 through $2n$ in clockwise order. Let K be the complete graph on V whose edges are straight line segments. Let $c : V \to \{0, 1\}$. Let $\phi(c)$ be the number of non-crossing perfect matchings of K that are properly colored by c. Interestingly, the $\phi(c)$ are precisely the non-zero moments of the circular operator of free probability (and also the renormalized asymptotic moments of a Gassian random matrix.)

We'll show the bound: $\phi(c) \leq C^{(\lceil n/k \rceil)}(k)$ where $2k$ is the number of x such that $c(x) \neq c(x+1 \mod 2n)$ and where $C^{(a)}(b) := \frac{1}{ab+1}\binom{b(a+1)}{b}$ is the Fuss-Catalan number. (Received September 14, 2010)

1064-05-281 **Zoltan Furedi*** (z-furedi@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W Green Street, Urbana, IL 61801. *Cycle-saturated graphs with minimum number of edges.*

A graph G is F-saturated if it does not contain any copy of F, but adding any edge of the complement $e \in E(\overline{G})$ the graph $G + e$ contains F. The minimum size of an F-saturated, n-vertex graph is denoted by $sat(n, F)$.

We give almost exact asymptotics for $sat(n, C_k)$ as k is fixed and $n \to \infty$.

This is a joint work with Younjin Kim. (Received September 12, 2010)

1064-05-282 **Robert B. Ellis*** (rellis@math.iit.edu), **James P. Ferry** (ferry@metsci.com), **Darren P. Lo** (lo@metsci.com) and **Dhruv Mubayi** (mubayi@math.uic.edu). *The block-cutpoint tree characterization of a covering polynomial of a graph.*

The block-cutpoint graph $BG(G)$ of a graph G is a tree with bipartite sets that are the cut-vertices of G and the blocks (maximal biconnected components) of G, respectively. An edge clique-cover of G is a set of cliques $X \subseteq G$ whose graph union is G. Motivated by the study of random intersection graphs, we define graph weight as $\mathrm{wt}(G) = \min_{\mathcal{S}} \sum_{X \in \mathcal{S}} (|V(X)| - 1)$, where $\mathcal{S}$ ranges over all edge clique-covers of G. We characterize the least-weight supergraphs of G in two ways: by partitions of $BG(G)$ into edge-disjoint subtrees whose leaves have no cut-vertices as external neighbors, and in terms of partitions of the neighborhoods of each cut-vertex in $BG(G)$. As a result the least-weight supergraphs can be encoded using Touchard polynomials. Determining $\mathrm{wt}(G)$ for K_4-free graphs is equivalent to the well-known extremal question of finding the maximum number of edge-disjoint triangles in G, and we prove that a K_4-free graph G with $\lfloor n^2/4 \rfloor + m$ edges has at least m edge-disjoint triangles when m close is to $n^2/12$. (Received September 12, 2010)

1064-05-290 **Matthew Hyatt*** (m.hyatt@math.miami.edu). *Eulerian quasisymmetric functions for the type B Coxeter group and other wreath product groups.*

Eulerian quasisymmetric functions were introduced by Shareshian and Wachs in order to obtain a q-analog, involving the permutation statistics major index and excedance number, of Euler's exponential generating function formula for the Eulerian polynomials. Applying the stable and nonstable principal specializations yields formulas for joint distributions of permutation statistics. We consider the wreath product of the cyclic group with the symmetric group, also known as the group of multicolored permutations. We use this group to introduce *multicolored Eulerian quasisymmetric functions*, which are a generalization of Eulerian quasisymmetric functions. We derive a formula for the generating function of these multicolored Eulerian quasisymmetric functions, which reduces to a formula of Shareshian and Wachs for the Eulerian quasisymmetric functions. We show that applying specializations yields formulas for joint distributions of multicolored permutation statistics of Adin, Brenti and Roichman and Foata and Han, which generalize Shareshian and Wachs' q-analog of Euler's formula. (Received September 13, 2010)

1064-05-306 **Drew Armstrong*** (armstrong@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33146. *Hyperplane Arrangements and Diagonal Harmonics.*

Hello. There are many talks at this meeting. If you attend this talk, you will see nice pictures. You will understand the Hilbert series of diagonal harmonics in a new way. You will meet a hyperplane arrangement with an unusual name. You will laugh, you will cry. P.S. Please remain seated for Brendon's talk. (Received September 13, 2010)

1064-05-311 **Andrew B Ray*** (ray.andrew@gmail.com), 2532 T St. Apt 5, Lincoln, NE 68503. *Reconstructing Trees from their Wiener Matrix or Subtree Matrix.*

Let T be a tree with vertex set $\{1, 2, \ldots, n\}$. The Wiener matrix is $W = (w_{ij})$ where w_{ij} $(i \neq j)$ is the number of paths in T containing both i and j. The subtree matrix is $S = (s_{ij})$ where s_{ij} $(i \neq j)$ is the number of subtrees of T containing both i and j. In both W and S the diagonal entries are 0. Given either of these matrices we will show that we can reconstruct the adjacencies of T using the following simple rule: $i \sim j$ in T if and only if the (i, j)-th entry of the matrix is the largest in its row or column. (Received September 13, 2010)

1064-05-333 **Steven Klee***, Mathematical Sciences Building, One Shields Ave., University of California, Davis, CA 95616, and **Benjamin Braun** and **Jonathan Browder**. *Cointerval Simplicial Complexes and Ordered Hom Complexes.* Preliminary report.

We introduce the class of cointerval simplicial complexes, which generalize the classes of cointerval hypergraphs, introduced by Dochterman and Engström, and shifted simplicial complexes, introduced by Erdős-Ko-Rado (combinatorial shifting) and Kalai (algebraic shifting). We will discuss some geometric properties of cointerval complexes, and introduce a (polyhedral) complex of order-preserving homomorphisms, $OHOM(\Gamma, \Delta)$, between

simplicial complexes Γ and Δ. We will show that the complex $OHOM(\Gamma, \Delta)$ supports a minimal free resolution of an associated monomial ideal when Δ is a cointerval simplicial complex. (Received September 13, 2010)

1064-05-335 **Saúl A. Blanco*** (sabr@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *Shortest path poset of Bruhat intervals.*

Let $u \leq v$ in Bruhat order. $[u, v]$ is endowed with rich topological and combinatorial structure; for instance, it is Gorenstein*. On the other hand, not much is known of the remaining u-v paths in the Bruhat graph $B(u, v)$ of $[u, v]$. Consider the poset $SP(u, v)$ of shortest u-v paths in $B(u, v)$. $SP(u, v)$ and $[u, v]$ have similarities; for example, if there is only one rising chain (using a reflection order) in $SP(u, v)$, then $SP(u, v)$ is also a Gorenstein*. Further properties of $SP(u, v)$ will be discussed. (Received September 14, 2010)

1064-05-352 **Brant Jones*** (brant@math.jmu.edu), Department of Mathematics and Statistics, MSC 1911, Harrisonburg, VA 22807, and **Alexander Woo** (woo@stolaf.edu). *Mask formulas for Kazhdan–Lusztig polynomials.*

The Iwahori–Hecke algebra is a deformation of the group algebra of a Coxeter group. In 1979, Kazhdan and Lusztig constructed a basis for this algebra that has found various applications in geometry and representation theory. Unfortunately, the Kazhdan–Lusztig basis is defined recursively, and no simple manifestly positive description is known, even for the symmetric groups. In this talk, we describe a framework developed by Deodhar that gives formulas for Kazhdan–Lusztig bases in terms of combinatorial objects called masks. We explain how to interpret a formula of Lascoux and Schützenberger for Kazhdan–Lusztig polynomials associated to cograssmannian permutations in this setting. (Received September 14, 2010)

1064-05-367 **Gregory S. Warrington*** (gwarring@cems.uvm.edu), Department of Mathematics & Statistics, University of Vermont, 16 Colchester Ave., Burlington, VT 05401, and **Andrew Crites** and **Greta Panova**. *On the shape of separable permutations.*

Under the Robinson-Schensted correspondence, each permutation σ has an associated partition shape $\lambda = (\lambda_1 \geq \lambda_2 \geq \cdots)$. Greene's Theorem says that the sum of the first k parts of λ gives the maximal total length of k disjoint increasing subsequences $u^1, \ldots, u^k$ of σ. However, it is not generally true that one can choose the u^i so that the length of u^i is λ_i for each i. Our main result is to show that the u^i's can be so chosen when σ is a *separable permutation* (i.e., a $3142, 2413$-avoiding permutation). We also give an application to shortest containing supersequences. (Received September 14, 2010)

1064-05-406 **Russ Woodroofe*** (russw@math.wustl.edu), Department of Mathematics, Washington University in St. Louis, One Brookings Drive, St Louis, MO 63130. *Chains of modular elements and shellability.*

Björner proved that if a lattice L has a maximal chain consisting of modular elements, then L is shellable. I'll show that if L has a chain of length r consisting of modular elements, then the $(r-2)$-skeleton of L is shellable (as was conjectured by Hersh), and indeed vertex-decomposable. (Received September 15, 2010)

08 ► General algebraic systems

1064-08-85 **Ben Phillips*** (benjamin.phillips@wmich.edu). *The Bruck Functor.* Preliminary report.

In this talk we shall re-examine a result due to Bruck, which describes a method for studying loops via their multiplication groups. We'll show that the process outlined by Bruck is actually best described in modern terms with Category Theory, by showing the existence of a covariant functor from the category of loops and loop homomorphisms to the category of groups and group homomorphisms. Time permitting, we'll also delve into some interesting properties and consequences relating to this functor. (Received August 30, 2010)

1064-08-203 **Maria de Lourdes Merlini Giuliani*** (maria.giuliani@ufabc.edu.br), Rua Santa Adelia, 166, Santo Andre, Brazil, and **Kenneth Jonhson** (kwj1@psu.edu), Pennsylvania State University, Abington, PA. **Half-Isomorphisms in Loops**. Preliminary report.

A half-homomorphism in a loop Q is a map $f : Q \to Q$ such that for all $g, h \in Q$, $f(gh)$ is either $f(g)f(h)$ or $f(h)f(g)$. If Q is a group then f is necessarily either a homomorphism or an anti-homomorphism. I will discuss half-isomorphisms in loops. Call a half-isomorphism trivial if it is either an isomorphism or an anti-isomorphism. Examining loops of order 6, it shows that there is only one with a non-trivial half-isomorphism. Using the Loops Package (GAP) it has been possible to show for example that (a) all the Bol loops of order 8 have trivial half-isomorphisms, (b) that the Chein loops $M(S_3.2)$ (of order 12) $M(D_8.2)$, $M(Q_8.2)$ (of order 16) have only trivial half-isomorphisms. By contrast, the Octonion loop has a group of half-isomorphisms of order 2^7.

We conjecture that all Chein loops have only trivial half-isomorphisms. We can prove that if a Chein loop $M(G,2)$ has a non-trivial half-isomorphism f then there is a non-trivial half-isomorphism f' such that $f'(g) = g$ for all $g \in G$. There are many open questions, for example the center of a loop is preserved by a half-isomorphism if the loop is diassociative, but the corresponding question is open for arbitrary loops. (Received September 09, 2010)

11 ► Number theory

1064-11-4 **Jordan S Ellenberg*** (ellenber@math.wisc.edu), Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706. *Geometric Analytic Number Theory.*

I will discuss some emerging relationships between asymptotic counting problems in number theory and stabilization results in topology and group theory, summed up by the slogan "stable cohomology implies asymptotics over function fields suggests asymptotics over number fields." A motivating example will be an analogy between two classical problems: counting squarefree integers and computing the cohomology of the braid group on many strands. We will go on to speculate about the light this point of view may shed on various asymptotic conjectures in number theory (e.g. the conjectures of Cohen-Lenstra, Malle, Bhargava, Batyrev-Manin...) The work discussed is joint with A. Venkatesh and C. Westerland. (Received August 31, 2010)

1064-11-114 **Seyfi Turkelli*** (turkelli@math.uga.edu), The Department of Mathematics, University of Georgia, Athens, GA 30602. *Cohomology of Bianchi groups with coefficients in $Sym^n(\mathbb{C}^2)$.*

Let $M_{n,m} = Sym^n(C^2) \otimes Sym^m(C^2)$. Bianchi groups are groups of the form $PSL_2(O)$ where O is the ring of integers of an imaginary quadratic field. A fundamental problem in the study of Bianchi modular forms, which are the modular forms for GL_2 over an imaginary quadratic field, is to compute the cohomology groups $H^1(PSL_2(O), M_{n,n})$. In this talk, as the first step towards computing $H^1(PSL_2(O), M_{n,n})$, we will compute the cohomology groups $H^1(PSL_2(O), M_{n,0})$ for the ring of integers O of certain imaginary quadratic fields. (Received September 01, 2010)

1064-11-133 **Manjul Bhargava** (bhargava@math.princeton.edu), **Arul Shankar*** (ashankar@math.princeton.edu) and **Jacob Tsimerman** (jtsimerm@math.princeton.edu). *Title: On the Davenport-Heilbronn theorems and second order terms.* Preliminary report.

In this joint work with Manjul Bhargava and Jacob Tsimerman, we present an elementary proof of the Davenport-Heilbronn theorems which give the main term in the asymptotic for the number of cubic fields having bounded discriminant as well as the main term in the asymptotic for the total number of 3-torsion elements in the class groups of quadratic fields having bounded discriminants. We also prove a conjecture of Roberts that gives the second main term for the first Davenport-Heilbronn theorem. (Received September 03, 2010)

1064-11-188 **Gunther Cornelissen** (g.cornelissen@uu.nl), Mathematisch Institut, Universiteit Utrecht, Utrecht, Netherlands, and **Matilde Marcolli*** (matilde@caltech.edu), Department of Mathematics, California Institute of Technology, Pasadena, CA 91125. *Quantum Statistical Mechanics, L-series and Anabelian Geometry.*

It is known that two number fields with the same Dedekind zeta function are not necessarily isomorphic. The zeta function of a number field can be interpreted as the partition function of an associated quantum statistical mechanical system, which is a C*-algebra with a one parameter group of automorphisms, built from Artin reciprocity. We prove that isomorphism of number fields is the same as isomorphism of these associated systems. Considering the systems as noncommutative analogues of topological spaces, this result can be seen as another version of Grothendieck's "anabelian" program, much like the Neukirch-Uchida theorem characterizes isomorphism of number fields by topological isomorphism of their associated absolute Galois groups. We also use these systems to prove that there is a continuous bijection between the character groups (viz., Pontrjagin duals) of the abelianized Galois groups of the two number fields that induces an equality of all corresponding L-series (not just the zeta function), then the number fields are isomorphic. (Received September 08, 2010)

1064-11-305 **Adrian Clingher** (clingerha@umsl.edu), 354 CCB, 1 University Boulevard, University of Missouri, St. Louis, MO 63121, and **Ravindra V Girivaru*** (girivarur@umsl.edu) and **Ramesh Sreekantan**. *The motive associated to the nilpotent monodromy operator.* Preliminary report.

Let X be a smooth, projective variety over a number field and $\mathcal{X}$ be a regular model of X defined over the ring of integers $\mathcal{O}_K$ of K. Let $\mathcal{P}$ be a prime ideal of $\mathcal{O}_K$ and assume that the fibre over $\mathcal{P}$, denoted by Y is a reduced normal crossing divisor and that the residue field $k(\mathcal{P})$ is finite.

Let N be the logarithm of the monodromy operator, which is assumed to be unipotent around $\mathcal{P}$. Then N defines a class in $\mathbb{H}^{2d}((X \times X)_{\bar{K}}, \mathbb{Q}(d-1))$ and Kato conjectured that, under certain conditions, N corresponds to an algebraic cycle on Y. This was proved by Consani and Consani-Kim in certain cases.

We develop this further: we show that one can in fact, associate a (higher) algebraic cycle to N on X, thus proving that N is motivic. (Received September 13, 2010)

1064-11-307 **Mihai Caragiu*** (m-caragiu1@onu.edu), Department of Mathematics and Statistics, Ohio Northern University, Ada, OH 45810. *On a Fibonacci-type recursion involving Euler's totient function.* Preliminary report.

The sequence 0, 1, 1, 2, 2, 4, 6, 10, 16, 18, 24, 42, 66, 108, 120, 228, 348, 576, 720, 1296, 2016,... is recursively defined by $X_n = \phi(X_{n-1} + X_{n-2} + 1)$ for $n \geq 2$, starting from $X_0 = 0$ and $X_1 = 1$, where ϕ is the Euler's totient function. While the terms of this "phi-bonacci" sequence are bounded from above by the regular Fibonacci numbers ($X_n \leq F_n$ for all n), a computational exploration of the behavior of the sequences $\{X_n\}$ and $\{X_{n+1}/X_n\}$ suggests a series of intriguing open problems which will be discussed. (Received September 13, 2010)

13 ► Commutative rings and algebras

1064-13-71 **Drew Lewis*** (andrew@math.wustl.edu), Washington University in St. Louis, Department of Mathematics, One Brookings Drive, Campus Box 1146, St. Louis, MO 63119. *A note on the Venereau polynomials.* Preliminary report.

The Vénéreau polynomials $f_n = y + x^n(xz + y(yu + z^2))$ are a well known sequence of polynomials which define hyperplanes in $\mathbb{C}^4$. It is well known that for $n \geq 3$, f_n is an x-coordinate. We give an elementary calculation demonstrating that f_2 is an x-coordinate as well (in fact, the resulting automorphism is stably tame and an exponential). We will then discuss some related polynomials and some partial results about determining their status with respect to the Embedding Conjecture. (Received August 26, 2010)

1064-13-74 **Andrew Kustin**, **Hamid Rahmati** and **Adela Vraciu*** (vraciu@math.sc.edu). *The resolution of Frobenius powers of the maximal ideal in diagonal hypersurface rings.*

We consider ideals of the from $I_N = (x^N, y^N, z^N)$ in the ring

$$R_{n,p} = \frac{k[x,y,z]}{(x^n + y^n + z^n)},$$

where k is a field of characteristic p.

Our main result gives a necessary and sufficient condition for the ideal I_N to have finite projective dimension. Our criterion depends only on the values of a and p, where $a = \lfloor \frac{N}{n} \rfloor$.

In the case when the projective dimension is infinite, we give an explicit description of the periodic part of the resolution, which depends only on the parity of a, and the value of r, where r is such that $N = an + r$. (Received August 27, 2010)

1064-13-86 **Claudia Polini** and **Yu Xie*** (yxie@nd.edu), 2314 Coachmans Trail, South Bend, IN 46637. *Minimal j-multiplicity.* Preliminary report.

We define the minimal j-multiplicity and almost minimal j-multiplicity for a finite module over a Noetherian local ring with any ideal filtration. For a Cohen-Macaulay module with minimal j-multiplicity or almost minimal j-multiplicity, we prove that under certain conditions, the associated graded module is Cohen-Macaulay or almost Cohen-Macaulay. Our work generalizes the results for minimal multiplicity and almost minimal multiplicity done by J. Sally, M. Rossi and G. Valla, and H. J. Wang. We also discuss the Hilbert functions and Hilbert polynomials for Cohen-Macaulay modules with minimal j-multiplicity or almost minimal j-multiplicity. (Received August 30, 2010)

1064-13-99 **Christine Berkesch**, **Daniel Erman*** (derman@math.stanford.edu), **Manoj Kummini** and **Steven V Sam**. *Poset Structures in Boij–Söderberg Theory: I - Modules with pure resolution.*

We look at the partial order of degree sequences of Cohen–Macaulay modules with pure resolution. We show that for two degree sequences $d = (d_0, \dots d_n)$ and $d' = (d'_0, \dots, d'_n)$ in $(\mathbb{Z} \cup \{\infty\})^{n+1}$, $d_i \leq d'_i$ for all i if and only if there exist modules finitely generated Cohen–Macaulay modules M and M' with pure resolutions of type d and d', respectively, such that $\mathrm{Hom}(M', M)_{\leq 0} \neq 0$. This provides an interpretation of the partial order on degree sequences in terms of homomorphisms, thus suggesting that the partial order and the Boij–Söderberg decomposition of the cone of Betti tables are natural. (Received September 01, 2010)

1064-13-103 **Stefan O Tohaneanu***, Department of Mathematics, Middlesex College, The University of Western Ontario, London, Ontario N6A 5B7, Canada. *Points, regularity, minimum distance.*

Given $\Gamma \subset \mathbb{P}^n$ a non-degenerate (reduced) set of m points, finding $hyp(\Gamma)$, the maximum number of these points lying in a hyperplane is an interesting geometrical and computational question (e.g., Migliore-Peterson study the case of maximum number of points lying on a hypersurface of degree d), with an important impact in algebraic coding theory: $m - hyp(\Gamma)$ is the minimum distance of the code with generating matrix having as columns the coordinates of the points. Gold-Little-Schenck showed that if Γ is a complete intersection, then $m - hyp(\Gamma) \geq r$, where r is the regularity of $A = k[x_0, \dots, x_n]/I(\Gamma)$. We extended this result to the case when Γ is arithmetically Gorenstein, and in this talk we present the general case: for any $\Gamma \subset \mathbb{P}^n$ non-degenerate set of m points, we have $m - hyp(\Gamma) \geq a(\Gamma) - n$, where $a(\Gamma)$ is the minimum shift in the last module in the minimal graded free resolution of A. Also, we present a class of examples (due to J. Migliore) for which the bound is attained. The tools used are: computation of Hilbert function of ideal of points, separators, Cayley-Bacharach Theorem, mapping cone and free resolutions. (Received September 01, 2010)

1064-13-116 **Ezra Miller** (ezra@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708-032, **Isabella Novik*** (novik@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350, and **Ed Swartz** (ebs@math.cornell.edu), Cornell University, Department of Mathematics, Ithaca, NY 14853-4201. *Face rings of complexes with singularities.*

We provide a generalization of Schenzel's result characterizing Buchsbaum simplicial complexes to simplicial complexes with singularities. Specifically, our main result asserts that a simplicial complex has singularity dimension at most $m - 1$ if and only if the face ring of this complex modulo m generic linear forms has finite local cohomology. Here a face of a complex is called non-singular if its link has the homology of a wedge of spheres of the expected dimension, and it is called singular otherwise. (Received September 02, 2010)

1064-13-126 **Emilie Dufresne*** (emilie.dufresne@unibas.ch), Mathematisches Institute, Universität Basel, Rheinsprung 24, 4056 Basel, Switzerland, and **Andreas Maurischat** (andreas.maurischat@iwr.uni-heidelberg.de), IWR, Im Neuenheimer Feld 368, Ruprecht-Karls-Universität Heidelberg, 69120 Heidelberg, Germany. *Additive group actions in positive chracteristic.*

Roberts, Freudenburg, and Daigle and Freudenburg have given the smallest counterexamples to Hilbert's fourteenth problem. Each arises as the ring of invariants of an additive group action on a polynomial ring over a field of characteristic zero, and thus, each corresponds to the kernel of a locally nilpotent derivation. In positive characteristic, additive group actions correspond to locally finite iterative higher derivations, a more restrictive notion. We set up characteristic-free analogs of the three examples mentioned above, and show that, contrary to characteristic zero, in every positive characteristic, the invariant rings are finitely generated. (Received September 03, 2010)

1064-13-148 **Shigeru Kuroda***, Dept. of Mathematics and Information Sciences, Tokyo Metropolitan University, 1-1 Minami-Osawa, Hachioji, Tokyo 192-0397, Japan. *Wildness of polynomial automorphisms in three variables.*

It was a longstanding open question whether there exists a wild automorphism of the polynomial ring in three variables over a field of characteristic zero. This was settled in the affirmative by Shestakov-Umirbaev, who gave a criterion for deciding tameness and wildness of automorphisms. Later, the criterion was modified by us, and became more useful. In this talk, we give several applications of the Shestakov-Umirbaev theory and its modification. We discuss the following topics:

1. A necessary and sufficient condition for the wildness of $\exp(hD)$, where D is a triangular derivation and $h \in \ker D$.

2. Relation between tameness and triangularizability of locally nilpotent derivations.
3. Construction of "very wild" coordinates f (such that $\phi(f) = f$ implies ϕ is wild for every $\phi \neq \mathrm{id}$).
4. Local slice construction and wild automorphisms (We give new families of rank three locally nilpotent derivations D, and show that $\exp(hD)$ is wild for each D and $0 \neq h \in \ker D$). (Received September 05, 2010)

1064-13-163 **David L Wehlau*** (wehlau@rmc.ca), Dept. of Mathematics and Computer Science, Royal Military College of Canada, Kingston, Ontario K7L 4V1, Canada. *Modular Invariants From Classical Covariants.*

A central problem in algebra in the late nineteenth century and early twentieth century was to compute (generators for) the ring of covariants of a complex representation of $\mathrm{SL}_2(C)$. About one third of the algebra papers published in the 1880's in North America concerned this problem.

An important problem in modern invariant theory is to compute (generators for) the ring of invariants of a C_p representation over a field F of characteristic p where C_p denotes the cyclic group of order p. Up until now, this has only been done for a handful of representations.

In this talk I will describe a surprising connection between these two problems and my recent result which demonstrates that the two problems are equivalent. Using this we are able to use classical results to give generators for many new modular representations of C_p. (Received September 07, 2010)

1064-13-201 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu) and **Benjamin Anderson** (benjamin.j.anderson@ndsu.edu). *Finite Generation of Ext and ascent of module structures.*

Let $\varphi\colon (R, \mathfrak{m}, k) \to (S, \mathfrak{m}S, k)$ be a flat local ring homomorphism, and let M be a finitely generated R-module. We show that the following conditions are equivalent:

(1) M has an S-module structure compatible with its R-module structure via φ;
(2) $\mathrm{Ext}^i_R(S, M) = 0$ for $i \geq 1$;
(3) $\mathrm{Ext}^i_R(S, M)$ is finitely generated over R for $i = 1, \ldots, \dim_R(M)$;
(4) $\mathrm{Ext}^i_R(S, M)$ is finitely generated over S for $i = 1, \ldots, \dim_R(M)$;
(5) $\mathrm{Ext}^i_R(S, M)$ satisfies Nakayama's Lemma over R for $i = 1, \ldots, \dim_R(M)$.

This improves upon recent results of Frankild, Sather-Wagstaff, and Wiegand and results of Christensen and Sather-Wagstaff. This is joint work with Ben Anderson (North Dakota State University). (Received September 09, 2010)

1064-13-218 **Juan Migliore** and **Megan Patnott*** (mpatnott@nd.edu), Department of Mathematics, University of Notre Dame, 255 Hurley Hall, Notre Dame, IN 46556. *Minimal Free Resolutions of General Points on Cubic Surfaces.* Preliminary report.

The Minimal Resolution Conjecture (MRC), roughly stated, says that the graded minimal free resolution of a general set of points in $\mathbb{P}^n$ has no "ghost terms." A generalization of the MRC for arbitrary varieties in $\mathbb{P}^n$, given by Mustaţă, predicts that the graded Betti numbers of the ideal of such a variety completely determine those of the ideal of a general set of points on it. In particular, it predicts that the graded minimal free resolution of a general set of points on an arbitrary variety, X, in $\mathbb{P}^n$ has no ghost terms, except where forced to do so by X. Casanellas showed that this generalized MRC holds for t general points on a smooth cubic surface in $\mathbb{P}^3$ for certain special values of t, using Gorenstein liaison. Our result extends hers by verifying the conjecture for all t and allowing the cubic surface to have isolated double points. We give an overview of the work done on both the MRC and the generalized MRC, and then discuss our result. (Received September 09, 2010)

1064-13-220 **David Wright*** (wright@math.wustl.edu), Campus Box 1146, One Brookings Drive, St. Louis, MO 63130, and **Arno van den Essen** and **Wenhua Zhao**. *New conjectures related to the Jacobian Conjecture.*

The famous Jacobian Conjecture has been reformulated in several equivalent ways. We present an intriguing new conjecture of Zhao, the Image Conjecture, which would imply the Jacobian, and which leads to a fascinating assertion dubbed the Factorial Conjecture. These utilize the newly defined concept of a Mathieu subspace of a ring. (Received September 09, 2010)

1064-13-226 **Lars Winther Christensen**, **David A Jorgensen**, **Hamidreza Rahmati**, **Janet Striuli** and **Roger Wiegand*** (rwiegand@math.unl.edu), 203 Avery Hall, PO Box 880130, Lincoln, NE 68588-0130. *Exact zero divisors and totally acyclic complexes.*

Let $(R, \mathfrak{m}, k)$ be a local ring. A complex

$$\mathbf{F}: \qquad \ldots \to F_{n+1} \to F_n \to F_{n-1} \to \ldots$$

of finitely generated free R-modules is said to be *totally acyclic* provided both $\mathbf{F}$ and $\mathrm{Hom}_R(\mathbf{F}, R)$ are exact. One way such complexes can arise is from a pair of "exact zero divisors", that is, a pair x, y of elements of $\mathfrak{m}$ such that $Rx = (0 :_R y)$ and $Ry = (0 :_R x)$. The complex

$$\cdots \to R \to R \to R \to R \to \dots ,$$

where the maps are alternating multiplications by x and y, is then totally acyclic.

We will discuss the converse: When does the existence of a totally acyclic complex guarantee the existence of a pair of exact zero divisors? More generally, which rings have such pairs? We will focus mainly on the case of Artinian rings. (Received September 09, 2010)

1064-13-231 **Enrico Carlini*** (enrico.carlini@polito.it), Department of Mathematics, Corso Duca degli Abruzzi 24, 10129 Torino, Italy. *Star configuration points and hypersurfaces.*

A l-star configuration set of points in $\mathbb{P}^n$ is the n-wise intersection of a collection of l hyperplanes. A l-star configuration set of points $\mathbb{X}$ consists of $\binom{l}{n}$ points and of course it is very special among the sets of points having the same cardinality. Nevertheless, $\mathbb{X}$ has the Hilbert Function of $\binom{l}{n}$ generic points. This simple remark makes star configuration set of points extremely useful in the study of Hilbert Functions. In this talk we will try to study how star configuration set of points are special with respect to hypersurfaces. More precisely, we will ask the following question: does the generic degree d hypersurface contain a l-star configuration? We will see a complete answer in the case of $\mathbb{P}^2$ and some ideas for the general situation. This is a joint work with Adam van Tuyl (Lakehead University, Ontario) and an ongoing project involving also Elena Guardo (University of Catania, Italy). (Received September 10, 2010)

1064-13-240 **Takayuki Hibi**, **Akihiro Higashitani**, **Kyouko Kimura** and **Augustine B. O'Keefe*** (aokeefe@tulane.edu). *Depth of Edge Rings Arising from Finite Graphs.*

If G is a finite graph with edge ring $K[G]$, we will show that given integers f and d with $7 \leq f \leq d$, there exists a finite graph G on $[d] = \{1, \dots, d\}$ such that the depth of $K[G]$ is equal to f and the Krull dimension of $K[G]$ is d. We will sketch a proof using Gröbner bases, simplicial complexes and initial ideals. (Received September 10, 2010)

1064-13-246 **William Heinzer**, **Christel Rotthaus** and **Sylvia M Wiegand*** (swiegand@math.unl.edu), Dept of Mathematics, UNL, LINCOLN, NE 68502. *Building examples using power series.* Preliminary report.

We build various families of interesting non-Noetherian domains that are very close to being Noetherian. (Received September 10, 2010)

1064-13-255 **Susan Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, 601 University Drive, San Marcos, TX 78748. *Associated Primes of Powers of Monomial Ideals.*

There is a one-to-one correspondence between square-free monomial ideals generated in degree two and graphs that extends naturally to a correspondence between more general square-free monomial ideals and simple hypergraphs (also called clutters). This correspondence will be exploited to describe which prime ideals are associated primes of R/I^t for some integer t when either I is a square-free monomial ideal generated in degree two, or when the generators of I that are not square-free of degree two are pure powers. For square-free monomial ideals with higher degree generators, the focus will be on when the homogeneous maximal ideal is an associated prime of a power of I. (Received September 11, 2010)

1064-13-256 **Bernadette M Boyle*** (bboyle2@nd.edu), 255 Hurley Hall, University of Notre Dame, Notre Dame, IN 46556. *The unimodality of pure O-sequences of type three in three variables.* Preliminary report.

In this presentation we will look at some properties of the Hilbert functions of monomial algebras, particularly to see when they are unimodal. Due to Macaulay's theorem, one knows that algebras in two variables are unimodal. Furthermore, it has been shown that monomial Artinian level algebras of type two in three variables have the Weak Lefschetz Property, and thus are unimodal. On the other hand, for any $r \geq 3$, there exists a monomial Artinian level algebra in r variables whose Hilbert function fails unimodality with an arbitrary number of peaks. In this presentation, we will show the unimodality of the Hilbert function in the smallest open case, namely that of monomial Artinian level algebras of type three in three variables. Since the Weak Lefschetz Property does not necessarily hold for such algebras, we give a new approach. (Received September 11, 2010)

1064-13-258 **Shiro Goto** and **Jooyoun Hong*** (hongj2@southernct.edu), Department of Mathematics, Southern Connecticut State University, 501 Crescent Street, New Haven, CT 06515, and **Mousumi Mandal**. *The positivity of the first normalized Hilbert coefficients.*

In this joint work with Goto and Mandal, we are interested in the analysis of the first normalized Hilbert coefficient $\overline{e}_1(I)$. Let $(R, \mathfrak{m})$ be an analytically unramified local ring of positive dimension. For an $\mathfrak{m}$–primary ideal I, the normalized Hilbert function of R with respect to I is the length $\lambda_R(R/\overline{I^{n+1}})$, where $\overline{I^{n+1}}$ denotes the integral closure of I^{n+1}. This function is of polynomial type with degree d and we write

$$\lambda_R(R/\overline{I^{n+1}}) = \overline{e}_0(I)\binom{n+d}{d} - \overline{e}_1(I)\binom{n+d-1}{d-1} + \cdots + (-1)^d\overline{e}_d(I)$$

for sufficiently large n. One of our main results is to settle the positivity conjecture on $\overline{e}_1(I)$ posed by Wolmer V. Vasconcelos. More specifically we proved that if $(R, \mathfrak{m})$ is unmixed and analytically unramified local ring of positive dimension, then $\overline{e}_1(I)$ is nonnegative for every $\mathfrak{m}$–primary ideal I of R. (Received September 11, 2010)

1064-13-269 **Janet Striuli*** (jstriuli@fairfield.edu), North Benson Road, Fairfield, CT, and **W. Lars Christensen** (lars.w.christensen@ttu.edu), **David Jorgensen** (djorgens@uta.edu), **Hamid Rahmati** (hamid2r@gmail.com) and **Roger Wiegand** (rwiegand1@math.unl.edu). *Infinite families of totally reflexive modules.*

For a local noetherian ring R, the category of reflexive R-modules has been shown very useful in detecting properties of the ring itself.

Recently it was shown that if the ring is not Gorenstein and there exists a non-free totally reflexive module, then there is an infinite family of totally reflexive modules, which are pairwise not isomorphic. We construct such a family over certain local rings with *exact pairs of zero-divisors*. We pay particular attention to local ring with the cube of the maximal ideal being zero. (Received September 12, 2010)

1064-13-275 **Huy Tai Ha** (tha@tulane.edu), **Erik Stokes*** (stokes.erik@gmail.com) and **Fabrizio Zanello** (zanello@mtu.edu). *Pure O-sequences and Matroid h-vectors.*

A long-standing conjecture of Stanley states that the h-vector of any matroid is a pure O-sequence. A number of special cases have been proven but, to date, they have been generally been based on explicitly constructing the required artinian, level monomial ideals. We take a different approach and concentrate instead on the properties of pure O-sequences. In particular, we state a conjecture on pure O-sequences, which we are able prove for small socle degrees. Using this new technique we are able to prove Stanley's conjecture for all rank 3 matroids. (Received September 12, 2010)

1064-13-317 **C-Y. Jean Chan*** (chan1cj@cmich.edu), Department of Mathematics, PE 214, Central Michigan University, Mt. Pleasant, MI 48858, and **Kazuhiko Kurano**, Meiji University, Japan. *An application of Chow groups to Hilbert-Kunz functions.*

In this talk, we discuss the Hilbert-Kunz functions of modules over a local ring regular in codimension one and show that the functions stabilize up to the second highest term. When a ring under consideration is not normal, the Chow group is utilized in place of the divisor class group. Our proof extends that of Huneke, McDermott and Monsky where rings are assumed to be normal (Math. Res. Lett. 11 (2004), no. 4, 539–546). This is a joint work with Kazuhiko Kurano. (Received September 13, 2010)

1064-13-321 **Dennis K. Moore*** (dmoore@ms.uky.edu), Department of Mathematics, 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **Uwe R. Nagel** (uwe.nagel@uky.edu), Department of Mathematics, 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506. *Stable monomial ideals with a given Hilbert polynomial.*

Stable ideals are a class of monomial ideals with a simple combinatorial description. We present a recursive algorithm for generating all saturated strongly stable ideals with a given Hilbert polynomial. It adapts and extends ideas from the Ph.D. thesis *On the combinatorial structure of the Hilbert Scheme* by Alyson Reeves. (Received September 13, 2010)

1064-13-336 **Kevin Tucker*** (kevtuck@math.utah.edu), Department of Mathematics, University of Utah, 155 S 1400 E Room 233, Salt Lake City, UT 84112-0090. *The F-Signature.*

Let R be a reduced F-finite local ring with prime characteristic $p > 0$ and perfect residue field. Let R^{1/p^e} be the ring of p^e-th roots of elements of R for $e > 0$. The F-signature of R is $s(R) := \lim_{e\to\infty} \frac{\#\text{ of } R\text{-free direct summands of } R^{1/p^e}}{p^{ed}}$, assuming this limit exists. This invariant was first formally defined by C. Huneke and G. Leuschke, and its existence up to this point has only been shown in various special cases. We give a general existence proof of this limit, based on certain uniform Hilbert-Kunz estimates. (Received September 14, 2010)

1064-13-337 **Christopher A Francisco** and **Jeff Mermin*** (mermin@math.okstate.edu), Oklahoma State University, Department of Mathematics, Stillwater, OK 74078, and **Jay Schweig**. *Borel ideals via Borel generators, I.*

We compute various invariants of a Borel ideal without knowing a generating set. (Received September 14, 2010)

1064-13-341 **Andrew Crabbe** and **Graham J Leuschke***, Syracuse University, Syracuse, NY 13244. *Wild Hypersurfaces.*

In the representation theory of finite-dimensional algebras over a field, Drozd's trichotomy theorem says that an algebra has either tame module type or wild module type. Loosely, these two possibilities correspond to hoping for a classification theorem, versus throwing up our hands in despair. We'd very much like a similar trichotomy result in other representation-theoretic contexts, specifically for maximal Cohen–Macaulay modules over a Cohen–Macaulay local ring. The talk will give a little background on the problem, including definitions of tame and wild CM type, and describe recent work giving a unified proof that hypersurfaces of multiplicity four or more in three or more variables have wild CM type. (Received September 14, 2010)

1064-13-361 **Jay Schweig*** (jschweig@math.ku.edu), 405 Snow Hall, 1460 Jayhawk Blvd., Lawrence, KS 66045, and **Christopher Francisco** and **Jeffrey Mermin**. *Borel Ideals Via Borel Generators II.*

We continue the study of Borel ideals, investigating the Betti numbers of principal Borel ideals. We use a special filling of a Young tableau to prove a recursion related to these ideals, and finally show a surprising connection between the Betti numbers of certain principal Borel ideals and pseudo-triangulations of certain point sets. (Received September 14, 2010)

1064-13-363 **Massimo Caboara** (caboara@@dm.unipi.it) and **Sara Faridi*** (faridi@mathstat.dal.ca). *Componentwise linear ideals arising from simplicial trees.* Preliminary report.

The motivation behind this talk is studying resolutions of monomial ideals. We discuss classes of ideals arising from simplicial trees (a generalization of graph-trees) which are componentwise linear. This means that the ideal can be broken into several components, each of which has a linear resolution. We also consider the dual property of sequential Cohen-Macaulayness in the class of ideals under study. (Received September 14, 2010)

1064-13-377 **Ben Babcock** and **Adam Van Tuyl*** (avantuyl@lakeheadu.ca), Dept. of Mathematical Sciences, 955 Oliver Road, Thunder Bay, ON P7B5E1, Canada. *Revisiting the Spreading and Covering Numbers.* Preliminary report.

The spreading and covering numbers were introduced by Geramita, Gregory, and Roberts in the 1980's to study the Ideal Generation Conjecture. Although they are related to a problem in algebraic geometry, these numbers can be redefined as a problem as about graphs or simplicial complexes. After recalling the Ideal Generation Conjecture, and the connection to the spreading and covering numbers, I will discuss some of my joint work with my summer student to compute some of these numbers (which appear very hard to compute). (Received September 14, 2010)

1064-13-383 **Anthony A. Iarrobino, Jr.*** (a.iarrobino@neu.edu), Mathematics Department 567 Lake, Northeastern University, 360 Huntington Avenue, Boston, MA 02115, **Roberta Basili** (robasili@alice.it), Via dei Ciclamini 2B, 06126 Perugia, Italy, and **Leila Khatami** (l.khatami@neu.edu), Mathematics Department, 567 Lake Hall, Northeastern University, 360 Huntington Avenue, Boston, MA 02115. *When do two nilpotent matrices commute?* Preliminary report.

We outline recent progress in understanding the irreducible family N_B of nilpotent matrices commuting with a given nilpotent matrix B of Jordan block partition P. What is the Jordan block partition Q(P) of a generic element of N_B? This question has been related to standard bases for ideals of given Hilbert function in the local ring $k\{x, y\}$, and also to paths in a certain weighted poset W_P of integer points of the plane. We discuss these connections, and in particular a proof using W_P of a result of Polona Oblak giving the largest part of Q(P). (Received September 14, 2010)

1064-13-386 **Bonnie Smith*** (bonnie.smith@uky.edu), Department of Mathematics, 719 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **Angela Kohlhaas** (angela.kohlhaas@loras.edu). *The shape of the core of certain monomial ideals.* Preliminary report.

A fruitful way of studying blow-up algebras associated to an ideal I, such as the Rees algebra $R[It]$, is through minimal reductions of I. These can be thought of as simpler ideals contained in I which carry much of the information about I. The core of an ideal is the intersection of all of its reductions. The core also has geometric significance, including a connection to multiplier ideals, yet is difficult to describe explicitly. In this talk we focus on certain classes of zero-dimensional monomial ideals. In particular, we will show how the combinatorial structure of these ideals is reflected in the shape of their cores. (Received September 14, 2010)

1064-13-393 **Kia Dalili*** (dalilik@missouri.edu). *On applications of regularity bounds to length complexity of tensor product and HomAB problems.*

The length complexity of tensor product problem is the problems of finding uniform bounds for the length of the finite support portion of the tensor product of two finitely generated modules. While the HomAB problem is the the problem of bounding the number of generators of the module of homomorphisms of a pair of finitely generated modules. These seemingly unrelated problems are both connected to study of extended multiplicities of the modules involved.

I will briefly review these problems giving a quick survey of the known results. Then connecting the extended multiplicities with regularity of module, I will use results that bound the regularity of a graded module to solve these problems for standard graded algebras. (Received September 14, 2010)

1064-13-394 **Inês Bonacho dos Anjos Henriques*** (henriques@math.ucr.edu), University of California, 900 University Avenue, Riverside, CA 92521, **Luchezar L. Avramov**, University of Nebraska, Lincoln, and **Liana M. Şega**, University of Missouri, Kansas City. *Ascent and Descent modulo quasi-complete intersections.* Preliminary report.

Let R be a local ring. An ideal I is *quasi-complete intersection* if the homology of the Koszul complex E on a generating set of I is free as a module over $S = R/I$, and the canonical map of graded S-algebras $\wedge^S \mathrm{H}_1(E) \to \mathrm{H}(E)$ is bijective.

We show that several basic invariants of R determine those of S by the same formulas that hold in the particular case when I is generated by a regular sequence. We conclude that, under some additional hypothesis, R and S are equally far from being Cohen-Macaulay, Gorenstein, or complete intersection. (Received September 14, 2010)

14 ► Algebraic geometry

1064-14-8 **Jing Zhang*** (jzhang@albany.edu), 1400 Washington Avenue, Department of Mathematics and Statistics, ES 110, Albany, NY 12222. *Singularity of a Holomorphic Map.*

Let f be a holomorphic map between two complex manifolds M and N. We will discuss its singularity. We are particularly interested in the map obtained from a holomorphic line bundle and will investigate the relationships among Milnor number, singularity of the map and the global smooth sections of the line bundle. (Received July 08, 2010)

1064-14-52 **Shin-Yao Jow*** (jows@math.upenn.edu), University of Pennsylvania, Department of Mathematics, 209 South 33rd Street, Philadelphia, PA 19104-6395. *Multigraded Fujita approximation.*

The original Fujita approximation theorem states that the volume of a big divisor D on a projective variety X can always be approximated arbitrarily closely by the self-intersection number of an ample divisor on a birational modification of X. One can also formulate it in terms of graded linear series as follows: let $W_\bullet = \{W_k\}$ be the complete graded linear series associated to a big divisor D:

$$W_k = H^0\big(X, \mathcal{O}_X(kD)\big).$$

For each fixed positive integer p, define $W_\bullet^{(p)}$ to be the graded linear subseries of $W_\bullet$ generated by W_p:

$$W_m^{(p)} = \begin{cases} 0, & \text{if } p \nmid m; \\ \mathrm{Image}\big(S^k W_p \to W_{kp}\big), & \text{if } m = kp. \end{cases}$$

Then the volume of $W_\bullet^{(p)}$ approaches the volume of $W_\bullet$ as $p \to \infty$. We will show that, under this formulation, the Fujita approximation theorem can be generalized to the case of multigraded linear series. (Received August 23, 2010)

1064-14-66 **Mirel Caibar**, **Manuel Gonzalez Villa**, **Gary Kennedy*** (kennedy@math.ohio-state.edu) and **Lee McEwan**. *Motivic Milnor fibers associated to quasi-ordinary surfaces.* Preliminary report.

In prior work, two of the authors have developed a recursion for computing the horizontal and vertical monodromies associated to a component of the singular locus of a quasi-ordinary surface. These are monodromies on the Milnor fiber obtained by taking a slice of the surface transverse to the component. We are developing a motivic version of that recursion, which should allow for practical calculation of the associated spectra (including a hypothesized vertical spectrum). (Received August 25, 2010)

1064-14-82 **Ivan Arzhantsev**, 119991, Russia, and **Hubert Flenner** and **Shulim Kaliman*** (kaliman@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33176, and **Frank Kutzschebauch** and **Mikhail Zaidenberg**. *Flexible varieties.*

Given an affine algebraic variety X of dimension $n \geq 2$, we let $SAut(X)$ denote the special automorphism group of X i.e., the subgroup of the full automorphism group $Aut(X)$ generated by all one parameter unipotent subgroups. We show that if $SAut(X)$ is transitive on the smooth locus X_{reg} then it is infinitely transitive on X_{reg}. In turn, the transitivity is equivalent to the flexibility of X. The latter means that for every smooth point $x \in X_{reg}$ the tangent space T_xX is spanned by the velocity vectors at x of one parameter unipotent subgroups of $Aut(X)$. Usually, the flexibility is easier to verify. (Received August 30, 2010)

1064-14-98 **Matthew Satriano*** (satriano@umich.edu). *Hodge Theory and Liftability Results for Quotients by Groups.*

This talk is concerned with quotients of smooth varieties by finite group schemes. We begin by reviewing the classical Chevalley-Shephard-Todd theorem in Invariant Theory. We show how a new look at this theorem leads to Hodge theoretic results for quotients by finite group schemes. (Received August 31, 2010)

1064-14-100 **Christine Berkesch**, **Daniel Erman**, **Manoj Kummini*** (nkummini@math.purdue.edu) and **Steven V Sam**. *Poset Structures in Boij–Söderberg Theory: II - Supernatural sheaves.*

We look at the partial order of root sequences of sheaves on $\mathbb{P}^{n-1}$ with supernatural cohomology. We show that for two root sequences $f = (f_1, \ldots, f_{n-1})$ and $f' = (f'_1, \ldots, f'_{n-1})$ in $(\{-\infty\} \cup \mathbb{Z})^{n-1}$, $f_i \leq f'_i$ for all i if and only if there exist supernatural sheaves $\mathcal{F}, \mathcal{F}'$ of type f and f', respectively, such that $\mathrm{Hom}(\mathcal{F}', \mathcal{F}) \neq 0$. We will also look at equivariant versions of these theorems. (Received September 01, 2010)

1064-14-101 **Anatoly Libgober*** (libgober@math.uic.edu), Department of mathematics, UIC, 851 S.Morgan, Chicago, IL 60607. *Alexnader modules and Mordell Weil groups.*

Alexander polynomial of a plane algebraic curve can be related to the rank of Mordell-Weil group of an isotrivial elliptic threefold having this curve as the discriminant. This relation works for curves within certain class of singularities which will be described in this talk. As a corollary we obtain an upper bound on the degree of the Alexander polynomial which is linear in the degree of the curve. Another corollary describes the equations of curves with non trivial Alexander polynomial. This is a report on results of joint work with J.I.Cogolludo-Agustin (arxive: 1008.2018) (Received September 01, 2010)

1064-14-112 **Mathias Schulze*** (mschulze@math.okstate.edu), Oklahoma State University, Department of Mathematics, Stillwater, OK 74078. *Free divisors, adjoint divisors, and partial normalizations.*

Free divisors occur naturally as discriminants in singularity theory. Understanding how they are built from components is one of the fundamental questions. For instance, Terao's conjecture states that freeness is combinatorial for hyperplane arrangements. We describe cases, where a hypersurface becomes free by adding an adjoint divisor. For certain free divisors, our constructions yields a partial normalization, which we can describe explicitly in case of Coxeter arrangements and their discriminants. The presented results are joint work with David Mond and Michel Granger. (Received September 01, 2010)

1064-14-118 **Brian Harbourne*** (bharbour@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Fat points, graded Betti numbers and geometry.*

Let $p_1, \ldots, p_r \in \mathbf{P}^2$ be generic points (and let $\pi : X \to \mathbf{P}^2$ be obtained by blowing up the points p_i). The Hilbert function and graded Betti numbers of the ideal of every fat point subscheme $Z = \sum_i m_i p_i$ are known if $r < 9$. When $r > 9$ neither are known in general, but there is a conjecture for the Hilbert function. If $r = 9$, then the Hilbert function is known, but not in general the graded Betti numbers. A geometric way to study the graded Betti numbers, due to Fitchett, involves the splitting $(\pi^*\Omega_{\mathbf{P}^2})|_E = \mathcal{O}_E(-a) \oplus \mathcal{O}_E(-b)$ for exceptional curves E on X. When $r = 9$, recent joint work with A. Gimigliano and M. Idà suggests the following conjecture: $|b - a| \geq 2$ if and only if $E + L$ is a semi-adjoint (i.e, there is a divisor A such that $E + L + K_X = 2A$, where L is the pullback to X of a line in $\mathbf{P}^2$), in which case $|b - a| = 2$. This conjecture, if true, determines the graded Betti numbers for all Z in all degrees but one when $r = 9$. (Received September 02, 2010)

1064-14-144 **Sylvain Cappell** and **Laurentiu Maxim*** (maxim@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706, and **Joerg Schuermann** and **Julius Shaneson**. *Characteristic classes of complex hypersurfaces.*

An old problem in geometry and topology is the computation of topological and analytical invariants of complex hypersurfaces, e.g., Betti numbers, Euler characteristic, signature, Hodge-Deligne numbers, etc. While the non-singular case is easier to deal with, the singular setting requires a subtle analysis of the intricate relation between the local and global topological and/or analytical structure of singularities. In this talk I will explain how to compute characteristic classes of complex hypersurfaces in terms of local invariants of singularities. (Received September 05, 2010)

1064-14-179 **Francois Loeser*** (loeser@math.jussieu.fr), University Pierre et Marie Curie, 75005 Paris, France. *Non-archimedean geometry and the incidence complex of singularities.*

Let X be an algebraic variety over a perfect field k and x an isolated singular point. Using Berkovich non-archimedean geometry over the field k endowed with the trivial norm, Amaury Thuillier proved in Manuscripta Math. 123 (2007), 381–451, that the homotopy type of the incidence complex of the exceptional divisor of a resolution of singularities at x does not depend on the resolution chosen. In this talk we shall focus on the basic ideas behind Thuillier's result, in particular the construction of a punctured tubular neighborhood of a singularity. We shall then present some applications to radicial and quotient singularities motivated by recent work of Kerz and Saito. (Received September 08, 2010)

1064-14-199 **Julianna Tymoczko***, Department of Mathematics, 14 MacLean Hall, University of Iowa, Iowa City, IA 52242, and **Robert MacPherson**, School of Mathematics, Institute for Advanced Studies, Einstein Drive, Princeton, NJ 08540. *Generalizing Springer representations to Hessenberg varieties.*

The Springer representation is a classical geometric representation: it refers to a particular representation of the symmetric group on the cohomology of a family of subvarieties of the flag variety called Springer varieties. This talk will show how to generalize the Springer representation to a family of varieties called Hessenberg varieties, which naturally extend the one-parameter family of Springer varieties to a two-parameter family. We will describe what's different for Hessenberg varieties (the group action is really the monodromy representation, not the Springer action), and what stays the same (a beautiful formula for the graded character of the representation, governed by the symmetric group action on the "generic" Hessenberg varieties). Time permitting, we'll describe some combinatorial results and conjectures, as well. This work is joint with R. MacPherson (IAS). (Received September 09, 2010)

1064-14-229 **Peter Russell*** (russell@math.mcgill.ca), Pavillon Andre Aisenstadt, Rue de la Tour, Montreal, QC , Canada. *Contractible normal affine surfaces.*

I will discuss two results at opposite ends of the spectrum for surfaces S as in the title.

I. Suppose S has negative Kodaira dimension and only quotient singularities. Then the smooth locus of S has negative Kodaira dimension.

II. Suppose S is not smooth and the smooth locus has Kodaira dimension two. Then S has a unique singular point, and it is a cyclic quotient singular point.

In both cases there is a consequence relevant to the topic of this session.

I.1 A two-dimensional quotient of C^n by a reductive group is isomorphic to C^2 modulo a finite group.

II.1 The automorphism group of a smooth contractible surface of general type is finite cyclic.

This is joint work with R. Gurjar, M. Koras and M. Miyanishi. (Received September 09, 2010)

1064-14-236 **Uli Walther*** (walther@math.purdue.edu), 150 N University Street, Dept of Mathematics, Purdue University, West Lafayette, IN 47906. *2 Bernstein–Sato polynomials.* Preliminary report.

We discuss Bernstein–Sato polynomials of arrangements with equal intersection lattice. (Received September 10, 2010)

1064-14-242 **Adrien Dubouloz** (Adrien.Dubouloz@u-bourgogne.fr), Institut de Mathématiques de Bourgogne, Université de Bourgogne, 9 Avenue Alain Savary, BP 47870 21078 Dijon Cedex, France, and **David R Finston*** (dfinston@nmsu.edu), Department of Mathematical Sciences, New Mexico State Unversity, Las Cruces, NM 88003. *Twin triangular derivations revisited Part 1.* Preliminary report.

It has been conjectured that every proper action of the complex additive group on complex affine four space is conjugate to a translation with quotient isomorphic to affine three space. Examples showing the necessity of the properness and dimension assumptions abound. The conjecture was shown to hold for a special class of actions (so-called twin triangular actions of type 1 and 2). This two part talk will sketch a proof of the conjecture for general twin triangular actions. Part 1 gives a necessary criterion for properness of a triangular action, which is also sufficient for a twin triangular action, and a reduction of the problem to that of demonstrating local triviality. (Received September 10, 2010)

1064-14-262 **Sebastien Boucksom** and **Tommaso de Fernex*** (defernex@math.utah.edu), 155 S 1400 E, Salt Lake City, UT 84103, and **Charles Favre**. *The valuation space of an isolated normal singularity.*

We study positivity properties of divisors on the Zariski space of a normal variety X, which encodes all resolutions of X. In the case X has an isolated singularity, we concurrently work on the full space of valuations of rank one centered at the singular point and study properties of various functions on it. We define a notion "volume" of an isolated singularity which relates to the singularities in the minimal model program, extending previous work of Wahl on surfaces. Our work has also applications to global geometry, and address questions of the following type: - Which projective varieties admit polarized finite endomorphisms of degree > 1? - Is the property of being log-Fano preserved by surjective morphisms of projective varieties? (Received September 12, 2010)

1064-14-293 **M. Ballard*** (ballardm@math.upenn.edu), Department of Mathematics, David Rittenhouse Laboratory, 209 South 33rd Street, Philadelphia, PA 19104, and **D. Favero** and **L. Katzarkov**. *Orlov Spectra of Categories Arising in Mirror Symmetry.*

A simple question to ask about an object, G, in a triangulated category, $\mathcal{T}$, is the following: can every other object be built from G using cones, shifts, finite coproducts, and splitting of summands? If the answer is yes, then G is called a generator of $\mathcal{T}$. If G is a generator, then a natural follow-up question is: how many cones do we have use? In particular, is there a uniform bound? The minimal upper bound is called the generation time of G. To $\mathcal{T}$, we can associate a subset of $\mathbf{N}$ which records the generation times of all generators of $\mathcal{T}$. It is called the Orlov spectrum of $\mathcal{T}$. In this talk, we will take some categories of interest in mirror symmetry and discuss the structure of their Orlov spectra. Upper and lower bounds for the Orlov spectrum will be tied closely to geometry and relations with questions of rationality will be discussed. Examples to be considered include: Calabi-Yau hypersurfaces in projective space, Riemann surfaces, and isolated hypersurface singularities. (Received September 13, 2010)

1064-14-295 **Lucy Moser-Jauslin*** (moser@u-bourgogne.fr), Universite de Bourgogne, Institut de Math. de Bourgogne, CNRS-UMR 5584, 9, avenue Alain Savary - B.P. 47 870, 21078 Dijon, France, and **Adrien Dubouloz** and **Pierre-Marie Poloni**. *Counter-examples to cancellation for exotic complex spaces of dimension 3.*

An exotic complex space is a smooth affine complex variety which is diffeomorphic but not algebraically isomorphic to affine space. A three-dimensional smooth affine variety is diffeomorphic to affine three-space if and only if it is contractible. Koras and Russell constructed a family of contractible threefolds for their proof that all actions of $\mathbf{C}^*$ on $\mathbf{C}^3$ are linearizable. In this lecture, we will study a generalisation of these exotic complex three-dimensional varieties with new interesting properties. For example, we can construct non-isomorphic contractible affine threefolds with isomorphic cylinders, showing that the generalized Cancellation Problem has a negative answer for contractible affine threefolds. We also find a family of contractible affine varieties which are biholomorphic as complex analytic varieties but are all non-isomorphic as algebraic varieties. These results were obtained in collaboration with A. Dubouloz and P.M. Poloni. (Received September 13, 2010)

1064-14-296 **Nicole Marie Lemire*** (nlemire@uwo.ca), Department of Mathematics, University of Western Ontario, London, Ontario N5Y 2T3, Canada, and **Ajneet Dhillon** and **Indranil Biswas**. *The Essential Dimension of the Moduli Stack of Vector Bundles over a Curve.*

In joint work with Indranil Biswas and Ajneet Dhillon, we determine upper bounds on the essential dimension of the moduli stack of parabolic vector bundles over a curve. When there is no parabolic structure, we improve our previously known upper bound on the essential dimension of the usual moduli stack of vector bundles over a curve. Our calculations also give lower bounds on the essential dimension of the semistable locus inside the usual moduli stack. (Received September 13, 2010)

1064-14-316 **Ursula A. Whitcher*** (ursula@math.hmc.edu), Dept. of Mathematics, 301 Platt Blvd., Claremont, CA 91711. *Computing Picard-Fuchs equations for hypersurfaces in toric varieties.* Preliminary report.

Mirror symmetry predicts that varying the complex structure of a family of Calabi-Yau varieties should correspond to varying the Kaehler structure of a mirror family. One may study variations of complex structure for a family of Calabi-Yau varieties using the Picard-Fuchs equation of a holomorphic form. Hypersurfaces in toric varieties offer a rich source of examples of Calabi-Yau varieties. We describe a version of the Griffiths-Dwork technique which may be used to compute the Picard-Fuchs equation for families of quasismooth, semiample hypersurfaces in toric varieties. We use our techniques to study families of K3 surfaces with high Picard rank. (Received September 13, 2010)

1064-14-322 **Adrien DUBOULOZ***, Institut de Mathematiques de Bourgogne, 9 av. Alain Savary, 21800 DIJON, France, and **David FINSTON**. *Twin triangular derivations revisited Part 2.*

The local triviality of proper twin triangular $\mathbb{G}_a$-actions on $\mathbb{A}^4$ is derived from a careful analysis of the algebraic space quotient, which always exists for a proper action. This quotient is explicitly constructed for certain open subsets of $\mathbb{A}^4$ and shown to be a scheme, i.e. not merely an algebraic space. Finally, these open subsets are shown to cover $\mathbb{A}^4$, yielding the local triviality. (Received September 13, 2010)

1064-14-331 **Jimmy Dillies*** (dillies@math.utah.edu), Dept of Mathematics, University of Utah, 155 S 1400 E, Salt Lake City, UT 84103. *Toda lattices and Galois invariants.*

We discuss a relation between integrable systems and dessins d'enfants. (Received September 13, 2010)

1064-14-332 **Hirotachi Abo** and **Chris Peterson*** (peterson@math.colostate.edu). *Locally Cohen-Macaulay unions of surfaces in P^4.*

This talk will consider several special constructions of locally Cohen-Macaulay unions of surfaces in P^4. Interest in such constructions is motivated by the apparent connection of such degenerations with varieties possessing special properties. The talk will present several instances where the combinatorial data of the degenerate union can be directly related to geometric properties of the smoothed variety. (Received September 13, 2010)

1064-14-338 **Jae-Hyouk Lee*** (jaehyoukl@gmail.com), KIAS Hoegiro 87, 207-43 Cheongnyangni-dong, Dongdaemun-gu, Seoul, 130-722, South Korea. *E_8 lattice and del Pezzo surface.*

The holomorphic curves in del Pezzo surfaces play important roles in the Mysterious Duality between M-theory on tori and del Pezzo surfaces. In fact, the curves are the subset of E lattices in the Picard group of the del Pezzo surfaces, and the configuration of the curves are given by the E action on the E lattices. Here we consider the polytopes with E type symmetry in E lattice and explore the configuration of curves along the combinatorics of the polytopes. In particular, we focus on the configuration of curves in del Pezzo surfaces of degree 1 along the E_8 lattices. (Received September 14, 2010)

1064-14-342 **Matthew D Kerr*** (matkerr@math.wustl.edu), WUSTL Math Department, 1 Brookings Dr., Campus Box 1146, Cupples I, Room 100, St. Louis, MO 63130-4899. *What is ... the mirror of an algebraic cycle?*

This talk is based on work of Morrison-Walcher and others in open mirror symmetry and my work with C. Doran in the local setting. In each case, certain invariants of algebraic cycles on the B-model, turn out to be mirror to Gromov-Witten generating functions. I'll offer some speculation as to how one might want to complete this story on the A-model, at least on the level of Hodge theory. (Received September 14, 2010)

1064-14-344 **Mircea I Mustata*** (mmustata@umich.edu), Department if Mathematics, University of Michigan, Ann Arbor, MI 48103. *Valuations and invariants of graded sequences of ideals.*

I will discuss an asymptotic version of the log canonical threshold, and its connection to valuation theory. This is based on joint work with Mattias Jonsson. (Received September 14, 2010)

1064-14-345 **Benjamin Howard*** (howardbj@umich.edu), Math Dept, University of Michigan, Ann Arbor, MI 48109, and **John Millson**, **Andrew Snowden** and **Ravi Vakil**. *The geometry of eight points in projective space.*

We describe a fascinating relationship between the Geometric Invariant Theory quotients $(\mathbb{P}^1)^8//\mathrm{PGL}_2$ and $(\mathbb{P}^3)^8//\mathrm{PGL}_4$. (Received September 14, 2010)

1064-14-347 **Leonid Makar-Limanov*** (lml@math.wayne.edu). *A property of a Jacobian mate.*

A polynomial $f \in C[x, y]$ is called a Jacobian mate if there exists a polynomial $g \in C[x, y]$ such that the Jacobian $J(f, g) = 1$.

Newton's procedure can be applied to solve an equation $f(x, y) = 0$ and present y as an infinite power series in fractional powers of x, either by decreasing or increasing powers. In the process the Newton polygon is attached to a solution. It turns out that though a priory polygons which correspond to different solutions may be different, the Newton polygons attached to different solutions by decreasing powers are the same.

This observation sheds additional light on the Jacobian conjecture. (Received September 14, 2010)

1064-14-357 **Daniel Bates**, **Jon Hauenstein**, **Matthew Niemerg*** (niemerg@math.colostate.edu) and **Frank Sotille**. *Computational Aspects of Gale Duality.* Preliminary report.

Certain polynomial systems can be solved more efficiently by transforming the system to its gale dual. Various symbolic choices in the conversion of a polynomial system to its Gale dual have an impact on the numerical methods (Khovanskii-Rolle continuation) used to solve the Gale dual system. The point of this effort (joint with D. Bates, J. Hauenstein, and F. Sottile) is to create heuristics for making reasonable symbolic choices in the context of numerical conditioning and efficiency. (Received September 14, 2010)

1064-14-360 **Roi Docampo*** (docampo@math.utah.edu), Department of Mathematics, University of Utah, 155 S 1400 E RM 233, Salt Lake City, UT 84112, and **Tommaso de Fernex**. *Geometry of arcs under birational maps.*

We study the effect of birational transformations on the topology of arc spaces of singular varieties. Our analysis focuses on the behavior of divergent wedges: arcs in the arc space whose limit points lie at infinity. This approach gives new insights for the understanding of Nash-type questions for singularities. (Received September 14, 2010)

1064-14-364 **Jaroslaw Wlodarczyk*** (wlodar@math.purdue.edu), 965 Onyx Street, West Lafayette, IN. *On resolution of singularities in positive characteristic.*

We discuss some aspects of extending the resolution algorithm in characteristic zero to characteristic p. In particular, we discuss increase of a classical invariant associated to so called hypersurfaces of maximal contact. (Received September 14, 2010)

1064-14-365 **Daniel Daigle*** (ddaigle@uottawa.ca), University of Ottawa, Department of mathematics, 585 King-Edward, Ottawa, Ontario K1N 6N5, Canada. *On factoring out the birational part of a morphism.*

Let us say that a morphism $f : \mathbb{A}^2 \to \mathbb{A}^1$ is *lean* if, for any factorization $\mathbb{A}^2 \xrightarrow{\beta} \mathbb{A}^2 \xrightarrow{f'} \mathbb{A}^1$ of f with β a birational morphism, β is actually an automorphism of $\mathbb{A}^2$. Then it is interesting to ask whether a given morphism $f : \mathbb{A}^2 \to \mathbb{A}^1$ can be factored as $\mathbb{A}^2 \xrightarrow{\beta} \mathbb{A}^2 \xrightarrow{f'} \mathbb{A}^1$ where β is birational and f' is lean. This question and variants of it are related to the notions of "good and bad field generators" and to the theory of birational morphisms $\mathbb{A}^2 \to \mathbb{A}^2$. We present some new results on birational endomorphisms of $\mathbb{A}^2$ with applications to the above question.

(Joint work with Pierrette Cassou-Noguès.) (Received September 14, 2010)

1064-14-368 **Harlan Kadish*** (hmkadish@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church St, Ann Arbor, MI 48109. *Counting Generating Invariants for Representations of Semisimple Groups.*

Although degree bounds for the generators of various invariant rings have been known for almost a century, little is said about the cardinality of minimal generating sets. Estimates of such would provide lower bounds for the complexity of algorithms that compute invariants. For a semisimple group G, choose an irreducible representation of highest weight λ, and consider the irreducible representations of highest weight $n\lambda$. As n goes to infinity, we show that the cardinality of a minimal set of generating invariants grows faster than any polynomial in n. When SL_2 acts on the binary forms of degree d, we show that the minimal set grows faster than any polynomial in d, and we provide combinatorial evidence that the growth is likely sub-exponential. (Received September 14, 2010)

15 ► Linear and multilinear algebra; matrix theory

1064-15-340 **Witold Kraskiewicz**, Institute of Mathematics UMK, 12/18 Chopin st., Torun, Poland, and **Jerzy Weyman*** (j.weyman@neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115. *Orbit closures in representations with finitely many orbits.*

Let L be a simple Lie algebra, and alpha in L a simple root. The root alpha defines a Z-grading on L, We are interested in the action of the adjoint group G_0 of a Lie algebra L_0 on the space L_1. Such representations are closely related to irreducible representations of simple Lie algebras with finitely many orbits. It is well known that the action of G_0 x C^* on L_1 has finitely many orbits. By using geometric invariant theory we calculate Hilbert polynomials of (normalizations) of orbit closures. In many cases we can deduce normality, Cohen–Macaulay and Gorenstein properties of the orbit closures. (Received September 14, 2010)

16 ► Associative rings and algebras

1064-16-297 **Milen Yakimov*** (yakimov@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Quantum Schubert cells.*

De Concini, Kac, and Procesi defined a family of subalgebras $U_q^w(g)$ of a quantized universal enveloping algebra $U_q(g)$ associated to the elements of the corresponding Weyl group W. They are deformations of universal enveloping algebras of nilpotent Lie algebras and can be interpreted as quantizations of coordinate rings of Schubert cells. We will describe explicitly all torus invariant prime ideals of the algebras $U_q^w(g)$, construct efficient generating sets, and describe the poset of those ideals. We will then apply these results to prove a conjecture of Goodearl and Lenagan on polynormal generating sets of torus invariant primes, prove that the spectrum of $U_q^w(g)$ is normally separated, and describe the dimensions of the strata of the Goodearl-Letzter stratification of $SpecU_q^w(g)$. We will furthermore use the above results to classify the torus invariant prime ideals of all quantum partial flag varieties. (Received September 13, 2010)

1064-16-356 **Ualbai Umirbaev*** (umirbaev@math.wayne.edu), 656 W Kirby, Detroit, MI 48202. *Universal enveloping algebras and universal derivations of Poisson algebras.*

Let k be an arbitrary field of characteristic 0. It is shown that for any $n \geq 1$ the universal enveloping algebras of the Poisson symplectic algebra $P_n(k)$ and the Weyl algebra $A_n(k)$ are isomorphic and the canonical isomorphism between them easily leads to the Moyal product. A basis of the universal enveloping algebra P^e of a free Poisson algebra $P = k\{x_1, \ldots, x_n\}$ is constructed and proved that the left dependency of a finite number of elements of P^e over P^e is algorithmically recognizable. We prove that if two elements of a free Poisson algebra do not generate a free two generated subalgebra then they commute. The Fox derivatives on free Poisson algebras are defined and it is proved that an analogue of the Jacobian Conjecture for two generated free Poisson algebras is equivalent to the two-dimensional classical Jacobian Conjecture. A new proof of the tameness of automorphisms of two generated free Poisson algebras is also given. (Received September 14, 2010)

17 ► Nonassociative rings and algebras

1064-17-48 **Alper Bulut*** (alper.bulut@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008. *On Properties of Topological Linear Loops.* Preliminary report.

Let H and K be a topological groups such that K is locally compact Hausdorff space and H has compact open topology such that $H \leq Aut(K)$. We may define a topological loop $\mathcal{L}$ by twisting the semi-direct product of H by K. We call $\mathcal{L}$ as a topological linear loop if $K = F^n$ and H is a closed topological subgroup of $GL(F, n)$. if F is real, complex or quaternion field we show that $\mathcal{L}$ is locally compact metric loop with inverse property which is Moufang if and only if it is a group, we compute its nucleus, and we discuss its right and left multiplication groups.
(Received August 21, 2010)

1064-17-141 **Julienne Dare Houck*** (julie.houck@wmich.edu), 724 W South St #1, Kalamazoo, MI 49007. *Quasigroup Factorization Theorems, a non-associative adventure.* Preliminary report.

If we study quasigroups categorically, then we need to ask what the morphisms should be. In this talk we will discuss the possible candidates for the morphisms in a quasigroup category: first that of J.D.H. Smith in

'Quasigroup homotopies, semisymmetrization, and reversible automata', then that suggested by A.A.Albert in 'Quasigroups I'. We will discuss the categories given by these sets of morphisms and their relationship to each other. We will also discover some interesting factorizations of homotopies hidden in Quasigroups I and discuss the factorization of homotopies given by J. D. H. Smith. (Received September 05, 2010)

1064-17-155 **Geoffrey M Dixon*** (gdixon@7stones.com), 103 Dover Rd, Durham, NH 03824. *Integral Octonions, Octonion XY-Product, and the Leech Lattice.*

The integral octonions arise from the octonion XY-product. A parallel is shown to exist with the quaternion Z-product. Connections to the laminated lattices, Λ_4, Λ_8, Λ_{16} and Λ_{24} (Leech), are developed. (Received September 06, 2010)

1064-17-170 **Andrew T. Wells*** (awells@ecok.edu), 1014B N. Highland Ave., Ada, OK 74820. *The Zorn vector matrix algebra over $\mathbb{Z}/4\mathbb{Z}$.*

This talk will summarize all of my current structural results for the Zorn vector matrix algebra over $\mathbb{Z}/4\mathbb{Z}$, particularly its loop of units and that loop's automorphism group. Said loop is strongly related to the smallest Paige loop and many of the connections apply in the same way to Zorn vector matrix algebras over $\mathbb{Z}/p^2\mathbb{Z}$ in general and these will be highlighted throughout. This talk is meant to complete the talks on this topic given at the Kalamazoo meeting and the Mile High Conference in Denver, but also stands on its own. (Received September 07, 2010)

1064-17-176 **Tevian Dray*** (tevian@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331. *A New Look at the Freudenthal-Tits Magic Square.* Preliminary report.

Freudenthal and Tits independently showed how to construct a Lie algebra from a pair of division algebras. The resulting magic square includes all of the exceptional Lie algebras except g_2, and does so precisely when one (or both) of the division algebras is the octonions.

The goal of this ongoing project is to provide a direct construction of the Lie groups in the magic square, based on Vinberg's symmetric construction of the corresponding Lie algebras. We are most interested in the "half-split" magic square, when one of the division algebras is split, and which includes some real forms of the exceptional Lie groups, such as $E_{6(-26)}$, which are of particular interest to particle physics.

It is well known that E_6 admits a representation in terms of 3×3 octonionic matrices. We first consider a simpler magic square, again of relevance to particle physics, which involves 2×2 matrices over tensor products of division algebras, and find that the corresponding Lie groups can all be represented as "$SU(2, \mathbb{K} \otimes \mathbb{K}')$". We then discuss our partial success in interpreting the Freudenthal-Tits magic square as "$SU(3, \mathbb{K} \otimes \mathbb{K}')$".

The author thanks John Huerta, Corinne Manogue, and Robert Wilson for discussions. (Received September 07, 2010)

1064-17-402 **John Huerta*** (huerta@math.ucr.edu) and **John C. Baez**, Department of Mathematics, University of California, Riverside. *Division algebra technology for supersymmetric physics.*

It is well-known, thanks to the work of Dray, Manogue and others, that the vectors and spinors in spacetimes of dimension 3, 4, 6 and 10 can all be constructed in a uniform way using the normed division algebras. I will show how to extend this construction to spacetimes one dimension higher: 4, 5, 7 and 11. I will then use these constructions to give proofs of certain spinor identities, which are crucial to the existence of superstring and supermembrane theories in these dimensions. (Received September 15, 2010)

1064-17-403 **Tomasz Kowalski*** (kowatomasz@gmail.com), Av. Professof Gama Pinto 2, Lisbon, Portugal. *Independent varieties of loops.*

We characterise joins of disjoint varieties $\mathcal{V}_1$, $\mathcal{V}_2$ of loops. The problem amounts to characterising independent varieties of loops. We obtain:

Theorem 1. *$\mathcal{V}_1$ and $\mathcal{V}_2$ are independent if and only if there exist unary terms $s(x)$ and $s'(x)$, satisfying*

(1) $\mathcal{V}_1 \models s(x) = x$, $s'(x) = s'(y) = e$,

(2) $\mathcal{V}_2 \models s(x) = s(y) = e$, $s'(x) = x$.

For varieties of power-associative loops with inverse property we can do better:

Theorem 2. *$\mathcal{V}_1$ and $\mathcal{V}_2$ are independent if and only if there is an integer ℓ such that $\mathcal{V}_1 \models x^\ell = e$ and $\mathcal{V}_2 \models x^{\ell-1} = e$. Moreover, if both $\mathcal{V}_1$ and $\mathcal{V}_2$ are nontrivial, then $\ell > 2$.*

Theorem 3. *The following are equivalent.*

(1) $\mathcal{V}$ *satisfies the identities* $x^{k(k-1)} = e$ *and* $(xy)^{1-k}(zu)^k = x^{1-k}z^k y^{1-k}u^k$ *for some* $k > 2$.

(2) $\mathcal{V} = \mathcal{V}_1 \times \mathcal{V}_2$, *for nontrivial independent varieties* $\mathcal{V}_1$ *and* $\mathcal{V}_2$.

(Received September 15, 2010)

18 ► Category theory; homological algebra

1064-18-369 **John Huerta*** (huerta@math.ucr.edu) and **John C. Baez**, Department of Mathematics, University of California, Riverside. *Supersymmetry, Lie n-algebras and division algebras.*

There is a relationship between normed division algebras and certain supersymmetric theories of physics which lies at the heart of the following pattern:

- The only normed division algebras are $\mathbb{R}$, $\mathbb{C}$, $\mathbb{H}$ and $\mathbb{O}$. They have dimensions $k = 1$, 2, 4 and 8.
- The classical superstring makes sense only in spacetimes of dimension $k + 2 = 3$, 4, 6 and 10.
- The classical super-2-brane makes sense only in spacetimes of dimension $k + 3 = 4$, 5, 7 and 11.

I will sketch how to use the normed division algebras to prove the spinor identities necessary for the existence of the classical superstring and 2-brane theories. Then I will describe how *exactly the same mathematics* implies the existence of certain higher structures, namely:

- In the superstring dimensions $k + 2 = 3$, 4, 6 and 10, we can use the normed division algebras to construct a Lie 2-superalgebra $\mathfrak{superstring}$ which extends the Poincaré Lie superalgebra in these dimensions.
- In the super-2-brane dimensions $k + 3 = 4$, 5, 7 and 11, we can use the normed division algebras to construct a Lie 3-superalgebra $\mathfrak{2\text{-}brane}$ which extends the Poincaré Lie superalgebra in these dimensions.

(Received September 14, 2010)

20 ► Group theory and generalizations

1064-20-6 **Kamal Aziziheris*** (kazizihe@math.kent.edu), Summit Street, Kent, OHIO 44242, Kent, OH 44242. *Determining Group Structure from the Sets of Character Degrees.* Preliminary report.

Let $\mathrm{cd}(G)$ be the set of degrees of the irreducible complex characters of a finite group G. In 1998, Lewis proved that if p, q, r, and s are distinct primes and $\mathrm{cd}(G) = 1, p, q, r, pq, pr$ or $\mathrm{cd}(G) = 1, p, q, r, s, pr, ps, qr, qs$, then G is the direct product of two normal non-abelian subgroups of G. We generalize Lewis' results by loosening the primeness hypothesis of $\mathrm{cd}(G)$. In particular, we work on the structure of finite solvable groups whose character degree sets are in the form $1, a, b, c, ab, ac$, where a, b, and c are pairwise coprime integers. (Received June 11, 2010)

1064-20-11 **Michael JJ Barry*** (mbarry@allegheny.edu), Department of Mathematics, Allegheny College, 520 N. Main, Meadville, PA 16335. *Decomposing Tensor Products and Exterior and Symmetric Squares.*

If K is a field of finite characteristic p and G a cyclic group of order $q = p^t$, we describe a new algorithm for decomposing tensor products of indecomposable KG-modules into a direct sum of indecomposable KG-modules. We use this algorithm to extend reciprocity results of Gow and Laffey relating the exterior and symmetric squares of indecomposable modules when p is odd. (Received July 15, 2010)

1064-20-12 **David H. Gluck*** (dgluck@math.wayne.edu), 656 W. Kirby St., Detroit, MI 48202. *Rational defect groups and 2-rational characters.*

Let D be a defect group of a 2-block B of a finite group G. We conjecture that if D is a rational group and $D' \leq Z(D)$, then the values of all irreducible characters in B lie in a cyclotomic field Q_m, for some odd integer m. We prove the conjecture when G is solvable or $|D|$=8. Examples show that the condition $D' \leq Z(D)$ cannot be relaxed. (Received July 22, 2010)

1064-20-14 **Luis Valero-Elizondo*** (valero@fismat.umich.mx), Edificio B, planta baja, Ciudad Universitaria, 58060 Morelia, Mich, Mexico, and **Alberto Gerardo Raggi-Cardenas**. *Minimal groups with isomorphic tables of marks.* Preliminary report.

The table of marks of a finite group is a square matrix with non-negative entries that provides a great deal of information about the group. With this matrix one can determine, for example, if the parent group is abelian (and in this case, one can also determine the isomorphism class of the group), and in general one can identify the order of the group, which are its cyclic subgroups, its derived subgroup, its Frattini subgroup, and other important invariants. Two non-isomorphic groups may have isomorphic tables of marks, and the smallest known example of pairs of groups with this property have order 96. In this paper we prove that for many integers $n < 96$, there are no non-isomorphic groups of order n with isomorphic tables of marks. (Received July 26, 2010)

1064-20-21 **Jonathan D.H. Smith*** (jdhsmith@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011-2064. *Linear hyperquasigroups and group representations.* Preliminary report.

The theory of quasigroups has a duality (left/right) symmetry, and linear quasigroups are equivalent to representations of 2-generated groups. Recently, the concept of a hyperquasigroup was introduced to provide a more symmetrical version of quasigroup theory, carrying a triality symmetry. In this talk, linear hyperquasigroups are shown to be equivalent to general group representations. (Received August 05, 2010)

1064-20-22 **J. D. Phillips*** (jophilli@nmu.edu), Department of Mathematics and Computer Scienc, 1401 Presque Isle, New Science Facility 1001, Marquette, MI 49855. *Moufang and extra elements.*

There are many possible ways to define both *Moufang element* and *extra element*. In this talk we analyze these possibilities and present what we believe are the most algebraically tractable definitions of both. (Received August 06, 2010)

1064-20-34 **Thomas Philip Wakefield*** (tpwakefield@ysu.edu), Department of Mathematics and Statistics, Youngstown State University, One University Plaza, Youngstown, OH 44555. *Results Concerning Huppert's Conjecture.*

In the late 1990s, Bertram Huppert conjectured that if G is a finite group and H a finite nonabelian simple group such that the sets of character degrees of G and H are the same, then $G \cong H \times A$, where A is an abelian group.

Huppert verified the conjecture for many nonabelian simple groups, including many of the sporadic simple groups. His method of proof relies upon a five step procedure which ultimately requires properties of the character degrees and maximal subgroups of the simple group in question. We will examine the verification of Huppert's Conjecture for the simple groups of Lie type of rank two, some of the simple groups of exceptional Lie type, and the remaining sporadic groups. (Received August 16, 2010)

1064-20-35 **Ronald Solomon*** (solomon@math.ohio-state.edu), Department of Mathematics, The Ohio State University, Columbus, OH 43210. *A recognition theorem for the generic simple groups.*

This is a report on joint work with Richard Lyons directed towards an identification of the alternating groups of degree at least 13 and (most of) the finite simple groups of Lie type of Lie rank at least 4, starting from data concerning the centralizer of a (semisimple) element of prime order and certain of its so-called neighbors. I will explain the role of this theorem in the general classification theorem for the finite simple groups, and I will describe some of the key ideas of the proof. (Received August 16, 2010)

1064-20-46 **I. Martin Isaacs*** (isaacs@math.wisc.edu), Math. Dept., Univ. of Wisconsin, 480 Lincoln Dr., Madison, WI 53706. *Bounding the order of a group with a large character degree.*

Let d be the degree of an irreducible character of a finite group G. Since d divides $|G|$ and $|G|/d \geq d$, we can write $|G| = d(d+e)$, where $e \geq 0$. If $e = 0$, then G is trivial, and if $e = 1$ then G is a 2-transitive Frobenius group, which can have arbitrarily large order. If $e > 1$, however, N. Snyder showed that showed that $|G| \leq ((2e)!)^2$.

We prove that $|G| \leq Be^6$ for some universal constant B. In fact, $B = 2$ is sufficient except perhaps when G has a unique minimal normal subgroup N, and N is nonabelian. In that case, our bound depends on some recent work of Larsen, Malle and Tiep on irreducible character degrees of simple groups. (Received August 20, 2010)

1064-20-49 **Julie Deserti*** (deserti@math.cnrs.fr). *Dynamical properties to solve a problem in group theory.*

We will give the description of the embeddings from $\mathrm{SL}(3,\mathbb{Z})$ into the Cremona group; the tools used for such a description come from group theory (presentation and structure of $\mathrm{SL}(3,\mathbb{Z})$) and from dynamical properties of birational maps. (Received August 22, 2010)

1064-20-51 **Javier Aramayona** and **Juan Souto*** (jsouto@umich.edu), Mathematics Department, University of Michigan, Ann Arbor, MI 48109. *Homomorphisms between mapping class groups.*

By analogy with Margulis's superrigidty, it is expected that every homomorphism $Map(X) \to Map(Y)$ between mapping class groups of surfaces X and Y of sufficiently large genus $g(X)$ and $g(Y)$ belongs to some to-be-determined list of obvious homomorphisms. We prove that this is indeed the case if $g(X) \geq 6$ and $g(Y) \leq 2g(X) - 1$. (Received August 22, 2010)

1064-20-62 **Gabriel Navarro** and **Pham Huu Tiep*** (tiep@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *Brauer's height zero conjecture for the 2-blocks of maximal defect.* Preliminary report.

Brauer's Height Zero Conjecture states that all irreducible complex characters in a p-block B of a finite group G have height zero if and only if the defect groups of B are abelian. We prove the conjecture for every 2-block of maximal defect. (Received August 25, 2010)

1064-20-73 **Mark L. Lewis** (lewis@math.kent.edu), Department of Mathematical Sciences, Kent State University, Kent, OH 44242, and **James B. Wilson*** (wilson@math.ohio-state.edu), Department of Mathematics, The Ohio State University, Columbus, OH 43210. *Distinguishing exponentially many non-isomorphic groups having no known isomorphism invariants.* Preliminary report.

For every integer n there is an integer d such that the Sylow p-subgroup of $\mathrm{GL}(3,p^d)$ has $p^{n^2/8-O(n)}$ pairwise non-isomorphic quotients of order p^n. Yet, two such quotients have in common many powerful isomorphism invariants. For instance, they have isomorphic character tables, all proper centralizers are elementary abelian of the same order, they are centrally indecomposable and of the same type, and the bulk of their automorphisms are identical. Nevertheless, there is a linear-time algorithm that decides when two such groups are isomorphic. (Received August 27, 2010)

1064-20-83 **Mark L. Lewis** and **Donald L. White*** (white@math.kent.edu), Department of Mathematical Sciences, Kent State University, Kent, OH 44242. *Nonsolvable groups with no prime dividing three character degrees.*

We consider nonsolvable finite groups G with the property that no prime divides at least three distinct character degrees of G. We first show that if $S \leqslant G \leqslant \mathrm{Aut}S$, where S is a nonabelian finite simple group, and no prime divides three degrees of G, then $S \cong \mathrm{PSL}_2(q)$ with $q \geqslant 4$. Moreover, in this case, no prime divides three degrees of G if and only if $G \cong \mathrm{PSL}_2(q)$, $G \cong \mathrm{PGL}_2(q)$, or q is a power of 2 or 3 and G is a semidirect product of $\mathrm{PSL}_2(q)$ with a certain cyclic group.

More generally, we give a characterization of nonsolvable groups with no prime dividing three degrees. Using this characterization, we conclude that any such group has at most 6 distinct character degrees, extending to the nonsolvable case the analogous earlier result of D. Benjamin for solvable groups. (Received August 30, 2010)

1064-20-87 **J Kyle Pula*** (jpula@du.edu), Department of Mathematics, University of Denver, 2360 S. Gaylord St, Denver, CO 80208. *Complete Mappings of Finite Moufang Loops.*

A complete mapping of a loop $(Q,\cdot)$ is a permutation π of Q such that the map $x \mapsto x\cdot\pi(x)$ is also a permutation. Over the past 50 years, a rich body of work has developed to sort out the necessary and sufficient conditions for existence of complete mappings of finite groups. We prove that these same conditions hold in several classes of finite Moufang loops and discuss the prospects for further extensions. (Received August 30, 2010)

1064-20-89 **Jenya Kirshtein*** (ykirshte@du.edu), 2360 S Gaylord St, Denver, CO 80208. *Multiplicative structures arising from Cayley-Dickson doubling process.*

Cayley-Dickson loop contains a closure of basis units of an algebra constructed by Cayley-Dickson doubling process (the first few examples of such algebras are complex numbers, quaternions, octonions, sedenions).
We will discuss properties of Cayley-Dickson loops, show that these loops are Hamiltonian and describe the structure of their automorphism groups. (Received August 31, 2010)

1064-20-105 **Hung Ngoc Nguyen*** (hungnguyen@uakron.edu), Dept. of Theoretical and Applied Math., The University of Akron, Akron, OH 44325. *Complex characters of small degrees of the orthogonal groups.*

The representations as well as characters of small degrees of finite groups of Lie type have proved to be very useful in various applications and the recent proof of the Ore conjecture is one example. Based on the Lusztig's classification of irreducible complex characters of finite groups of Lie type, we classify the irreducible complex characters of the orthogonal groups of degrees up to a good bound. (Received September 01, 2010)

1064-20-122 **Steven V Sam*** (ssam@math.mit.edu), 77 Massachusetts Avenue, Massachusetts Institute of Technology, Department of Mathematics, Cambridge, MA 02139. *Saturation theorems for the classical groups.*

Let G be either the symplectic or special orthogonal group defined over the complex numbers. Given dominant weights λ, μ, ν, let V_λ, V_μ, V_ν denote the simple modules with the corresponding highest weights. We prove that if the space of invariants $(V_{N\lambda} \otimes V_{N\mu} \otimes V_{N\nu})^G$ is nonzero for some positive integer N, then $(V_{2\lambda} \otimes V_{2\mu} \otimes V_{2\nu})^G$ is also nonzero. In this case, we say that 2 is a saturation factor for G. This was previously shown by Belkale-Kumar in the case of symplectic and odd orthogonal groups, and improves a result of Kapovich-Millson that 4 is a saturation factor for even orthogonal groups.

Our techniques involve the study of semi-invariants of representation varieties of some algebras of global dimension 2 related to symmetric quivers. The results in this direction extend some results of Derksen-Weyman on semi-invariants of quivers as well as some results of Schofield on generic representation theory. (Received September 02, 2010)

1064-20-132 **Jonathan I Hall*** (jhall@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Presentations of universal groups with triality.*

A group with triality that is universal, for a fixed Moufang loop and as the domain of homomorphisms, is typically given via presentation. We discuss the relationships among several of the presentations that have been considered in the past. (Received September 03, 2010)

1064-20-135 **Michael Aaron Geline*** (geline@math.niu.edu), Northern Illinois University, Department of Mathematics, Watson Hall, DeKalb, IL 60115. *Integral representations of defect groups, and irreducible character heights.*

Richard Brauer conjectured that the irreducible characters in a p-block of a finite group should all be of height zero if and only if the defect groups of the block are abelian. Reinhard Knörr found a relationship between this conjecture and the sources of the lattices (ie integral representations) affording the irreducible characters. In particular, he showed that if an abelian p-group possesses no lattices which simultaneously have rank divisible by p and satisfy a property he called virtual irreducibility, then all blocks of finite groups with this particular defect group would contain height zero characters only.

Unfortunately, lattices satisfying Knörr's conditions can be constructed quite easily. We will outline Knörr's work, give a construction of some "bad" lattices, and pose the question of how to go about proving Brauer's conjecture in view of their existence. (Received September 03, 2010)

1064-20-138 **Stephen M Gagola III*** (sgagola@bgsu.edu), Department of Mathematics, Bowling Green State University, Bowling Green, OH 43403. *Hall's Theorem for Moufang loops.*

In 1966, G. Glauberman proved the complete analogue of Hall's Theorem for Moufang loops of odd order. In this talk we show that Hall's Theorem holds for all finite Moufang loops. (Received September 04, 2010)

1064-20-142 **Kari Ragnarsson*** (kragnars@math.depaul.edu), 2320 N Kenmore Avenue, Chicago, IL 60614, and **Radu Stancu**. *Saturated fusion systems as idempotents in the double Burnside ring.*

A fusion system is an abstract model for the structure of a finite group when regarded locally at a prime p. Given a finite p-group S, a fusion system on S is a category whose objects are the subgroups of S and whose morphism sets satisfy certain axioms that make them look like they are induced by (sub)conjugation in a group G having S as Sylow subgroup. These axioms are rather complicated and in this talk I will present joint work with Radu Stancu in which we obtain a simplified model by showing that fusion systems on S are in bijective correspondence with idempotents in the double Burnside ring of S that satisfy a Frobenius reciprocity relation. The idempotent corresponding to a fusion system also has implications for the representation theory of that fusion system which I will discuss if time allows. (Received September 05, 2010)

1064-20-146 **Liudmila Sabinina*** (liudmila@uaem.mx), UAEM, Cuernavaca, Mexico, **Alexander Grishkov**, USP, Sao Paulo, Brazil, and **Peter Plaumann**, University of Erlangen, Erlangen, Germany. *The structure of free Moufang A-loops.*

We describe the structure of a free loop of rank n in the variety of Moufang A–loops as a subdirect product of a free group and a free commutative Moufang loop, both of rank n. (Received September 05, 2010)

1064-20-147 **Peter Plaumann*** (peter.plaumann@yahoo.com) and **Wolfgang Herfort**. *Boolean and Profinite Loops.*

We investigate boolean loops, i.e., compact totally disconnected loops. When such a loop K is describable by a *loop folder* (G, H, K) with G a profinite group, H a closed subgroup and K a closed transversal in G for H^g for every $g \in G$ and with G topologically generated by K, we provide suffient conditions for K being a *profinite* loop – the projective limit of finite loops. (Received September 05, 2010)

1064-20-157 **Petr Vojtěchovský*** (petr@math.du.edu), Department of Mathematics, University of Denver, 2360 S Gaylord St, Denver, CO 80208. *Searching for simple automorphic loops.*

A loop is said to be automorphic if all its inner mappings are automorphisms. Many deep structural results for groups remain valid for automorphic loops, particularly in the commutative case. Using the classification of primitite groups, we show that there are no simple automorphic loops of order less than 2500, excluding groups. This is joint work with Kenneth W. Johnson, Michael K. Kinyon and Gábor P. Nagy. (Received September 07, 2010)

1064-20-158 **Thomas Michael Keller*** (tk04@txstate.edu), Department of Mathematics, 601 University Drive, San Marcos, TX 78666, and **Yong Yang** (yy10@txstate.edu), Department of Mathematics, 601 University Drive, San Marcos, TX 78666. *Regular and p-regular orbits of solvable linear groups.*

Let G be a finite solvable group and V a finite faithful irreducible G-module. An element $v \in V$ is said to be in a regular orbit of G if $C_G(v) = 1$. For a prime number p, an element $v \in V$ is said to be in a p-regular orbit of G if $|C_G(v)|$ is not divisible by p. Clearly, if $v \in V$ is in a regular orbit of G, then it is in a p-regular orbit of G for any prime p. J. P. Zhang asked whether the converse of this statement is also true. We show that in general the answer to this question is no, but answer it in the affirmative for groups of odd order. (Received September 07, 2010)

1064-20-165 **Adriana Nenciu*** (anenciu@otterbein.edu), Department of Mathematics, Otterbein University, 1 South Grove Street, Westerville, OH 43081. *Character tables of 2–generator p–groups of class two.*

The 2–generator p–groups of class two have been recently classified and their conjugacy classes have been computed. In this talk I will discuss the irreducible characters and the character tables of 2–generator p–groups of class two. I will give necessary and sufficient conditions for two groups in this family to have isomorphic character tables. (Received September 07, 2010)

1064-20-173 **YONG YANG*** (yang@txstate.edu), Department of Mathematics, 601 University Drive, San Marcos, TX 78666. *Orbits of finite solvable linear groups.*

Suppose that a finite solvable group G acts faithfully, irreducibly and quasi-primitively on a finite vector space V. Then G has a uniquely determined normal subgroup E which is a direct product of extraspecial p-groups for various p. We denote $e = \sqrt{|E/\mathbf{Z}(E)|}$ (an invariant measuring the complexity of the group). We prove that when $e = 5, 6, 7$ or $e \geq 10$ and $e \neq 16$, G will have at least two regular orbits on V.

As an application of the orbit theorem, we settle a conjecture by Espuelas and Carlip. Suppose that G is a finite solvable group, V is a finite faithful G-module over a field of characteristic p and assume $O_p(G) = 1$. Let H be a nilpotent subgroup of G. Assume that H involves no wreath product $Z_r \wr Z_r$ for $r = 2$ or r a Mersenne prime, then H has at least one regular orbit on V.

Let G be a finite group and denote by $b(G) = \max\{\psi(1) \mid \psi \in Irr(G)\}$ the largest degree of an irreducible character of G. For solvable group, Gluck conjectures that $|G : \mathbf{F}(G)| \leq b(G)^2$. We prove Gluck's conjecture for all solvable groups with order not divisible by 3 as another application of the orbit theorem. (Received September 07, 2010)

1064-20-181 **John Maginnis** (maginnis@math.ksu.edu), Department of Mathematics, 137 Cardwell Hall, Manhattan, KS 66506, and **Silvia Onofrei*** (onofrei@math.ohio-state.edu), Department of Mathematics, 100 Mathematics Tower, 231 West 18th Avenue, Columbus, OH 43210. *On the vertices of indecomposable summands of certain Lefschetz modules.*

Let G be a finite group of parabolic characteristic p and assume that the centralizer of a noncentral p-element has a component which also has parabolic characteristic p. Consider the complex of p-centric and p-radical subgroups in G. I will discuss the nature of the fixed point sets under the action of p-subgroups of G. Next, I will explain how the properties of the reduced Lefschetz module associated to the complex of p-centric and p-radical subgroups in a component of the centralizer of a p-element of G, determine the behavior of the corresponding Lefschetz module in G. Based on this information the vertices of the indecomposable summands of the reduced Lefschetz module in G are determined. Applications to the sporadic simple groups will be presented in the end. (Received September 08, 2010)

1064-20-204 **kenneth W johnson*** (kwj1@psu.edu), Math Department, PSU Abington, 1600 Woodland Road, Abington, PA 19001. *On the existence of simple loops with two non-trivial conjugacy classes.* Preliminary report.

The Paige loop of order 120 has conjugacy classes of orders $63 = (2^3-1)(2^3+1)$ (containing elements of order 2) and $56 = (2^3-1)2^3$ (containing elements of order 3). The question of whether this loop is part of a series of simple loops $Q(n)$ or order $2^n(2^{n+1}-1)$ with exactly two non-trivial conjugacy classes of sizes $(2^n-1)2^n$ and $(2^n-1)(2^n+1)$ may be interesting to examine. There is no such $Q(2)$. This uses the GAP list of primitive groups and the Nagy program which constructs a loop transversal. For $n = 3$ the Paige loop is the only loop with such classes. If $Q(4)$ exists it has order $496 = 16.31$ and classes of orders 240 and 255. There are two primitive groups of degree 496 with suborbits of size 240 and 255.

It seems more likely that a loop would exist for $n = 5$ of order $32.63 = 2016$ with classes of order $31.32 = 992$ and $31.33 = 1023$. There are two primitive permutation groups of degree 2016 with suborbits of orders 992 and 1023, of orders $500275571482165248000 = 2^{30}.3^8.5^2.7^2.11.17.31$ and $1000551142964330496000 = 2^{31}.3^8.5^2.7^2.11.17.31$. (Received September 09, 2010)

1064-20-221 **Stephen M. Gagola, Jr*** (gagola@math.kent.edu), Department of Mathematics, Kent State University, Kent, OH 44242, and **Sezgin Sezer** (sezgin@cankaya.edu.tr), Ankara, Turkey. *Characters Inducing to Characters all having the same Degree.* Preliminary report.

Say that the pair (G,H) satisfies property (*) if H is a subgroup of G and every non-principal irreducible character of H induces to a sum of irreducible characters of G all having the same degree. It is easy to see that if (G,H) satisfies (*) then H either contains G' (commutator subgroup of G) or else is contained in G'. Moreover, if H contains G' then (G,H) always satisfies (*).

The case of interest then occurs when (G,H) satisfies (*) where H is properly included in G'. We are able to show, among other things, that H is necessarily solvable when its normal closure in G is proper in G'. (Received September 09, 2010)

1064-20-222 **Nathaniel Thiem***, Campus Box 395, Boulder, CO 80309, and **C R Vinroot**. *Explicit Shintani lifting from finite unitary groups to general linear groups.* Preliminary report.

Shintani lifting gives a mechanism for starting with irreducible characters of a finite algebraic group G defined over a field F, and obtaining irreducible characters in the algebraic group over some extension E of F. While the correspondence is well-known, it turns out to be difficult to actually compute these lifts, or even show that they exist in the first place. This talk describes a pleasing combinatorial construction for lifts from the finite unitary group to the finite general linear group, and some applications of this correspondence. (Received September 09, 2010)

1064-20-250 **Klaus Lux**, **Amanda Schaeffer** and **C. Ryan Vinroot*** (vinroot@math.wm.edu), Department of Mathematics, College of William and Mary, P. O. Box 8795, Williamsburg, VA 23187. *Strong reality properties of normalizers of parabolic subgroups in finite Coxeter groups.*

If W is a finite Coxeter group, it is a result of Carter that every element of W is a product of two involutions in W. Another result about a finite Coxeter group W is that all of its irreducible complex characters has Frobeinus-Schur indicator 1. We prove these results for the normalizer of any parabolic subgroup of W. That is, if W is a finite Coxeter group, P is a parabolic subgroup of W, and $G = N_W(P)$ is the normalizer of P in W, then we prove that every element of G is a product of two involutions in G, and every irreducible complex character of G has Frobenius-Schur indicator equal to 1. (Received September 10, 2010)

1064-20-263 **Anthony B Evans*** (anthony.evans@wright.edu), Dept. of Math. and Stat., Wright State Univ., Dayton, OH 45435. *The existence of strong complete mappings of finite groups.* Preliminary report.

A strong complete mapping of a group G is a bijection $\theta\colon G \to G$ for which both mappings $x \mapsto x\theta(x)$ and $x \mapsto x^{-1}\theta(x)$ are bijections.

A problem of interest is that of characterizing groups that admit strong complete mappings. We will study this problem with particular emphasis on finite abelian groups. (Received September 12, 2010)

1064-20-283 **Kevin Wortman*** (wortman@gmath.utah.edu), **Mladen Bestvina** and **Alex Eskin**. *Cohomology of arithmetic groups.*

I'll discuss that in some low dimensions, the cohomology groups of arithmetic subgroups of simple groups defined over global fields are finitely generated. (Received September 12, 2010)

1064-20-292 **Jeffrey M Riedl*** (riedl@uakron.edu), Department of Mathematics, 302 Buchtel Common, University of Akron, Akron, OH 44325-4002. *Duality for normal subgroups of wreath product p-groups.* Preliminary report.

Let B denote the direct product of n copies of the cyclic group of order m. For each subgroup N of B there is a natural way (related to the character theory of B) to define a particular subgroup of B that we denote as $N^{\perp}$. This map $N \mapsto N^{\perp}$ is inclusion-reversing and satisfies $|N| \cdot |N^{\perp}| = |B|$ and $(N^{\perp})^{\perp} = N$. Because of this last condition, we call $N^{\perp}$ the "dual" of N in B. For each group H that acts via automorphisms on B, the dual of every H-invariant subgroup of B is easily seen to be H-invariant.

Now fix a prime p and an integer $d \geq 2$. Taking $n = p^d$ and $m = p^2$, we may regard B as the base group for the regular wreath product group W of the cyclic group of order p^2 by the cyclic group of order p^d. Let $\mathcal{N}$ denote the set of all normal subgroups of W that are contained in B, and note that for each $N \in \mathcal{N}$ we have $N^{\perp} \in \mathcal{N}$. We have previously obtained a detailed description of all the members of the set $\mathcal{N}$. In this talk we present a result that describes in some detail how the dual map $N \mapsto N^{\perp}$ behaves on the set $\mathcal{N}$. (Received September 13, 2010)

1064-20-313 **Tim Bonner*** (tb25@txstate.edu), Department of Mathematics, Texas State University, 601 University Drive, San Marcos, TX 78666. *Normally serially monomial p-groups.*

We define a p-group, P, to be *normally serially monomial*, if the following holds. There exists a single normal series,

$$P = P_0 \geq P_1 \geq \ldots \geq P_{n-1} \geq P_n = 1_P,$$

such that $|P_{i-1}/P_i| = p$ for $i \in \{1, \ldots, n\}$, and for each $\chi \in \operatorname{Irr}(P)$, there exists P_j with $0 \leq j \leq n$ and $\lambda \in \operatorname{Irr}(P_j)$, such that λ is linear and $\lambda^P = \chi$. We investigate the character theoretic properties of such groups and the relation of the character degrees (and their multiplicities) to the group theoretic structure. Specifically, we show that for $i \in \{1, \ldots, n\}$,

$$\left|\left\{\chi \in \operatorname{Irr}(P) \mid \chi(1_P) = p^i\right\}\right| = \frac{\left[P_i : P_i'\right] - \left[P_i : P_{i-1}'\right]}{[P : P_i]}.$$

(Received September 13, 2010)

1064-20-318 **Oliver Ruff*** (oruff@kent.edu), Department of Mathematics, Kent State University at Stark, 6000 Frank Avenue NW, North Canton, OH 44720. *Centers of various cyclotomic algebras.*

The algebras collectively referred to here as *cyclotomic* arise in a variety of contexts as families of finite-dimensional quotients of a larger affine algebra. These families of quotients can often be interpreted as being indexed by weights in a way that exhibits deep connections with Lie theory. The most classical example is the degenerate affine Hecke algebra of type A, for which the group algebra of the symmetric group appears as the cyclotomic quotient associated with the highest weight of the natural representation of $\mathfrak{sl}_n$.

In this talk we will discuss algebraic techniques for identifying the centers of certain cyclotomic algebras, focusing on the degenerate and quantum cyclotomic Hecke algebras of type A and the cyclotomic Sergeev superalgebra: these include applications to the representation theory of – respectively – the symmetric group and its double cover. As time permits we will also discuss the analogous case of the degenerate cyclotomic Birman-Murakami-Wenzl algebra, which includes as a special case the classical Brauer algebra. (Received September 13, 2010)

1064-20-320 **Matvei Libine*** (mlibine@indiana.edu). *Quaternionic Analysis, Representation Theory and Physics.*

This is a joint work with Igor Frenkel.

I will describe our new developments of quaternionic analysis using representation theory of various real forms of the conformal group. We show that the counterparts of Cauchy and Poisson formulas solve the problem of separation of the discrete and continuous series for SL(2,R) and the imaginary Lobachevski space SL(2,C)/SL(2,R). We also obtain a surprising formula for the Plancherel measure on SL(2,R) in terms of the Poisson integral on the split quaternions.

Along the way we discover striking new connections between quaternionic analysis and mathematical physics. In particular, the quaternionic counterpart of the Cauchy formula for the second order pole are the Maxwell equations. We find a representation-theoretic meaning of the polarization of vacuum and one-loop Feynman integrals. Finally, we show that the massless singular functions of four-dimensional quantum field theory are nothing but the kernels of projectors onto the discrete and continuous series on the imaginary Lobachevski space.

The talk is based on two recent papers "Quaternionic Analysis, Representation Theory and Physics" (published in Adv in Math 2008) and "Split Quaternionic Analysis and Separation of the Series for SL(2,R) and SL(2,C)/SL(2,R)" (submitted). (Received September 13, 2010)

1064-20-330 **Darci L. Kracht*** (darci@math.kent.edu), Department of Mathematical Sciences, Kent State University, Kent, OH 44242. *Some subgroups of finite algebra groups.* Preliminary report.

An algebra group is a group of the form $1 + J$, where J is a finite-dimensional, nilpotent algebra over a field of prime characteristic. Properties of strong subgroups and normalizers of subgroups of finite algebra groups will be investigated. (Received September 13, 2010)

1064-20-370 **Michael Kinyon*** (mkinyon@du.edu), 2360 S Gaylord St, Denver, CO 80208. *Loops with abelian inner mapping groups: recent progress.*

In 2005, P. Csörgő settled in the negative the question of whether a loop with abelian inner mapping group must be nilpotent of class 2. Since then, many other counterexamples of class 3, now generally referred to as loops of Csörgő type, have been constructed. There are still interesting questions to be answered in this line of research, such as: (1) Does there exist a counterexample of class greater than 3? (2) Given a particular well-known variety of loops, does there exist a loop of Csörgő type in the variety or does every loop in the variety with abelian inner mapping group have class 2? In this talk, I will stick my neck out and give a detailed conjecture regarding question (1), and discuss recent progress in question (2). This is a combination of work with various people, including J.D. Phillips, Petr Vojtěchovský, Aleš Drápal and Robert Veroff. (Received September 14, 2010)

1064-20-374 **Mark B Greer*** (mgreer7@du.edu), 2360 S Gaylord St, Denver, CO 80208. *Constructions of Diassociative Loops.*

Moufang and Steiner loops are the most well-studied varieties diassociative loops. Moufang and Steiner loops are generalized by a variety called RIF loops. RIF and flexible C-loops are, in turn, generalized by ARIF loops, which are diassociative. We give constructions for RIF and ARIF loops analogous to the Chein construction for Moufang loops and the de Barros and Jurrians construction for RIF loops. We also show the stabilization of these two constructions at the RIF and ARIF levels. (Received September 14, 2010)

1064-20-384 **Clifton E Ealy*** (clifton.e.ealy@wmich.edu), Department of Mathematics, Western Michigan University, Kalamazoo, MI 49008-5152, and **Julia F Knight** and **Clifton F Ealy**. *On Computable Loops.* Preliminary report.

n this talk, we will study computable loops following M. Rabin's, Computable Algebra, General Theory and Theory of Computable Fields. We first consider the case, G is a finitely (recursively) generated computable group, and show that Inn(G), Rmlt(G) and Lmlt(G) are computable groups. If F is a finitely generated free group, we show that Inn(F), Rmlt(F) , Lmlt(F), and Mult(F) are computable. We give examples of computable loops. Finally, If L is a finitely generated free loop, we show that L, Rmlt(L), and Lmlt(F) are computable. (Received September 14, 2010)

1064-20-398 **Andrew Rajah*** (andy@cs.usm.my), School of Mathematical Sciences, Universiti Sains Malaysia, Penang, 11800 USM , Malaysia, and **Wing Loon Chee** (wlchee@ymail.com), School of Mathematical Sciences, Universiti Sains Malaysia, Penang, 11800 USM , Malaysia. *Moufang loops of odd order pq^4.* Preliminary report.

We have previously proven that all Moufang loops of order pq^3, where p and q are distinct odd primes, are associative if and only if p cannot divide $q - 1$. We now extend this result by proving that all Moufang loops

of order pq^4, where p and q are distinct odd primes with $p < q$ or $q > 3$, are associative if and only if p cannot divide $q - 1$. (Received September 14, 2010)

1064-20-407 **David Ben McReynolds***, 5734 S. University, Chicago, IL 60637. *Submanifold spectra of Riemannian manifolds.*

I will present some recent results on the relationship between the geometry of submanifolds of a manifold and the geometry of the manifold. This work is joint with Alan Reid and separately Amir Mohammadi. (Received September 15, 2010)

22 ► Topological groups, Lie groups

1064-22-2 **David Fisher***, 1310 East Hunter Avenue, Bloomington, IN 47401. *Coarse Geometry of Solvable Groups.*

I will describe recent progress on classifying groups up to quasi-isometry with emphasis on the case of solvable groups. A quasi-isometry is a map that is bilipschitz at large enough scales but that may distort small distances arbitrarily. To view finitely generated groups as metric spaces, it is natural to take quasi-isometries, rather than isometries, as morphisms. In the early 1980's Gromov initiated a program to classify groups up to quasi-isometry.

I will discuss recent progress on this program in joint work with Eskin, Peng and Whyte. A key ingredient is a notion of coarse differentiation, which allows us to take derivatives of quasi-isometries despite the fact that quasi-isometries need not be continuous. The other major ingredient is an understanding of the geometry of solvable groups. (Received September 13, 2010)

1064-22-88 **Amir Mohammadi*** (amirmo@math.uchicago.edu), Dept. of Mathematics 5734 S. University Ave., Chicago, IL 60637. *Inhomogeneous quadratic forms.*

We will address a joint work with G. Margulis on a quantitative version of the Oppenheim conjecture for inhomogeneous quadratic forms. This generalizes the previous works of Eskin, Margulis and Mozes in the homogeneous setting also the work of J. Marklof. (Received August 30, 2010)

1064-22-92 **Amir Mohammadi*** (amirmo@math.uchicago.edu), Dept. of Mathematics 5734 S. University Ave., Chicago, IL 60637. *Measure rigidity in positive characteristic.*

We will address recent developments on classifying measures which are invariant under various groups, in positive characteristic setting. Some applications will also be discussed. (Received August 31, 2010)

1064-22-153 **GOPAL PRASAD*** (gprasad@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Weakly commensurable arithmetic groups and isospectral locally symmetric spaces.*

I will speak on the recent joint work with Andrei S. Rapinchuk (a part of which has appeared in Publ.Math.IHES, #109(2009)) in which we have introduced the notion of weak commensurability of arithmetic (and, more generally, of Zariski-dense) subgroups of semi-simple Lie groups, and investigated when weak commensurability of arithmetic groups implies their commensurability. We apply our results to investigate isospectral and length commensurable locally symmetric spaces of simple Lie groups. (Received September 06, 2010)

1064-22-192 **Nimish A Shah*** (shah@math.osu.edu), The Ohio State Univ, Dept of Mathematics, 100 Math Tower, 231 W 18th Ave, Columbus, OH 43210, and **Hee Oh**. *Counting points and circles in orbits of geometrically finite hyperbolic groups.*

We extend some of the earlier results of Duke, Rudnick and Sarnak about counting points in large balls on discrete orbits of lattices acting linearly on vectors spaces, to the case of counting on orbits of geometrically finite hyperbolic groups. We also consider the problem of counting circles in various circle packing invariant under actions of Kleinian groups. (Received September 08, 2010)

1064-22-260 **Sasha Lyapina*** (sashulya@hku.hk), Department of Mathematics, The University of Hong Kong, Pokfulam, Hong Kong. *The Variety of Lagrangian Subalgebras of Real Semisimple Lie algebras.*

We study the geometry of the variety of Lagrangian subalgebras of a real semisimple Lie algebra. The main motivation for studying Lagrangian subalgebras is through the connection with the theory of Poisson Lie groups. The analogous problem for complex semisimple Lie algebras was studied by Evens and Lu.

We describe the irreducible components of the real algebraic variety of Lagrangian subalgebras. In particular, some irreducible components are compactifications of the corresponding real adjoint group. (Received September 12, 2010)

1064-22-329 **Mark A Colarusso*** (mark.colarusso.1@ulaval.ca), Pavillon Alexandre-Vachon, 1045 Av. de la Médecine, Québec, QC G1V 0A6, Canada, and **Sam Evens** (sevens@nd.edu), 255 Hurley Hall, University of Notre Dame, Notre Dame, IN 46556. *Linear and nonlinear Gelfand-Zeitlin integrable systems.*

In the 1950's, Gelfand and Zeitlin produced a basis for finite dimensional highest weight representations for certain classical groups. Thirty years later, Guillemin and Sternberg produced an integrable system on conjugacy classes of Hermitian matrices that is related to the Gelfand-Zeitlin basis for the unitary group via geometric quantization. In 2006, Kostant and Wallach developed a complexified version of the Gelfand-Zeitlin integrable system on the full Lie algebra of $n \times n$ complex matrices, $\mathfrak{gl}(n)$.

The Gelfand-Zeitlin system on $\mathfrak{gl}(n)$ integrates to a holomorphic action of a group $A \cong \mathbb{C}^{\frac{n(n-1)}{2}}$ on $\mathfrak{gl}(n)$ whose orbits of dimension $\frac{n(n-1)}{2}$ are Lagrangian submanifolds of regular adjoint orbits. In this talk, we will describe the orbit structure of the group A and discuss the algebraic integrability of the Gelfand-Zeitlin system. We will also discuss the construction of a nonlinear version of the Gelfand-Zeitlin system for the dual Poisson Lie group $GL(n, \mathbb{C})^*$. (Received September 13, 2010)

26 ► Real functions

1064-26-168 **Uri Bader** and **Alex Furman*** (furman@math.uic.edu), MSCS (m/c 249), 851 S. Morgan Str, Chicago, IL 60607, and **Roman Sauer**. *Latice envelops.*

We consider the following general problem:

given a countable group Γ determine all its lattice envelops, that is all locally compact second countable groups G that admit a lattice embedding $\Gamma < G$.

We describe the solution to this problem for a wide class of groups Γ. (Received September 07, 2010)

30 ► Functions of a complex variable

1064-30-28 **Yusuke Okuyama** (okuyama@kit.ac.jp), Department of Comprehensive Sciences, Graduate School of Science and Technology, Kyoto Institute of Technology, Kyoto, 606-8585, Japan, and **Malgorzata Stawiska*** (stawiska@ku.edu), Department of Mathematics, University of Kansas, 1460 Jayhawk Blvd., Lawrence, KS 66045. *Potential theory and a characterization of polynomials in complex dynamics.*

We obtain a measure theoretical characterization of polynomials among rational functions on $\mathbb{P}^1$, which generalizes a theorem of Lopes. Our proof applies both classical and dynamically weighted potential theory. (Received August 11, 2010)

1064-30-358 **David Dumas*** (ddumas@math.uic.edu). *Skinning maps are finite-to-one.*

We show that Thurston's skinning map for a hyperbolic manifold with totally geodesic boundary has finite fibers. The proof uses the theory of complex projective structures, a stratified Kähler metric on the space of measured geodesic laminations, and analytic geometry in the $\mathrm{SL}(2, \mathbb{C})$ character variety of a surface group. (Received September 14, 2010)

32 ► Several complex variables and analytic spaces

1064-32-7 **Jonsson Mattias*** (mattiasj@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109-1043, and **Sébastien Boucksom** and **Charles Favre**. *Non-archimedean pluripotential theory.*

Pluripotential theory is the study of plurisubharmonic functions on complex manifolds, and has recently seen important applications to complex geometry. For various reasons it is natural to develop pluripotential theory also in a non-archimedean context. I will explain what this means and how to solve the Monge-Ampere equation in a particular setting. (Received July 03, 2010)

1064-32-81 **Cinzia Bisi*** (bsicnz@unife.it), Via Machiavelli 35, 44121 Ferrara, Italy, and **Francesco Polizzi**. *On Proper Polynomial Maps of $\mathbb{C}^n$.*

Two proper polynomial maps $f_1, f_2 \colon \mathbb{C}^2 \longrightarrow \mathbb{C}^2$ are said to be *equivalent* if there exist $\Phi_1, \Phi_2 \in \mathrm{Aut}(\mathbb{C}^2)$ such that $f_2 = \Phi_2 \circ f_1 \circ \Phi_1$. We investigate proper polynomial maps of topological degree $d \geq 2$ up to equivalence. Under the further assumption that the maps are Galois coverings we also provide the complete description of

equivalence classes. This widely extends previous results obtained by Lamy in the case $d = 2$. Moreover we partially work up these results in higher dimension. (Received August 30, 2010)

1064-32-91 **David B. Massey*** (d.massey@neu.edu), Dept. of Mathematics, Northeastern University, Boston, MA 02115. *Relative Vanishing Cycles and Distinguished Bases.* Preliminary report.

There are two inequivalent notions of relative nearby cycles for a complex analytic function; while the two collections of cohomology modules are isomorphic, the monodromy acts very differently on them. The two corresponding notions of relative vanishing cycles have non-isomorphic cohomology modules, and yet are related in a way that is easy to visualize via polar curves and discriminant loci. This relationship, when combined with properties of distinguished bases for vanishing cycles, leads to nontrivial bounds on the Betti numbers of Milnor fibers, and to restrictions on the types of perverse sheaves that can be vanishing cycles of intersection cohomology complexes. (Received August 31, 2010)

1064-32-244 **Liz Raquel Vivas*** (lvivas@math.purdue.edu), 150 N. University Street, West Lafayette, IN 47901. *Basins of Attraction.*

Let f be a germ in $\mathbb{C}^2$ tangent to the identity and D an open connected region attracted to the origin under the action of f. We show that f is conjugate to a translation in D, under certain conditions on f. (Received September 10, 2010)

1064-32-343 **Florian Bertrand** (bertrand@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706, **Xianghong Gong***, Department of Mathematics, University of Wisconsin-Madison, Madison, WI 53706, and **Jean-Pierre Rosay** (gong@math.wisc.edu), Department of Mathematics, University of Wisconsin-Madison, Madison, WI 53706. *Common boundary values of holomorphic functions for two-sided complex structures.*

Let Ω_1, Ω_2 be two disjoint open sets in $\mathbf{C}^n$ whose boundaries share a smooth real hypersurface M as relatively open subsets. Assume that Ω_i is equipped with a complex structure J^i which is smooth up to M. Assume that the operator norm $\|J^2 - J^1\|$ is less than 2 on M. Let f be a continuous function on the union of Ω_1, Ω_2, M. If f is holomorphic with respect to both structures in the open sets, then f must be smooth on the union of Ω_1 with M. Although the result as stated is far more meaningful for integrable structures, our methods make it much more natural to deal with the general almost complex structures without the integrability condition. The result is therefore proved in the framework of almost complex structures. (Received September 14, 2010)

35 ► Partial differential equations

1064-35-3 **Jared Wunsch*** (jwunsch@math.northwestern.edu), Northwestern University, Department of Mathematics, 2033 Sheridan Road, Evanston, IL 60208-2730. *Geometry and analysis of diffracted waves.*

The principle of geometric optics tells us that in some regimes, solutions to the Schrödinger or the wave equation are closely related to the motion of classical particles. This relationship, which explains the physical principle of wave-particle duality, gives rise to a very effective method for producing approximate solutions to the wave and Schrödinger equations (often known as the "WKB method").

When the geometry of particle trajectories is affected by singularities, however, the structure of solutions to the wave equation becomes intriguingly complex, and the relationship to classical mechanics becomes subtle. For instance, to see how a wave behaves on a domain or manifold with corners, we need to allow one geodesic ray striking a corner to explode into a whole family of rays leaving it. This is the phenomenon of *diffraction.* I will discuss some recent progress in understanding the relationship of particle and wave motion in such singular settings. (Received September 07, 2010)

1064-35-17 **Thomas Bellsky*** (bellskyt@msu.edu). *Nonlinear Asymptotic Stability for Semi-Strong Pulse Interactions.*

This paper shows the nonlinear asymptotic stability in the semi-strong regime of two-pulse interactions in a general activator-inhibitor setting. We prove results for a general non-linearity that includes more specific equations such as the Gierer-Meinhardt model. In the semi-strong regime, the pulse amplitudes and speeds change as the pulse separation evolves on algebraically slow time scales. We use renormalization group techniques to prove the nonlinear asymptotic stability. We achieve this by examining the eigenvalue problem and proving semigroup estimates. (Received July 26, 2010)

1064-35-23 **Dmitry E. Pelinovsky*** (dmpeli@math.mcmaster.ca), 1280 Main Street West, Hamilton, ON L8S 4K1, Canada. *Wave breaking in the dispersive wave equations.*

The Ostrovsky-Hunter equation governs evolution of shallow water waves on a rotating fluid in the limit of small high-frequency dispersion. Sufficient conditions for the wave breaking in the Ostrovsky-Hunter equation are found both on an infinite line and in a periodic domain. Using the method of characteristics, we also specify the blow-up rate at which the waves break. Numerical illustrations of the finite-time wave breaking are given in a periodic domain. This is a joint work with Yue Liu (University of Texas at Arlington) and Anton Sakovich (McMaster University). (Received August 06, 2010)

1064-35-27 **Jaime Angulo Pava*** (angulo@ime.usp.br), Rua do Matao 1010, Cidade Universitaria, Department of Mathematics, IME-USP, Sao paulo, 05508-090, Brazil, and **Gustavo Ponce** (ponce@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, Santa Barbara, CA 93106. *The Cubic Schrodinger Equation with a Periodic Delta Interaction: Existence and Stability of Periodic Standing Wave.* Preliminary report.

We study the existence and stability of periodic standing waves for the cubic nonlinear Schrödinger equation with a point defect determined by the periodic Dirac distribution at the origin. We obtain that in the case of a attractive defect the periodic-peak traveling waves with a profile of dnoidal type are stable in H^1_{per} with respect to perturbations which have the same period as the wave itself. In the case of a repulsive defect, the dnoidal-peak waves are stable in the subspace of even functions of H^1_{per} and unstable in H^1_{per}. Also, we obtain that in the case of a repulsive defect the periodic-peak traveling waves with a profile of cnoidal type are unstable in H^1_{per}. Global well-posedness is obtained in H^1_{per}. This is a joint work with Gustavo Ponce - UCSB, USA. (Received August 09, 2010)

1064-35-47 **Hans G Othmer*** (othmer@math.umn.edu), School of Mathematics, 270A Vincent Hall, University of Minnesota 206 Church St SE, Minneapolis, MN 55449. *Robustness of Pattern Formation in Development.*

Pattern formation during development of an adult organism requires precise spatio-temporal control of gene expression, which involves complex signal transduction and control networks. Spatio-temporal signaling is often described by systems of reaction-diffusion equations, and in this talk we will address the question of robustness of such complex systems under various disturbances, and in particular, analyze mechanisms for scale-invariant pattern formation. (Received August 21, 2010)

1064-35-59 **Chaoqun Huang*** (huang65@math.purdue.edu), west lafayette, IN 47906, and **Aaron Nung Kwan Yip**. *Singular Perturbation and Bifurcation of Transition Layers in Inhomogeneous Media.*

The connection between diffused and sharp interfacial problems in the variational setting are well developed to a large extent by means of Gamma-convergence and also purely analytical techniques such as asymptotic expansion and implicit function theorem. They work well for the case of global minimizers and non-degenerate critical points. This talk will describe some results which extend the above framework to analyze the degenerate case, in particular the bifurcation of diffused interface and its connection to sharp interfacial limit. Examples of such bifurcation phenomenon using bistable nonlinearity together with parameter dependent spatial inhomogeneity are provided. The appearance and disappearance of the multiple transition layer is analyzed as well. We treat the unbalanced and balanced settings separately due to the fact that in higher dimensions the motion law of the sharp interfaces differs significantly, as one is an algebraic equation while the other is a PDE involving the mean curvature of the interface. This is joint work with Aaron Yip. (Received September 10, 2010)

1064-35-76 **Steve Zelditch*** (zelditch@math.northwestern.edu), Department of Mathematics, Northwestern University, Evanston, IL 60208. *Volumes of nodal sets of Laplace eigenfunctions.*

We present some new results on volumes of nodal sets. We also present new and simple proofs of some old results. (Received August 29, 2010)

1064-35-143 **Mimi Dai*** (mdai@slugmail.ucsc.edu), 828 Koshland Way, Santa Cruz, CA 95064, and **Jie Qing** and **Maria Schonbek**. *Norm inflation for incompressible magneto-hydrodynamic system in $\dot{B}^{-1,\infty}_{\infty}$.*

Based on the construction of Bourgain and Pavlović for Navier-Stokes equations, we demonstrate that the solutions to the Cauchy problem for the three dimensional incompressible magneto-hydrodynamics (MHD) system can develop different types of norm inflation in $\dot{B}^{-1,\infty}_{\infty}$. Particularly the magnetic field can develop norm inflation in short time even when the velocity remains small and vice verse. Another interesting case is that, even

with zero initial velocity, the velocity field can develop norm inflation in short time. We constructed different initial data to obtain these results using plane waves. (Received September 05, 2010)

1064-35-151 **Dan Andrei Geba*** (dangeba@math.rochester.edu), Department of Mathematics, University of Rochester, 806 Hylan Building, Rochester, NY 14627. *Energy arguments for a semilinear Skyrme model.*

In this talk, we discuss a couple of results obtained for a semilinear modification of the wave map problem in 3+1 dimensions, that appears naturally in nuclear physics. Precisely, we show that the energy associated to the equation does not concentrate and, as a result, the map remains continuous at the first possible singularity. This is joint work with Sarada Rajeev. (Received September 06, 2010)

1064-35-154 **Frederic Y. M. Wan*** (fwan@uci.edu), Department of Mathematics, University of California, Irvine, Irvine, CA 92697-3875. *An Efficient Method for Linear PDE with Stochastic Input*.*

Linear PDE are often models for biological phenomena, e.g., Rall's equivalent cylinder model for cable neurons and morphogen gradients with low receptor occupancy. For linear models with random excitations, the solution is given by a Green's function representation. Statistical properties (mean, correlations, higher order moments) can be determined from the corresponding measures of the input by the expectation of combinations of the Green's function representation. In practice, Green's functions are often not available analytically. To compute the needed Green's function numerically and then evaluate the multiple integrals involved in the desired statistics require excessive computing. Equally serious is the huge storage requirement for a function of four or more variables that may be impractical for the needed accuracy. While Monte Carlo simulations are possible, determining statistical properties of interest by solving directly some deterministic problems in PDE (for which there is a large body of knowledge on their numerical solutions) is desirable. This paper 1) develops such a method; 2) applies it to several problems in biology, and 3) shows how the method takes advantage of recent efficient algorithms that reduce storage requirements by orders of magnitude. (Received September 06, 2010)

1064-35-156 **Erik Wahlén*** (erik.wahlen@math.lu.se), Centre for Mathematical Sciences, Lund University, PO Box 118, 22100 Lund, Sweden. *A variational method for quasilinear dispersive equations.*

A classical method for finding solitary waves of semilinear dispersive equations is to minimise the energy subject to the constraint of fixed momentum. I will describe how this method can be extended to some cases which are quasilinear in the sense that the quadratic part of the energy doesn't control the super-quadratic part. As a result of the method one also obtains the stability of the set of minimisers. The stability is however conditional on the well-posedness theory for the evolution problem. I will explain the method in detail for a model equation and then describe a few applications to water waves with surface tension.

This is joint work with Mats Ehrnström and Mark Groves. (Received September 07, 2010)

1064-35-169 **Temam M Roger*** (temam@indiana.edu), 831 East Third St, Rawles Hall, Bloomington, IN 47405. *The Zakharov-Kuznetsov (KZ) equation.*

The Zakharov-Kuznetsov equation is an n-dimensional extension of the Korteweg-de Vries (KdV) equation, appearing in the propagation of waves in a plasma under some conditions.

In a joint work with Jean-Claude Saut, we proved the existence and regularity of solutions in space dimension two and three, and the uniqueness in space dimension two. The proofs dealing with a nonlinear hyperbolic initial and boundary value problem require an involved analysis of the associated linear semi-group, and specific techniques for the nonlinear case.

The stochastic version of this equation is currently under investigation as well as some control problems, the later in collaboration with Gustavo Perla Menzala and Lionel Rosier. (Received September 07, 2010)

1064-35-191 **Anna L Mazzucato*** (alm24@psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802, and **Victor Nistor** and **Wen Cheng**. *Explicit parametrices for time-dependent Fokker-Planck equations.*

We construct explicit approximate Green's functions of certain time-dependent Fokker-Planck equations in terms of Dyson series, Taylor expansions, and exact commutator formulas. The algorithm gives an approximate solution that is accurate to arbitrary order in time in the short-time limit. (Received September 08, 2010)

1064-35-195 **Gerson Petronilho*** (gersonpetro@gmail.com), Universidade Federal de São Carlos, Departamento de Matemática, São Carlos, SP 13565-905, Brazil, **Alex Himonas** (himonas.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556, and **Heather Hannah** (hhannah@ecok.edu), Department of Mathematics, East Central University, Ada, OK 74820. *Regularity properties for solutions to the gKdV equation.*

Our main goal is to discuss the following question: Does the solution to the Cauchy problem for the gKdV equation preserve Gevrey initial data regularity? We start by showing that this is not true in the time variable by constructing a Gevrey function of order $\sigma > 1$, $\varphi \in G^{\sigma}(\mathbb{T})$, such that the solution to the correspondent Cauchy problem for the gKdV is not G^{σ} in the time variable. However, it always belongs to $G^{3\sigma}$ near the origin. Finally, we will give some ideas for how to use multilinear estimates in order to prove that the solution to the Cauchy problem for gKdV preserves Gevrey regularity in the space variable. (Received September 08, 2010)

1064-35-196 **Curtis A Holliman*** (chollima@nd.edu), Department of Mathematics, 255 Hurley, Notre Dame, IN 46556, and **Alex Himonas** (himonas.1@nd.edu), Department of Mathematics, 255 Hurley, Notre Dame, IN 46556. *On the Well-Posedness of the Degasperis-Procesi Equation.*

We will demonstrate, in both the periodic and the non-periodic cases, that the data-to-solution map for the Degasperis-Procesi (DP) equation is not a uniformly continuous map on bounded subsets of Sobolev spaces with exponent greater than 3/2. This result shows that continuous dependence on initial data of solutions to the this equation is sharp. The proof relies on well-posedness results, approximate solutions, and conserved quantities for the DP equation. (Received September 08, 2010)

1064-35-205 **Feride Tiglay*** (ftiglay@fields.utoronto.ca), Fields Institute, 222 College Street, 2nd Floor, Toronto, ON M5T 3J1, Canada. *The periodic Cauchy problem for Novikov's equation.*

We study the periodic Cauchy problem for an integrable equation with cubic nonlinearities introduced by V. Novikov. Like the Camassa-Holm and Degasperis-Procesi equations, Novikov's equation has Lax pair representations and admits peakon solutions, but it has nonlinear terms that are cubic, rather than quadratic. We show the local well-posedness of the problem in Sobolev spaces and existence and uniqueness of solutions for all time using orbit invariants. Furthermore we prove a Cauchy-Kowalevski type theorem for this equation, that establishes the existence and uniqueness of real analytic solutions. (Received September 09, 2010)

1064-35-245 **David Karapetyan*** (dkarapet@nd.edu). *On the Cauchy Problem for the Hyperelastic Rod Equation.*

We discuss recent well-posedness and ill-posedness results in Sobolev spaces in both the periodic and non-periodic cases. (Received September 10, 2010)

1064-35-252 **Peter Topalov*** (p.topalov@neu.edu), Boston, and **Thomas Kappeler** (thomas.kappeler@math.uzh.ch) and **Beat Schaad** (beat.schaad@math.uzh.ch). *On the asymptotics of the Birkhoff map.* Preliminary report.

I will discuss the proof of a conjecture of Kuksin and Perelman saying that the Birkhoff map of the KdV equation transforming it globally into normal form, is a 1-smoothing perturbation of its linearization at zero. (Received September 11, 2010)

1064-35-253 **Aynur Bulut*** (abulut@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712-0257. *The defocusing cubic energy-supercritical nonlinear wave equation in dimensions six and higher.*

In this talk, we will consider the defocusing energy-supercritical nonlinear wave equation in dimensions six and higher. We show that any solution satisfying an a priori bound in a critical norm must be global and scatter. (Received September 11, 2010)

1064-35-266 **Mats Ehrnstrom*** (mats.ehrnstrom@ifam.uni-hannover.de), Leibniz University, Institute for Applied Mathematics, Welfengarten 1, 301 67 Hanover, Germany. *Steady water waves with multiple critical layers.*

We construct steady periodic water waves with multiple critical layers. The mathematical setting is that of the two-dimensional Euler equations with a free top boundary; the corresponding waves are rotational gravity waves propagating over water of finite depth. Using bifurcation from a particular class of eigenvalues, some of which are not simple, we find i) waves with arbitrarily many critical layers and a single crest in each period, and ii)

waves with several crests and troughs in each period. The talk is based on joint work with J. Escher, G. Villari and E. Wahlén. (Received September 12, 2010)

1064-35-278 **Qingshan Chen*** (qchen3@fsu.edu), Department of Scientific Computing, Florida State University, Tallahassee, FL 32306, and **Max Gunzburger**. *Partial viscosity models for geophysical fluid dynamics.*

In this talk we discuss a set of models with partial viscosity, i.e., viscous dissipations applied to the higher modes only. Applications of such models include the modeling of geophysical turbulence, and the modeling of long-range coherent structures in the ocean and atmosphere. We establish the global well-posedness of the primitive equations with partial Δ viscosity. Employing a different technique, we also establish the well-posedness of the primitive equations with partial Δ^m viscosity; a constraint on the exponent m applies. (Received September 12, 2010)

1064-35-285 **Jerry L Bona*** (bona@math.uic.edu), Univeristy of Illinois at Chicago, Department of Math, Statistics & Computer Sci, 851 S. Morgan Street MC 249, Chicago, IL 60607. *Rogue Waves in Optical Cables.*

Originally an oceanographic phenomenon, rogue waves have recently been found in optical cables. We examine a model for the propagation of light pulses in fiber optics cables with an eye to determining the genesis of such large amplitude waves. (Received September 13, 2010)

1064-35-286 **Mihaela Ignatova*** (ignatova@usc.edu) and **Igor Kukavica** (kukavica@usc.edu). *Strong Unique Continuation Problem and Complexity of Solutions to Higher Order Elliptic and Parabolic Partial Differential Equations with Gevrey Coefficients.*

We study the strong unique continuation properties for 1D higher order parabolic partial differential equations with coefficients in the Gevrey class G^σ for $\sigma > 1$. We establish a quantitative estimate of unique continuation (observability estimate) under a very mild assumption on the Gevrey exponents σ; that is, $1 \leq \sigma \leq 1+\eta$, where η is a universal constant. As an application, we give a new upper bound on the number of zeros for the solutions with a polynomial dependence on the coefficients. We also address the strong unique continuation problem for elliptic and parabolic partial differential equations in higher dimensions. In particular, we cover the case of the Navier-Stokes equation with non-analytic Gevrey forcing. (Received September 13, 2010)

1064-35-291 **Giovanna Guidoboni*** (gguidobo@math.iupui.edu), 402 N. Blackford St., LD270, Indianapolis, IN 46202-3267. *Arterial blood flow modeling.*

We will present some new ideas related to the mathematical and numerical modeling of arterial blood flow. We will discuss the derivation of simplified closed effective models and the design of stable loosely-coupled numerical algorithms. 1) Standard one-dimensional models are obtained by averaging on the vessel cross-section, under the assumptions of cylindrical geometry and axially symmetric flows. One-dimensional models are not closed: an ad hoc velocity profile needs to be prescribed to obtain a closed system. In this talk we will present a different approach based on multi-scale analysis which leads to reduced effective models that do not need any ad hoc closure assumption. 2) Loosely-coupled algorithms are based on the idea of splitting the original problem in a sequence of simpler sub-problems. Stability of loosely-coupled schemes is a critical issue in blood-flow applications due to highly nonlinear interfacial coupling effects. In this talk, we will present a new type of loosely-coupled algorithm which does not suffer from the interfacial instabilities. The algorithm has been named kinematically-coupled scheme because of the crucial role played by the kinematic condition at the fluid-solid interface. (Received September 13, 2010)

1064-35-310 **Susan Friedlander*** (susanfri@usc.edu), USC Dept of Math KAP 108, 3620 S Vermont Avenue, Los Angeles, CA 90089, and **Vlad Vicol**. *Active Scalar Equations and a Geodynamo Model.*

We discuss an advection-diffusion equation that has been proposed by Keith Moffatt as a model for magneto-geostrophic turbulence in the Earth's fluid core. This nonlinear PDE (MG) has certain similarities to the critical surface quasi-geostrophic equation (SQG), however it also has some crucial differences. Inspired by the recent work of Caffarelli and Vasseur for the SQG equation, we use De Giorgi techniques to prove Holder continuity for a class of active scalar equations where the divergence free velocity is the derivative of a singular integral operator. This general result implies that solutions to the MG equation are smooth globally in time. (Received September 13, 2010)

1064-35-323 **H Chen*** (hchen1@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152, and **Jerry L Bona** and **Ohannes A Karakashian**. *Solitary waves and stability of some systems of nonlinear, dispersive equations.*

Considered here are coupled systems of equations

$$\begin{cases} u_t + u_{xxx} + P(u,v)_x = 0 \\ v_t + v_{xxx} + Q(u,v)_x = 0 \end{cases}$$

of KdV-type, where $u = u(x,t)$ and $v = v(x,t)$ for $x \in \mathbb{R}, t \geq 0$, $P(u,v)$ and $Q(u,v)$ are quadratic polynomial of variables u and v, more precisely, $P(u,v) = Au^2 + Buv + Cv^2$ and $Q(u,v) = Du^2 + Euv + Fv^2$, in which $A, B, \cdots, F$ are real number constants. For most of such P and Q, we show that the system posses hyperbolic square solitary-wave solutions, some of them are orbitally stable. (Received September 15, 2010)

1064-35-327 **Radu Dascaliuc*** (rd5bw@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22904, and **Zoran Grujic**. *On energy cascade and flux locality in physical scales of the 3D Navier-Stokes Equations.*

Rigorous estimates for the total flux in $\mathbb{R}^3$ are obtained in the framework of suitable solutions of the 3D Navier-Stokes equations. The bounds are used to establish a condition, involving Taylor length scale and the size of the domain, sufficient for existence of the inertial range and the energy cascade in decaying turbulence (zero driving force, non-increasing global energy). Several manifestations of the locality of the flux under this condition are obtained. All the scales involved are actual physical scale and no regularity or homogeneity/scaling assumptions are made. (Received September 13, 2010)

1064-35-339 **Jinhae Park*** (jhpark2003@gmail.com), PDE and Functional Analysis Research Center, Seoul National University, Seoul, 151-742, South Korea. *Existence of solutions to Boundary Value Problems for Smectic Liquid Crystals.*

In this talk, we consider the Chen-Lubensky energy describing smectic liquid crystals. One of difficulties of studying this energy is to prove existence of minimizers due to boundary conditions. We show that the Chen-Lubensky energy functional achieves its minimum in appropriate classes of functions with physically relevant boundary conditions. This is a joint work with P. Bauman and D. Phillips. (Received September 15, 2010)

1064-35-351 **Katarzyna Saxton** and **Ralph Saxton*** (rsaxton@uno.edu), Department of Mathematics, University of New Orleans, New Orleans, LA 70148. *Damping in Hyperbolic Equations with Parabolic Degeneracy.*

We examine the effect of damping on a nonstrictly hyperbolic 2 x 2 system. It is shown that the growth of singularities is not restricted as in the strictly hyperbolic case where dissipation can be strong enough to preserve the smoothness of small solutions globally in time. Here, irrespective of the stabilizing properties of damping, solutions are found to break down in finite time on a line where two eigenvalues coincide in state space. (Received September 14, 2010)

1064-35-353 **Jerry L. Bona*** (bona@math.uic.edu), Dept. Mathematics, Statistics & Computer Sci., University of Illinois at Chicago, 851 S. Morgan Street MC 249, Chicago, IL 60607. *Coupled Systems of Nonlinear, Dispersive Wave Equations.*

The lecture will focus on questions of local and global well-posedness for a certain class of coupled systems of nonlinear, dispersive wave equations. Joint work with Jonathan Cohen and Gang Wang (DePaul University) and with Hongqiu Chen (University of Memphis) and Ohannes Karakashian (University of Tennessee, Knoxville) will be featured in the discussion. (Received September 14, 2010)

1064-35-373 **Greg J Reid*** (reid@uwo.ca), Department of Applied Mathematics, University of Western Ontario, London, Ontario N6A 5B7, Canada. *Compatible discretization of constrained partial differential equations.* Preliminary report.

Many fundamental systems of partial differential equations of applied mathematics arise in constrained form. For example the equations of elasticity and Maxwell's equations in media are of this type. We discuss the application of Wu's fast prolongation method to such systems, and its interaction with discretization operators. To make the method algorithmic, we employ the methods of numerical algebraic geometry. (Received September 14, 2010)

1064-35-391 **Honghu Liu*** (liu40@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405, **M. Taylan Sengul**, Department of Mathematics, Indiana University, Bloomington, IN 47405, and **Shouhong Wang**, Department of Mathematics, Indiana University, Bloomington, IN 47405. *Phase transition of binary systems.* Preliminary report.

In this talk, we shall present a unified approach to study the thermal induced phase transition in binary systems, such as mixtures of two fluids, diblock copolymer melts, etc. Three different but related models are examined: the Cahn-Hilliard type equation with a nonlocal term in the corresponding energy functional, phase-field model, and the Cahn-Hilliard equation with the Onsager mobility. The main technical tool is the dynamic transition theory developed recently by Ma and Wang. Also, the study leads to some interesting physical conclusions. (Received September 14, 2010)

1064-35-392 **Igor Kukavica*** (kukavica@usc.edu), **Amjad Tuffaha** and **Mohammed Ziane**. *Local well-posedness for a fluid-structure interaction model.*

In the talk we address a system of PDEs describing an interaction between an incompressible fluid and an elastic body. The fluid motion is modeled by the Navier-Stokes equations while an elastic body evolves according to an elasticity equation. On the common boundary, the velocities and stresses are matched. We discuss available results on local well-posedness and prove new existence and uniqueness results with the velocity and displacement belonging to low regularity spaces. (Received September 14, 2010)

1064-35-397 **Alexey Cheskidov*** (acheskid@math.uic.edu), University of Illinois at Chicago, 322 Science and Engineering Offices, 851 S. Morgan Street, Chicago, IL 60607. *Beale-Kato-Majda type regularity criteria for the 3D Navier-Stokes equations.*

We present a new Beale-Kato-Majda type regularity criterion for the 3D Navier-Stokes equations. This criterion is weaker than every Ladyzhenskaya-Prodi-Serrin condition. (Received September 14, 2010)

1064-35-401 **Stephen C. Preston*** (stephen.preston@colorado.edu), Department of Mathematics, UCB 395, Boulder, CO 80309-0395. *The motion and geometry of whips and chains.*

A whip can be modeled as an inextensible string, which satisfies the wave equation $\eta_{tt} = \partial_s(\sigma\eta_s)$, where t is time and s is the length along the string. Inextensibility is expressed as the constraint $|\eta_s| \equiv 1$, which requires the tension σ to satisfy the ODE $\sigma_{ss} - |\eta_{ss}|^2\sigma = -|\eta_{st}|^2$. The tension is zero at the free end, making the problem nonlocal and degenerate.

I will discuss local well-posedness of this problem in weighted Sobolev spaces given by seminorms $\|\eta\|_{k,k}^2 = \int_0^1 s^k|\partial_s^k\eta|^2\,ds$: we prove that if the initial data is bounded in norms up to $k = 4$, then we have local existence and uniqueness. The solutions are constructed as limits of a discrete problem, the motion of a chain, which essentially reduces to the method of lines. I will also discuss some preliminary results and numerics of blowup.

Finally I will discuss the geometric context of this problem, showing that it can formally be viewed as a geodesic equation on an infinite-dimensional manifold. I will describe the properties of the exponential map and the sectional curvature of this manifold. (Received September 15, 2010)

37 ► Dynamical systems and ergodic theory

1064-37-1 **Laura DeMarco*** (demarco@math.uic.edu). *Polynomial dynamics, critical points and moduli.*

A classification of the dynamics of polynomials in one complex variable has remained elusive, even when considering only the simpler "structurally stable" polynomials. I will discuss progress towards this classification and a corresponding decomposition of the moduli space of polynomials. This is joint work with Kevin Pilgrim. (Received September 14, 2010)

1064-37-16 **Jiu Ding*** (jiudin@gmail.com), Department of Mathematics, 118 College Dr., Box 5045, Hattiesburg, MS 39406. *Incorporating Dynamical Geometry and Fractals into Undergraduate Mathematics Education.* Preliminary report.

In high school geometry, students study the Euclidean geometry in a traditional way. Recently the author and his co-authors published a series of papers related to dynamical geometry and fractals, in which various modern concepts of discrete dynamical systems and chaos are incorporated with the classic plane geometry. Some undergraduate-level mathematics, such as linear algebra and calculus, are used together with a basic theory of nonnegative matrices and iterated function systems for the study of iterated triangles and polygons, and their eventual regular and chaotic behaviors.

In this talk, some practice and proposal on teaching dynamical geometry and related modern mathematics topics at the undergraduate level will be presented. The study of modern mathematical ideas and methods in the undergraduate education will enable upper-level students to gain more insights about intrinsic relationships of seemingly different mathematical subjects and enjoy marvelous applications of one area into another one, and thus make them well-prepared in the 21st century for their future professional development. (Received July 26, 2010)

1064-37-40 **Jan-Li Lin*** (janlin@indiana.edu), Rawles Hall, 831 East 3rd St, Bloomington, IN 47403. *Degree growth of monomial maps.*

Given a rational monomial map $f_A : \mathbf{P}^n \to \mathbf{P}^n$ associated to an integer matrix A, it is well known that the first dynamical degree is equal to the spectral radius of A. Thus, it is natural to ask further about the asymptotic behavior of the degree sequence $\{\deg(f_A^k)\}_{k=1}^{\infty}$. We obtain several precise estimates of the degree sequences of monomial maps on $\mathbf{P}^n$. (Received August 18, 2010)

1064-37-45 **Elizabeth Aino Rebecka Wulcan*** (wulcan@umich.edu), Dept of Mathematics, University of Michigan, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Degree growth of monomial maps.*

I will discuss a joint work with Charles Favre, in which we study the degree growth in arbitrary codimension of monomial maps on complex projective space. We compute the dynamical degrees of a monomial map in terms of the eigenvalues of the corresponding matrix of exponents. (Received August 20, 2010)

1064-37-50 **Jayadev S Athreya*** (jathreya@illinois.edu), Department of Mathematics, University of Illinois, 1409 W. Green Street, Urbana, IL 61801. *Cusp Excursions for Horocycles.* Preliminary report.

Let $G = SL(2, \mathbb{R})$ and $\Gamma \subset G$ be a non-uniform lattice. It is well known that any non-closed horocycle orbit on G/Γ is equidistributed. We describe a method to distinguish the behavior of horocycles based on cusp excursions. Some results are based on joint work with G. Margulis. (Received August 22, 2010)

1064-37-55 **Eric Bedford*** (bedford@indiana.edu), Department of Mathematics, Rawles Hall, Bloomington, IN 47405. *Semi-parabolic implosion in C^2.* Preliminary report.

We consider a complex Hénon map f on C^2, and we suppose that the origin is fixed, and the multipliers there are 1 and $a < 1$. Specifically we suppose that $f(x, y) = (x + x^2 + \cdots, ay + \cdots)$, where "$\cdots$" indicates higher order terms in both x and y. We consider a 1-parameter familly of Hénon maps $f_\epsilon(x, y) = (x+\epsilon^2+x^2+\cdots_\epsilon, ay+\cdots_\epsilon)$, where $\epsilon \to 0$ is an essentially real parameter. We will show that the Julia sets for f_ϵ exhibit an "implosion" behavior which is analogous to the parabolic implosion that occurs in complex dimension 1.

This is joint work with John Smillie and Tetsuo Ueda. (Received August 23, 2010)

1064-37-80 **Hexi Ye*** (hye4@uic.edu), 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607. *The Schwarzian derivative of a polynomial and its iterates.*

We consider the Schwarzian derivative S_f of a complex polynomial f and its iterates. We would like to understand the sequence S_{f^n} as n tends to infinity and any limiting behavior. If we view S_{f^n} as a quadratic differential, it defines a flat geometric structure on a subset of the plane. We will study the limiting geometric object. (Received September 01, 2010)

1064-37-90 **Rodrigo Parra*** (rparra@umich.edu). *Equidistribution to the Green current.*

In this talk I will breafly describe the problem of equidistribution in holomorphic dynamics on the complex projective space. More precisely, given a holomorphic map $f : \mathbb{P}^k \to \mathbb{P}^k$ of algebraic degree $d \geq 2$ then there exist a positive closed (1,1)-current T_f which is invariant (i.e. $f^*T_f = dT_f$) and supported on the Julia set of f. We will try to address the following question: If S is a positive closed (1,1)-current of mass 1, when does the sequence $d^{-n}(f^n)^*S$ converges to T_f? This is always true if S is smooth and is always false if S is the current of integration of a totally invariant hypersurface. This question has been answered in dimensions $k = 1$ and 2 and I will describe some partial results recently obtained in higher dimensions. (Received August 31, 2010)

1064-37-106 **Magnus Aspenberg** and **Rodrigo A Perez*** (rperez@math.iupui.edu), LD-224R, 401 N. Blackford St., Indianapolis, IN 46074. *Control of cancellations, growth, and Catalan numbers.*

We study a recursion that generates real sequences depending on a parameter x. For negative x the growth of the sequence is very difficult to estimate due to canceling terms. We reduce the study of the recursion to a problem about a family of integral operators, and prove that for every parameter value except -1, the growth

of the sequence is factorial. In the combinatorial part of the proof we show that when $x = -1$ the resulting recurrence yields the sequence of alternating Catalan numbers. (Received September 01, 2010)

1064-37-130 **Eric Bedford** and **Kyounghee Kim*** (kim@math.fsu.edu), Department of Mathematics, FSU, Tallahassee, FL 32306. *Linear Fractional Recurrences as Birational maps of 3-space: Periodicities and pseudo-automorphisms of positive entropy.*

The family of 3-step linear fractional recurrences

$$z_{n+3} = \frac{\alpha_0 + \alpha_1 z_n \alpha_2 z_{n+1} + \alpha_3 z_{n+2}}{\beta_0 + \beta_1 z_n + \beta_2 z_{n+1} + \beta_3 z_{n+2}}, \quad \alpha_i, \beta_i \in \mathbf{C} \qquad (*)$$

induces the family of birational maps $f_{\alpha,\beta}$ on $\mathbf{P}^3$ with three exceptional hypersurfaces. We say that a birational map is a pseudo-automorphism if neither a forward map nor a backward map has an exceptional hypersurface. By examining orbits of exceptional hypersurfaces, we see that if $f_{\alpha,\beta}$ is pseudo-automorphism, then f is equivalent to the case $\alpha_2 \neq 0, \beta_1 = \alpha_3 = 1, \beta_2 = \beta_3 = 0$.

We show that the only possible periods for periodic recurrences of the form $(*)$ are 8 and 12. We also discuss a one parameter family of Pseudo-Automorphisms $f_{\alpha,\beta}$ with an exponential degree growth rate. This is a joint work with Eric Bedford. (Received September 03, 2010)

1064-37-174 **Tuyen Trung Truong*** (truongt@indiana.edu), Tuyen Trung Truong, Department of mathematics, Indiana University, Bloomington, IN 47405. *Degree growth of birational maps related to matrix inversions.*

For $q \geq 3$, let $\mathcal{M}_q$ denote the space of $q \times q$ matrices with coefficients in $\mathbb{C}$, and let $\mathbb{P}(\mathcal{M}_q)$ denote its projectivization. For a matrix $x = (x_{ij})_{1 \leq i,j \leq q}$, we consider two maps. One is the Hadamard inverse $J(x) = (x_{ij}^{-1})$ which takes the reciprocal of each entry of the matrix, and the other is the matrix inverse $I(x) = (x_{ij})^{-1}$. Define $K = I \circ J$. This map was introduced by some mathematical physicists to study some problems in statistical mechanics.

In this talk, I will show that the degree complexity $\delta(K)$ of K is equal to the largest modulus of the roots of the polynomial $\lambda^2 - (q^2 - 4q + 2)\lambda + 1$ (this is joint work with Professor Eric Bedford.). Time allowed, I will show that this number is also the degree complexity of the restriction of the map K to the space of symmetric matrices. These results were conjectured by Angles d'Auriac, Maillard and Viallet. (Received September 07, 2010)

1064-37-187 **Roland Roeder*** (rroeder@math.iupui.edu), IUPUI Department of Mathematical Sciences, LD Building, Room 224Q, 402 North Blackford Street, Indianapolis, IN 46202. *A fundamental dichotomy for Fatou components of polynomial skew products.*

We consider polynomial maps of the form $f(z, w) = (p(z), q(z, w))$ that extend as holomorphic maps of $\mathbb{CP}^2$. In an early paper on such maps, Mattias Jonnson introduced a notion of connectedness that is analogous to connectivity for the Julia set of a polynomial map in one-variable. We prove the following "Fundamental Dichotomy": if f is an Axiom-A polynomial skew product, and f is connected, then every Fatou component of f is homeomorphic to an open ball; otherwise, some Fatou component of f has infinitely generated first homology. (Received September 08, 2010)

1064-37-208 **Suzanne Hruska*** (shruska@uwm.edu), University of Wisconsin Milwaukee, PO Box 413, Milwaukee, WI 53201, and **Rodrigo Perez** and **John Smillie**. *Multivalued Dynamical Systems and Iterated Monodromy Groups.* Preliminary report.

This paper represents an effort to attune V. Nekrashevych's theory of iterated monodromy groups (IMGs) with Ishii and Smillie's notion of multivalued dynamical systems (MDS). The analogies are particularly striking in reference to expanding systems. We expect that the resulting dictionary will help and encourage the assimilation by the dynamics community of the rich algebraic language of IMGs. The connections will be illustrated with concrete examples of expanding maps, arising from holomorphic maps which are expanding on their Julia sets. (Received September 09, 2010)

1064-37-232 **Kevin M. Pilgrim*** (pilgrim@indiana.edu), Dept. Math., Rawles Hall, Indiana University, Bloomington, IN 47405, and **Laura DeMarco** (demarco@math.uic.edu), Dept. of Math., Stat., and Comp. Sci., University of Illinois at Chicago, 851 S. Morgan St. (MC 249), Chicago, IL 60607-7045. *Critical heights on the moduli space of polynomials.*

Motivated by the problem of classifying topological conjugacy classes of generic polynomials in the shift locus, we study the map $\mathcal{MP}_d \to [0, \infty)^{d-1}$ which sends a polynomial to the escape rates of its critical points. (Received September 10, 2010)

1064-37-235 **Kevin M. Pilgrim*** (pilgrim@indiana.edu), Dept. Math., Rawles Hall, Indiana University, Bloomington, IN 47405. *Heights, modular correspondences, and complex dynamics.* Preliminary report.

Let $f : \mathbb{P}^1\mathbb{C} \to \mathbb{P}^1\mathbb{C}$ be a rational function of degree $d \geq 2$ for which the post-critical set $P_f = \{f^n(c) : f'(c) = 0, n > 0\}$ has four points. The moduli space of configurations of four labelled points in $\mathbb{P}^1\mathbb{C}$ is naturally $\mathcal{M} = \mathbb{H}/\mathbb{P}\Gamma(2)$, where $\mathbb{H} = \{\tau \in \mathbb{C} : \mathrm{Im}(\tau) > 0\}$. Associated to f is a finite correspondence on $\mathcal{M}$ with a distinguished fixed-point. This correspondence lifts under the universal covering $\mathbb{H} \to \mathcal{M}$ to a map $\sigma_f : \mathbb{H} \to \mathbb{H}$ with a unique fixed-point. In turn, the map σ_f extends to

$$\overline{\sigma}_f : \mathbb{H} \cup \{\mathbb{Q} \cup \{1/0\}\} \to \mathbb{H} \cup \{\mathbb{Q} \cup \{1/0\}\}.$$

Group-theoretic and analytic techniques imply that in many cases, $\overline{\sigma}_f$ has finitely many periodic cycles. Explicit examples suggest that arithmetic considerations might yield additional insights. (Received September 10, 2010)

1064-37-248 **Alex Eskin*** (eskin@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 S. University Ave, Chicago, IL 60637. *Invariant and stationary measures for the SL(2,R) action on moduli space.*

We discuss some results on the classification of invariant measures for the SL(2,R) action. We also give a classification of the stationary measures in genus 2. This is joint work with Maryam Mirzakhani. (Received September 14, 2010)

1064-37-267 **Steven Broad*** (sbroad@saintmarys.edu), 343 Madeleva Hall, Saint Mary's College, Notre Dame, IN 46556. *Index formulas for Loewner vector fields.*

We prove a geometric index formula which produces a "defect" term for a conjecture of Charles Loewner about the index of vector fields of the form $\partial_{\bar{z}}^n f$ with isolated zeros for functions $f : \mathbb{C} \to \mathbb{R}$. A recent result of F. Xavier allows the index of such vector fields to be computed in terms of the set of eigenvalues of the Hessian of f in the case $n = 2$. Our result extends this formula to all $n \geq 2$. The Loewner conjecture has a deep connection to the Carathéodory conjecture which states that a smooth, convex embedding of the 2-sphere into $\mathbb{R}$ has at least two umbilics. (Received September 12, 2010)

1064-37-385 **Shawn C Shadden*** (sshadden@gmail.com), 10 W 32nd St, E1-243, Chicago, IL 60616. *Invariant manifolds and blood flow.* Preliminary report.

Numerous biological and clinically-relevant processes are regulated by the topological transport structure of blood flow. This is especially the case in large vessels where flow is often transiently turbulent. Precise characterization of flow conditions in such domains is widely-important yet very challenging. Significant progress has been made recently by combining imaged-based modeling techniques with computational dynamical systems methods, which we will discuss in this talk. More recently, we have been investigating the relationship between invariant manifolds and their potential biomechanical influence towards blood clotting. Specifically, platelet activation (a precursor for clotting) is strongly influenced by shear stress. Since most platelets are contained in the flow domain, it is important to consider stresses acting on platelets as they are advected. We will discuss recent work investigating the relationships between cumulative stress and invariant manifolds. (Received September 14, 2010)

1064-37-395 **Ning Ju*** (ningju@math.okstate.edu), 401 Mathematical Sciences, OSU, Stillwater, OK 74078. *Attractor Dimension Estimates for 2D Boussinesque System with Low Fractional Dissipation.*

2D Boussinesque equations make up an important system modeling geophysical fluid motions. Mathematically, this system for incompressible fluid flows is an interesting one possessing some of the essential properties of the well know Navier-Stokes equations, while at the same time reflecting its own special geophysical properties. In the talk, the long time dynamical behavier, especially dimension estimates for the attractor of the solutions of this system with low fractional dissipation will be disccussed in details. (Received September 14, 2010)

46 ► Functional analysis

1064-46-396 **Krzysztof Jarosz*** (kjarosz@siue.edu), Department of Mathematics & Statistics, Southern Illinois University, Edwardsville, IL 62026. *Real, Complex, and Quaternion Uniform Algebras.*

A uniform algebra A is a Banach algebra such that $\left\|f^2\right\| = \|f\|^2$, for all $f \in A$. We show that any such algebra is isometrically isomorphic with a subalgebra of $C_{\mathbb{H}}(X)$ - the algebra of all continuous functions defined on a compact set X and taking values in the field $\mathbb{H}$ of quaternions. Furthermore any such algebra is a sum of a commutative complex uniform algebra and $C_{\mathbb{H}}(X_1)$ for certain subset X_1 of X. (Received September 14, 2010)

49 ► Calculus of variations and optimal control; optimization

1064-49-379 **Henry C. Wente*** (hwente@math.utoledo.edu), Department of Mathematics, University of Toledo, 2801 Bancroft Street, Toledo, OH 43606. *Exotic Capillary Tubes.*

In contrast to the standard capillary tube, an exotic capillary tube is a rotationally symmetric tube of variable cross section which if positioned correctly in a vesel of fluid possesses a continuum of equilibrium configurations. The controlling variables are the capillary constant and the contact angle. Lowering the tube slightly from its natural position causes the tube to completely fill up while raising the tube slightly forces the tube to drain out. Other surprising consequences follow. We will also discuss possible applications. (Received September 14, 2010)

51 ► Geometry

1064-51-24 **Benjamin Schmidt*** (schmidt@math.msu.edu). *Spherical Rank Rigidity.* Preliminary report.

Let M denote a complete Riemannian manifold with $sec \geq 1$. The manifold M has positive spherical rank if along every complete geodesic in M there is a parallel normal vector field making extremal curvature one with the geodesic. The compact rank one symmetric spaces (and their quotients) give examples of manifolds with $sec \geq 1$ and positive spherical rank. It is unknown whether these are all examples. I'll discuss work in progress with R. Shankar and R. Spatzier concerning this problem. (Received August 08, 2010)

1064-51-25 **Benjamin Schmidt*** (schmidt@math.msu.edu). *Positively curved manifolds with large conjugate radius.*

Let M denote a complete simply-connected Riemannian manifold with $sec \geq 1$. I'll discuss three rigidity theorems characterizing the compact rank one symmetric spaces that follow from the following injectivity radius estimate: if the conjugate radius of M is at least $\pi/2$, then the injectivity and conjugate radii of M coincide. (Received August 08, 2010)

1064-51-53 **Irine Peng*** (ipeng@indiana.edu). *Quasi-isometric rigidities of nilpotent-by-cyclic groups.*

Following the work of Farb and Mosher who gave a compete quasi-isometric classifications of abelian-by-cyclic groups that are finitely presented and non-polycyclic, we show a similar rigidity phenomenon holds for a class of irreducible nilpotent-by-cyclic groups. (Received August 23, 2010)

1064-51-65 **Martha P. Dussan Angulo*** (dussan@ime.usp.br), Departamento de Matematica IME - USP, Rua do Matao 1010, Cidade Universitaria, Sao Paulo, 05508-090, Brazil. *Bjorling problem for timelike surfaces in the Lorentz-Minkowski space.*

We solve the Björling problem for timelike surfaces in the Lorentz-Minkowski space through a split-complex representation formula obtained for this kind of surface. Our approach uses the split-complex numbers and natural split-holomorphic extensions. As applications, we show that the minimal timelike surfaces of revolution as well as minimal ruled timelike surfaces can be characterized as solutions of certain adequate Björling problems in the Lorentz-Minkowski space. (Received August 25, 2010)

1064-51-70 **Irine Peng*** (ipeng@indiana.edu). *Assouad-Nagata dimension of Lie groups.*

The Assouad-Nagata dimension was introduced by Assouad inspired from the ideas of Nagata. Metric spaces of finite Assouad-Nagata dimension satisfy interesting geometric properties. For example they admit quasisymmetric embeddings into the product of finitely many trees and have nice Lipschitz extension properties. Here we prove that the Assouad-Nagata dimension of a connected Lie group G (with finitely many components) equipped with a left-invariant Riemannian metric coincides with the topological dimension of G/C where C is a maximal compact subgroup. (Received August 26, 2010)

1064-51-167 **Dennis Glenn Collins*** (d_collins_pr@hotmail.com), 1519 S. State Rd. 119, Apt. 2, Winamac, IN 46996-8550. *Continuous Symmetry of the Wedge and Other Shapes.*

For increments of 15 or 30 degrees, there is given, in a table and graph, calculated values of the continuous symmetry of the wedge shape (1/2 unit length each arm of the wedge), basically the hands of a clock, according to the author's definition of discrete and continuous symmetry. A typical program to calculate the value .8109

at 45 degrees is added. Also, as example, the continuous symmetry of the "plus sign" shape (1/2 unit each line) is approximated as .967. (Received September 07, 2010)

1064-51-309 **Andrew A Cooper*** (andrew.a.cooper@gmail.com), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Singular time of the mean curvature flow.*

At the first singular time of a compact mean curvature flow of general codimension, the contraction of the second fundamental form with the mean curvature vector blows up. (Received September 13, 2010)

1064-51-324 **Marianty Ionel*** (mionel@utnet.utoledo.edu), Toledo, OH , and **Maung Min-Oo**. *Calibrated Submanifolds in the Deformed G2-conifold.*

We will describe a class of cohomogeneity one co-associative submanifolds in the spin bundle over the 3-sphere, endowed with the complete G2-holonomy metric constructed by Bryant and Salamon. This is joint work with M. Min-Oo. (Received September 13, 2010)

53 ► Differential geometry

1064-53-20 **Oscar M Perdomo*** (perdomoosm@ccsu.edu). *Hypersurfaces of Space forms with constant m^{th} curvature.*

In this talk we explain the construction of all hypersurfaces with two principal curvatures and with constant m^{th}-curvature in Spheres, Hyperbolic spaces, Euclidean spaces, Minkowski spaces, Anti de Sitter spaces, de Sitter spaces and in general in any semi-riemannian space form. This construction allows us to decide when the hypersurface is embedded and when it admits the cyclic group Z_k in their group of isometries, it also allows us to decide, for any positive integer k, what values H_m can be achieved as the m^{th}-curvature of a hypersurface with two principal curvature that contains the group Z_k in its group of isometries. (Received August 02, 2010)

1064-53-30 **Igor Zelenko*** (zelenko@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Comparison theorems for number of conjugate points along sub-Riemannian extremals.* Preliminary report.

The classical Rauch comparison theorem in Riemannian geometry provides the estimation of the number of conjugate points along Riemannian geodesics in terms of bounds for the sectional curvature. We give a generalization of this theorem to extremals of a wide class of optimal control problems including sub-Riemannian extremals. The problem can be reformulated as the problem to estimate the number of conjugate points along a curve in a Lagrangian Grassmannian in terms of the invariants of this curve with respect to the natural action of the Linear Symplectic Group. Our treatment of this problem is based on the construction of the canonical bundle of moving frames and the complete system of symplectic invariants for curves in Lagrangian Grassmannians previously done in the joint works with Chengbo Li. We will explain how appropriately arranged bounds for these symplectic invariants effect the bounds for the number of conjugate points. The application for extremals of natural sub-Riemannian metrics on principal connections of principal bundles with one-dimensional fibers over Riemannian manifolds (i.e. magnetic fields on Riemannian manifolds) will be given. (Received August 12, 2010)

1064-53-31 **Igor Zelenko*** (zelenko@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77845-3368. *On geometry and symmetries of filtered structures on manifolds and curves of flags.* Preliminary report.

I will discuss the following two problems in local differential geometry and the interplay between them: the equivalence of filtered structures on manifolds (w.r.t. the action of the group of diffeomorphisms) and the equivalence of curves of flags in a linear space (w.r.t. the action of a subgroup of the General Linear group). In particular, I will show how the geometry of curves of flags of isotropic/coisotropic subspaces in a linear symplectic space (w.r.t. the action of Linear Symplectic Group) can be effectively used for the construction of canonical frames for non-holonomic vector distributions (subbundles of tangent bundles) satisfying very mild genericity assumptions and for the description of infinitesimal symmetries algebras of the most symmetric distributions from the considered classes. The talk is based on the joint work with Boris Doubrov (Minsk). (Received August 12, 2010)

1064-53-39 **David E. Blair*** (blair@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027, **Verónica Martín-Molina**, University of Sevilla, and **Adela Mihai**, University of Bucharest. *Geometry of normal complex contact metric manifolds.*

This is a brief expository talk on recent work on complex contact metric manifolds. After reviewing the ideas surrounding these manifolds, the notion of normality will be discussed in some detail. Then recent work (Blair, Mihai) on locally symmetric normal complex contact metric manifolds along with the role played by reflections in the integral submanifolds of the vertical subbundle will be discussed.

In Hermitian geometry the Bochner tensor plays the role of the conformal curvature tensor in Riemannian geometry. Treating these ideas in the normal complex contact metric setting (Blair, Martín-Molina), the Bochner flat case gives odd-dimensional complex projective space. It is also shown that there are no conformally flat normal complex contact metric manifolds. (Received August 18, 2010)

1064-53-43 **Nan Li*** (nli2@nd.edu), Department of Mathematics, University of Notre Dame, 255 Hurley Hall, Notre Dame, IN 46556, and **Xiaochun Rong** (rong@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Rd, Piscataway, NJ 08854. *Alexandrov spaces of relatively maximal volumes.*

We will discuss an isometric classification of compact Alexandrov spaces whose volumes are (relatively) maximal under certain constraint (that becomes trivial for Riemannian manifolds). A basic tool for this classification is a pointed version of the Bishop-Gromov relative volume comparison with rigidity in Alexandrov spaces. (Received August 19, 2010)

1064-53-57 **Jih-Hsin Cheng*** (cheng@math.sinica.edu.tw), Institute of Mathematics, Academia Sinica, Taipei, 11529, Taiwan. *A positive mass theorem in Cauchy-Riemann geometry.*

We define an ADM-like mass, called p-mass, for an asymptotically flat pseudohermitian manifold. The p-mass for the blow-up of a closed pseudohermitian manifold is identified with the constant term in the expansion of the Green function for the CR Laplacian. We deduce an integral formula for the p-mass. We prove the nonnegativity of the p-mass for (the blow-up of) a closed embeddable CR 3-manifold with positive Webster-Yamabe invariant and nonnegative Paneitz-like operator. We show the existence of nonembeddable CR 3-manifolds having nonpositive Paneitz-like operator through a second variation formula. We also discuss the zero p-mass situation, the relation to the CR Yamabe problem, and the higher dimensional case of spherical CR manifolds. (Received August 24, 2010)

1064-53-94 **Francois Ledrappier*** (fledrapp@nd.edu), Universite Paris 6, 4, Place Jussieu, Paris, France. *Volume entropy rigidity for hyperbolic manifolds.*

This is joint work with Xiaodong Wang.

Consider a compact manifold of dimension n and Ricci curvature $\geq -(n-1)$. Then the volume entropy of the universal cover is at most $(n-1)$. We prove that it is exactly $(n-1)$ only in the case of constant curvature -1. (Received August 31, 2010)

1064-53-107 **Damin Wu*** (dwu@math.ohio-state.edu), 1179 University Dr., Newark, OH 43055. *Form-type equations on Kähler manifolds.*

I will discuss the recent joint work with Jixiang Fu and Zhizhang Wang. We introduce a new equation on a balanced hermitian manifold. Solving the equation enables one to settle the problem of prescribed volume form for balanced metrics on the manifold. This can be viewed as a differential form level generalization of the classical Calabi–Yau equation. We establish the existence and uniqueness of the equation on complex tori, and prove certain uniqueness and openness on a general Kähler manifold. Very recently, we are able to solve the equation on Kähler manifolds under certain curvature assumption. (Received September 01, 2010)

1064-53-121 **Xiaodong Wang*** (xwang@math.msu.edu), Michigan State University, Wells Hall D202, East Lansing, MI 48824. *On the bottom of spectrum of certain complete Kahler manifolds.*

The bottom of spectrum is an important invariant for a complete Riemannian manifold. We are interested in both the upper and lower bounds assuming a negative lower bound on the Ricci curvature. I will first discuss some results in the Riemannian case. Then I will focus on the Kahler case. We will formulate a conjecture and discuss some partial results. This is a joint work with Song-Ying Li at UC Irvine. (Received September 02, 2010)

1064-53-125 **Zhongmin Shen*** (zshen@math.iupui.edu), Department of Mathematical Sciences, IUPUI, 402 N Blackford Street, Indianapolis, IN 46032. *Some Non-Riemannian Curvatures In Finsler Geometry.* Preliminary report.

In Finsler Geometry, there are several geometric quantities. The Riemann curvature is the natural extension of the Riemann curvature in Riemannian geometry. There are several other non-Riemannian quantities. They all vanish when the metric is Riemannian. It is important to understand the geometric meanings of these quantities and their interaction with the Riemann curvature. In this lecture, I will discuss some metric rigidity theorems for Finsler manifolds with special non-Riemannian curvature properties. (Received September 03, 2010)

1064-53-134 **Thomas E Cecil*** (cecil@mathcs.holycross.edu), Department of Mathematics/Computer Science, College of the Holy Cross, 1 College St., Worcester, MA 01610. *Compact proper Dupin hypersurfaces.*

A hypersurface M embedded in the sphere S^n is *proper Dupin* if the number g of distinct principal curvatures is constant on M, and each principal curvature is constant along each leaf of its corresponding principal foliation. Thorbergsson showed that for a compact, connected proper Dupin hypersurface $M \subset S^n$, the value of g must be $1, 2, 3, 4$ or 6, the same as Münzner's restriction for isoparametric hypersurfaces in S^n.

In 1985, P.J. Ryan and the author conjectured that every compact, connected proper Dupin hypersurface $M \subset S^n$ is equivalent to an isoparametric hypersurface by a Lie sphere transformation. The conjecture is true for $g = 1, 2$ and 3, but it was shown to be false in the cases $g = 4$ and 6 by counterexamples due to Pinkall-Thorbergsson and Miyaoka-Ozawa. These counterexamples do not have constant Lie curvatures, which are the cross-ratios of the principal curvatures taken four at a time. A revised conjecture with the additional assumption of constant Lie curvatures is still open, and we discuss recent progress on the revised conjecture in the case $g = 4$ by Q.-S. Chi, G. Jensen and the author. (Received September 03, 2010)

1064-53-137 **Quo-Shin Chi*** (chi@math.wustl.edu), Department of Mathematics, Washington University, St. Louis, MO 63130. *Classification of isoparametric hypersurfaces with four principal curvatures.*

We outline a classification of isoparametric hypersurfaces with four principal curvatures in spheres when the multiplicity pair $(m_1, m_2) = (3, 4)$. This leaves only the three cases $(m_1, m_2) = (4, 5), (6, 9)$ or $(7, 8)$ unsettled. (Received September 04, 2010)

1064-53-193 **Gary R Jensen*** (gary@math.wustl.edu), Math. Dept., Campus Box 1146, Washington University, St. Louis, MO 63130, and **Emilio Musso**. *A global result for the Bonnet problem.* Preliminary report.

Bonnet's problem is to find connected immersed surfaces in Euclidean space that admit another noncongruent immersion with the same first fundamental form and the same mean curvature. Such a deformation is called a Bonnet mate of the given immersion. If an immersion has at least two noncongruent mates, and the mean curvature is nonconstant, then it is called properly Bonnet. We prove that if a surface M has a proper Bonnet immersion, then there exists a nonconstant holomorphic function w = u+iv of M into the Poincare' right half space that satisfies the differential equation dw = -u rho, where rho is a 1-form on M determined by the derivative of the mean curvature. Results of Bonnet, Lawson-Tribuzy, and Chern follow as simple corollaries. (Received September 08, 2010)

1064-53-200 **Shu-Cheng Chang*** (scchang@math.ntu.edu.tw), Department of Mathematics, National Taiwan University, Taipei, 10617, Taiwan. *The CR Obata-Type Theorem in a Closed Pseudohermitian Manifold.*

In this talk, we will give a sharp lower bound estimate for diameter with respect to the adapted metric in a closed pseudohermitian manifold when a sharp lower bound estimate for the first positive eigenvalue of the sub-Laplacian is achieved. As consequences, we confirm the CR Obata Conjecture with respect to sub-Laplacian and Kohn Laplacian in a closed pseudohermitian manifold with an extra condition on covariant derivatives of torsion. (Received September 09, 2010)

1064-53-206 **Jon Wolfson*** (wolfson@math.msu.edu), Department of Mathematics, Michigan State University, Okemos, MI 48824. *Fill Radius and the Fundamental Group.*

In this talk we relate the geometric notion of fill radius with the fundamental group of the manifold. We prove: Suppose that a closed Riemannian manifold M satisfies the property that its universal cover has bounded fill radius. Then the fundamental group of M is virtually free. We explain the relevance of this theorem to some conjectures on positive isotropic curvature and 2-positive Ricci curvature. (Received September 09, 2010)

1064-53-213 **Marianty Ionel** and **Thomas A. Ivey***, Department of Mathematics, College of Charleston, 66 George St., Charleston, SC 29424. *Ruled Austere 4-folds and Holomorphic Curves.* Preliminary report.

Austere submanifolds in Euclidean space are those for which the eigenvalues of the second fundamental form, in any normal direction, are symmetrically arranged around zero. In this talk, I will discuss work with Marianty Ionel on classifying 4-dimensional austere submanifolds which are real Kahler submanifolds and admit a ruling by 2-planes. These can be sorted into cases according to the rank of the second fundamental form; in each case, the submanifold determines, and is partially determined by, a holomorphic curve in a compact homogeneous 'twistor' space. (Received September 09, 2010)

1064-53-224 **Jianguo Cao** (jcao@nd.edu), Notre Dame, IN 46556, and **Jian Ge*** (jge@nd.edu), 255 Hurley Hall, University of Notre Dame, Notre Dame, IN 46556. *A simple proof of Perelman's collapsing theorem for* 3*-manifolds.*

We will simplify earlier proofs of Perelman's collapsing theorem for 3-manifolds given by Shioya-Yamaguchi and Morgan-Tian. A version of Perelman's collapsing theorem states: *"Let* $\{M_i^3\}$ *be a sequence of compact Riemannian* 3*-manifolds with curvature bounded from below by* (-1) *and diam*$(M_i^3) \geq c_0 > 0$*. Suppose that all unit metric balls in* M_i^3 *have very small volume at most* $v_i \to 0$ *as* $i \to \infty$ *and suppose that either* M_i^3 *is closed or has possibly convex incompressible toral boundary. Then* M_i^3 *must be a graph-manifold for sufficiently large* i*".* This result can be viewed as an extension of the implicit function theorem. Among other things, we apply Perelman's critical point theory (e.g., multiple conic singularity theory and his fibration theory) to Alexandrov spaces to construct the desired local Seifert fibration structure on collapsed 3-manifolds.

The verification of Perelman's collapsing theorem is the last step of Perelman's proof of Thurston's Geometrization Conjecture. A version of Geometrization Conjecture asserts that any closed 3-manifold admits a *piecewise locally homogeneous metric*. Our proof of Perelman's collapsing theorem is accessible to advanced graduate students and non-experts. (Received September 09, 2010)

1064-53-225 **Songhao T Li*** (sli@math.utoronto.ca), Department of mathematics, Toronto, Ontario M5S 2E4, Canada. *Symplectic Groupoids of Radko Surfaces.* Preliminary report.

In 2001, Crainic and Fernandes gave an integrability criterion for Poisson manifolds by a formal construction of the symplectic groupoid. The previsiously known examples include Lie-Poisson strcture and Poisson Lie groups. In her thesis (2002), Olga Radko classified a generic class of Poisson structures on surfaces. In this talk, we will give an geometric construction of the symplectic groupoids of these Radko surfaces. The main technique is blow-up's. This is ongoing work under the supervision of Marco Gualtieri and Lisa Jeffrey. (Received September 09, 2010)

1064-53-227 **Shihshu Walter Wei** (wwei@ou.edu), Room 423, 601 Elm Ave., University of Oklahoma, Norman, OK 73019, and **Ye Li*** (yelicc@ou.edu), Room 423, 601 Elm Ave., University of Oklahoma, Norman, OK 73019. *Geometric Inequalities on Manifolds with Applications.*

I will talk about joint work with Shihshu Walter Wei on Recent progress in sharp geometric inequalities on Riemannian manifolds and on complex manifolds. Some local and global viewpoints as well as applications will be discussed. (Received September 09, 2010)

1064-53-254 **Shihshu Walter Wei*** (wwei@ou.edu), Department of Mathematics, The University of Oklahoma, Norman, OK 73019. *Conformal, complex, and* p*-harmonic geometry.*

We recall a smooth map $u : M \to N$ between Riemannian manifolds is said to be a *p-harmonic map*, $p \geq 1$ if it is a critical point of p-energy functional E_p , given by $E_p(u) = \int_M |du|^p dv$ with respect to any compactly supported variations, where $|du|$ is the Hilbert-Schmidt norm of the differential du of u, and dv is the volume element of M.

Examples of p-harmonic maps include rigid motions in classical differential geometry, linear transformations in linear algebra, holomorphic maps in complex analysis and in several complex variables(in which $p = 2$), angle-preserving maps between n-dimensional manifolds in conformal geometry(in which $p = n$), geodesics, (conformal) minimal submanifolds(for every $p \geq 1$) , harmonic maps(in which $p = 2$), and much more.

We'll explore several natural links between the geometry of p-harmonic maps, conformal geometry, and complex geometry. Some applications to topology and partial differential equations will be considered. (Received September 11, 2010)

1064-53-257 **Shihshu Walter Wei*** (wwei@ou.edu), Department of Mathematics, The University of Oklahoma, Norman, OK 73019. *Minimal submanifolds, p-harmonic maps, and geometric flows.*

In this talk, we will study minimal submanifolds, p-harmonic maps and geometric flows. We'll discuss their natural connections, common features, as well as special features, for example we can employ, p-harmonic maps to study topics or problems that do not seem to be approachable by ordinary harmonic maps (in which $p = 2$). (Received September 11, 2010)

1064-53-259 **Thomas A Ivey** and **Patrick J Ryan*** (ryanpj@mcmaster.ca), Department of Mathematics and Statistics, McMaster University, Hamilton, ON L8S4K1, Canada. *The *-Ricci tensor for hypersurfaces in complex space forms.*

The *-Ricci tensor of an almost-Hermitian manifold was introduced by Tachibana in 1959 and was later used (along with the related concept of *-Einstein) in work on the Goldberg conjecture, for example, by Oguro and Sekigawa. These ideas also apply naturally to contact metric manifolds, and in particular, to hypersurfaces in complex space forms, where they were introduced by T. Hamada.

In this talk, we refine, clarify, and extend Hamada's classification of *-Einstein Hopf hypersurfaces in the complex space forms $\mathbf{CP}^n$ and $\mathbf{CH}^n$. We also address existence questions using the methods of moving frames and exterior differential systems. (Received September 12, 2010)

1064-53-287 **Tomoo Matsumura*** (matsumura@math.cornell.edu), 310 Malott Hall, Mathematics Department, Cornell University, Ithaca, NY 14853, and **Tara Holm**. *Equivariant cohomology for Hamiltonian torus actions on symplectic orbifolds.*

We start with the definition of Hamiltonian R-actions on symplectic orbifolds $[M/\mathsf{S}]$, where R and S are tori. We show an injectivity theorem and generalize Tolman-Weitsman's proof of the GKM theorem in this setting. The main example is the symplectic reduction $X//\mathsf{S}$ of a Hamiltonian T-manifold X by a subtorus S of T. This includes the class of symplectic toric orbifolds which are classified by labeled polytopes by Lerman. We apply our method to show that the equivariant cohomology ring of a symplectic toric orbifold is isomorphic over $\mathbb{Z}$ to the Stanley-Reisner ring of the associated polytope. Furthermore, we define the equivariant Chen-Ruan cohomology ring and use the above results to establish a combinatorial method of computing this equivariant Chen-Ruan cohomology in terms of orbifold fixed point data. (Received September 13, 2010)

1064-53-289 **Xiangdong Li*** (xdli@amt.ac.cn), 55, Zhongguancun East Road, Beijing, 100190, Peoples Rep of China. *Riesz transforms and L^p-estimates of $\bar{\partial}$ on complete Kahler manifolds.* Preliminary report.

In this talk, we present some recent results in the study of the L^p-estimates and existence theorems of the $\bar{\partial}$-operator on holomorphic Hermitian vector bundles over complete Kahler manifolds. As application, we prove some vanishing theorems of the L^p-cohomology on complete Klahler manifolds. The Riesz transforms associated with the Kodaira Laplacian play an essential role in this work. (Received September 13, 2010)

1064-53-301 **Ivko M. Dimitric*** (ivko@psu.edu), 1 University Drive, PO Box 519, Uniontown, PA 15401. *Curvature-adapted hypersurfaces of 2-type in projective spaces and a question of stability.* Preliminary report.

This work is concerned with classification of curvature-adapted hypersurfaces of $\mathbb{C}P^m$ and $\mathbb{H}P^m$, which are of 2-type in a naturally defined Euclidean space of Hermitian matrices via the embedding by projectors. Up to translation, the position vector of each of these hypersurfaces allows a decomposition into a sum of two vector eigenfunctions of the Laplacian (from different eigenspaces). We give classification results for these hypersurfaces. For example, in $\mathbb{C}P^m$ curvature-adapted (i.e. Hopf) hypersurfaces include (1) Geodesic hyperspheres of arbitrary radius but one; (2)Two series of tubes about a canonically embedded $\mathbb{C}P^k, 1 \leq k \leq m-2$; (3) Two particular tubes about a complex quadric.

Some of these 2-type tubes have certain extremal properties regarding the stability, the connection we further explore. (Received September 13, 2010)

1064-53-348 **Stephanie B. Alexander** and **Richard L. Bishop*** (math@illinois.edu), Department of Mathematics, 1409 W Green St, Urbana, IL 61801, and **Robert Ghrist**. *Comparison geometry, total curvature, and pursuit-evasion games.* Preliminary report.

We explain why CAT(K) spaces are an appropriate setting for pursuit-evasion games. For a given evader curve, the flow of pursuit curves is a time-dependent gradient flow. We give lower bounds on capture times and an escape criterion in terms of integral of the square of the curvature of a pursuit curve. We had previous estimates on total curvature of a pursuit curve when the evader escapes, and this criterion shows they are sharp. We define

a model pursuit-evasion game in the plane and study comparisons for the separation and its derivative when the evader has variable speed. (Received September 14, 2010)

1064-53-349 **Bruce M Solomon*** (solomon@indiana.edu), Math Department, Indiana University, Bloomington, IN 47405. *Negative curvature obstructs small skewloops.*

A skewloop is a smooth loop in 3-space with no two tangent lines parallel.

Surprisingly, the absence of skewloops near a point p of positive Gauss curvature K on a surface $M \subset \mathbf{R}^3$ makes M quadric near p. For when M is non-quadric near p and $K(p) > 0$, one can construct skewloops on it by perturbing small geometric ellipses near p (Ghomi/Solomon 2002).

We can now show the situation to be quite different when $K < 0$. Specifically, when $K(p) < 0$ one cannot obtain a skewloop near p by perturbing any small (but not too eccentric) ellipse.

Strict negativity of $K(p)$ seems necessary here: on the Monkey Saddle, where $K \leq 0$ vanishes at just one point, we can find small, almost circular skewloops surrounding that point. (Received September 14, 2010)

1064-53-359 **David S Li-Bland*** (david.libland@gmail.com), Department of Mathematics BA6290, 40 St George St., Toronto, Ontario M5S2E4, Canada. *Some examples of symplectic groupoids.*

Suppose a quadratic Lie algebra, $\mathfrak{g}$, acts on a manifold M in such a way that all the stabilizer subalgebras are coisotropic in $\mathfrak{g}$. A choice of transverse Lagrangian subalgebras $\mathfrak{e}, \mathfrak{f} \subset \mathfrak{g}$ defines a Poisson structure on M. Examples include the Poisson structures of Lu-Yakimov, and in particular the Evens-Lu Poisson structures on the variety of Lagrangian Grassmannians and on the de Concini-Procesi compactifications.

In this talk we focus on the explicit construction of symplectic groupoids integrating these Poisson manifolds. Using a certain moduli space of flat $\mathfrak{g}$-connections, we show that the problem can be reduced to integrating a bundle of Lie algebras to a bundle of Lie groups. (Received September 14, 2010)

1064-53-382 **Chris Connell*** (connell@indiana.edu) and **Matilde Martinez** (matilde.mtz@gmail.com). *Harmonic measures on laminations by locally symmetric spaces.*

Harmonic measures relate both transverse and tangential (geometric and topological) information about a foliation. We will give an algebraic characterization of these measures on compact spaces foliated by locally symmetric spaces, and give an explicit geometric-dynamical description of these measures on an associated frame sub-bundle lamination which relies on recent sharp estimates of the heat kernel. The dynamical interpretation is particularly simple in the split Cartan case. (Received September 14, 2010)

1064-53-387 **Mihaela B Vajiac*** (mbvajiac@chapman.edu), Schmid College of Science, Chapman University, One University Drive, Orange, CA 92866. *Geometry of Bicomplex Spaces.* Preliminary report.

In this talk I will present new spaces called bicomplex spaces, and a theory of holomorphic functions in this context. I will outline a research program in the direction of bicomplex geometry and explain the difficulties and importance of the development of such a theory. (Received September 14, 2010)

1064-53-404 **Maura B. Mast*** (maura.mast@umb.edu), 100 Morrissey Boulevard, Department of Mathematics, University of Massachusetts Boston, Boston, MA 02125-3393, and **Ruth Gornet**. *Magnetic Geodesics in two-step Nilmanifolds.* Preliminary report.

A magnetic structure on a Riemannian manifold (M, g) is a pair (g, Ω), where Ω denotes a closed 2-form on M. Let ω_g denote the symplectic form on TM obtained by pulling back the canonical symplectic form on T^*M via the metric g. The magnetic flow on M corresponding to Ω is the Hamiltonian flow determined by the energy function $E(v) = \frac{1}{2}g(v, v)$ with respect to the symplectic structure $\omega_{mag} = \omega_g + \pi^*\Omega$, where $\pi : TM \to M$ is canonical projection. A magnetic geodesic in M corresponds to an orbit of the magnetic flow. We study these geodesics in two-step nilpotent Lie nilmanifolds, with a particular focus on magnetic geodesic behavior in the Heisenberg groups. (Received September 15, 2010)

55 ► Algebraic topology

1064-55-63 **Eric Zaslow*** (zaslow@math.northwestern.edu), 2033 Sheridan Road, Evanston, IL 60208. *Ribbon Graphs and Mirror Symmetry I.*

The moment map of the complex projective plane is a triangle. Generalizing this familiar observation somewhat, I will describe a correspondence between equivariant coherent sheaves on toric varieties and polyhedrally constant sheaves on vector spaces. Specializing to one dimension, I will then describe how to assign a category to a ribbon graph by appropriately gluing sheaves on the real line.

The ribbon graph category is conjecturally equivalent to the Fukaya category of the Riemann surface described by the graph. A glued version of the correspondence above allows us to prove that the ribbon graph category is equivalent to the category of coherent sheaves on a "mirror" algebraic curve.

I will develop the necessary mathematics from a *very* simple example.

This talk is based on joint work with Bohan Fang, Chiu-Chu Melissa Liu, Nicolo' Sibilla and David Treumann. (Received August 25, 2010)

1064-55-64 **Eric Zaslow*** (zaslow@math.northwestern.edu), 2033 Sheridan Road, Evanston, IL 60208. *Ribbon Graphs and Mirror Symmetry II.*

This will be a reasonably self-contained continuation of the talk, Ribbon Graphs and Mirror Symmetry I, in the Special Session on Topology, Geometry and Physics. In this talk, I will focus on examples. The abstract for the first talk is reproduced here.

The moment map of the complex projective plane is a triangle. Generalizing this familiar observation somewhat, I will describe a correspondence between equivariant coherent sheaves on toric varieties and polyhedrally constant sheaves on vector spaces. Specializing to one dimension, I will then describe how to assign a category to a ribbon graph by appropriately gluing sheaves on the real line.

The ribbon graph category is conjecturally equivalent to the Fukaya category of the Riemann surface described by the graph. A glued version of the correspondence above allows us to prove that the ribbon graph category is equivalent to the category of coherent sheaves on a "mirror" algebraic curve.

I will develop the necessary mathematics from a *very* simple example.

This talk is based on joint work with Bohan Fang, Chiu-Chu Melissa Liu, Nicoló Sibilla and David Treumann. (Received August 25, 2010)

1064-55-175 **Eric Harrelson**, **Alexander Voronov** and **J. Javier Zúñiga*** (jzuniga@math.purdue.edu), Department of Mathematics, 150 N. University Street, West Lafayette, IN 47906. *Open-closed moduli spaces and related algebraic structures.*

I will give an account of the construction of the BV-algebra structure on the (geometric) chains of the moduli space of bordered Riemann Surfaces. This leads to a Lie Bracket and a solution to the Quantum Master Equation. (Received September 07, 2010)

1064-55-184 **Justin D. Thomas*** (justmas@gmail.com), Department of Mathematics, 255 Hurley, Notre Dame, IN 46556. *Kontsevich's Swiss Cheese Conjecture.*

We prove a conjecture of Kontsevich which characterizes the Hochschild cohomology of an E_n algebra A as the universal E_{n+1} algebra acting on A. The notion of an action of an E_{n+1} algebra on an E_n algebra is defined using the swiss cheese operad of Voronov. This operad was introduced to address Deligne's conjecture. We will discuss the story surrounding Deligne's conjecture, introduce the swiss cheese operad, and sketch a proof of Kontsevich's conjecture. (Received September 08, 2010)

1064-55-185 **Alastair Hamilton***, Department of Mathematics, Texas Tech University, Lubbock, TX 79409. *On the extension of a TCFT to the boundary of the moduli space.*

There is a construction – due to Costello, and following ideas of Witten – of a closed differential form on the moduli space of Riemann surfaces, which takes a compact Riemannian manifold as its initial input.

Integrating this differential form over the moduli space is supposed to yield the perturbative expansion of a Chern-Simons type gauge theory. However, this differential form blows up at the boundary. In this talk, I will consider a toy model in which these singularities are absent, and discuss how to extend this form to a compactification of the moduli space in this case. I hope to have time to describe a simple example. (Received September 08, 2010)

1064-55-209 **Po Hu*** (po@math.wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202. *Higher String Topology - Old and New.*

I will discuss some work of mine on generalizing some aspects of string topology to higher dimension (and even beyond manifolds). I will relate this to some newer work of J. Lurie and others. If there is enough time, I may also comment on connections with Koszul duality and its possible "unbased" forms. (Received September 09, 2010)

1064-55-211 **Hu Po** (po@math.wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202, and **Igor Kriz*** (ikriz@umich.edu), Department of Mathematics, University of MIchigan, Ann Arbor, MI 48109-1043. *Topological Hermitian cobordism and related topics.*

Landweber's Real cobordism MR and finite group actions on related spectra is one of the most interesting current topics of homotopy theory because of the recent solution of the Kervaire invariant 1 problem by Hill, Hopkins and Ravenel, which used a Z/8-equivariant spectrum of this type. I will talk about topological Hermitian cobordism, which is a Z/2 x Z/2-equivariant enrichment of MR. I will discuss our results on this spectrum, pushing further our original calculation of the coefficients of MR. I will also discuss some related topics, in particular Mackey functors. (Received September 09, 2010)

1064-55-212 **Igor Kriz*** (ikriz@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109-1043. *Some remarks on the Verlinde Algebra.*

I will talk about various interrelated topics concerning the Verlinde algebra. In particular, I will discuss my joint paper with Westerland (with contributions of J.T.Levin) on "string K-theory", which involves numerical properties of the Verlinde algebra, and another joint paper with Kneezel on the completion of the Verlinde algebra, where number-theoretical properties enter in a different way. If time permits, I may discuss some observations on modular functors. (Received September 09, 2010)

1064-55-228 **Ben C Ward*** (bencward@gmail.com), Department of Mathematics, Purdue University, 150 North University Street, West Lafayette, IN 47907-2067. *BV Structures and Modular Operads.*

We associate a BV operator to a suitable type of modular operad, whose failure to be a derivation gives an odd Lie bracket associated to the underlying cyclic operad. This bracket is a cyclic generalization of Gerstenhaber's original bracket on the Hochschild cochains of an associative algebra. (Received September 09, 2010)

1064-55-362 **Matthew Ando*** (mando@illinois.edu), Department of Mathematics, University of Illinois, 1409 W Green St, Urbana, IL 61801. *Fibered WZW models and Lipsky's cocycle construction.* Preliminary report.

By work of Grojnowski and myself, and independently Lurie, the Verlinde algebra at level k of a simple and simply connected lie group G appears in elliptic cohomology as the k-twisted G-equivariant elliptic cohomology of a point. We'll describe this result, and explain how it provides insight on the equivariant string orientation. Then we'll explain how loop group representations give rise to exotic elliptic genera, which have been studied by Kefeng Liu and myself. Recently Distler and Sharpe have given a physical interpretation of these genera, and David Lipsky has made significant progress towards constructing the corresponding enriched topological field theories. (Received September 14, 2010)

57 ► Manifolds and cell complexes

1064-57-247 **Vladimir Turaev***, Department of Mathematics, Indiana University, Bloomington, IN 47405. *Monoidal categories and 3-dimensional TQFTs.*

One of the fundamental achievements of quantum topology is a discovery of deep connections between topology of 3-manifolds and monoidal categories. I will discuss several recent results in this direction including my recent paper with Alexis Virelizier on the connections between the state sum construction of TQFTs from fusion categories and the surgery construction of TQFTs from modular categories. (Received September 10, 2010)

1064-57-277 **Zhenyi Liu*** (zhenyi.liu@okstate.edu), 300 S. Roselle Rd. , #207, Schaumburg, IL 60193. *Classification of One-sided Incompressible Surfaces in Two Infinite Families of Seifert Fibered Spaces.*

In this paper, we identify all one-sided incompressible surfaces, up to isotopy, in the generalized quaternion spaces S^3/Q_{4k}, which are Seifert fibered spaces $M_k = (S^2 : (2,1),(2,1),(k,-k+1))$, $k \geq 2$. The techniques used can be expanded to give the classification of one-sided incompressible surfaces in the minimal layered chain pair triangulations of Seifert fibered spaces $(S^2 : (2,-1),(r+1,1),(s+1,1))$, $r,s \geq 1$. (Received September 12, 2010)

1064-57-326 **Mark Feshbach** and **Alexander A Voronov*** (voronov@umn.edu), School of Mathematics, 127 Vincent Hall, 206 Church St. S.E., Minneapolis, MN 55455-0488. *Higher Categories and TQFTs.* Preliminary report.

We describe categorical formalism for higher dimensional, a.k.a. extended, Topological Quantum Field Theories (TQFTs) and present them as functors from a suitable category of cobordisms with corners to a linear category, generalizing 2d open-closed TQFTs to higher dimensions. The approach is in the spirit of monoidal categories (associators, interchangers, Mac Lane's pentagons and hexagons), in contrast with the simplicial (weak Kan and complete Segal) approach of Jacob Lurie's. (Received September 13, 2010)

1064-57-372 **Thomas Church***, Department of Mathematics, 5734 S University Ave, Chicago, IL 60637. *Representation stability, configuration spaces, and points over finite fields.*

Given a space X, the configuration space $\mathrm{PConf}_n(X)$ parametrizes n–tuples of distinct points, while $\mathrm{Conf}_n(X) := \mathrm{PConf}_n(X)/S_n$ parametrizes n–element subsets of X. Arnold proved that the spaces $\mathrm{Conf}_n(\mathbb{C})$ satisfy *homological stability*: for each i, $H_i(\mathrm{Conf}_n(\mathbb{C})) \approx H_i(\mathrm{Conf}_{n+1}(\mathbb{C}))$ for $n \gg i$.

Unfortunately stability fails for $\mathrm{PConf}_n(\mathbb{C})$, so to talk about the "stable homology of $\mathrm{PConf}_n(\mathbb{C})$", B. Farb and I defined *representation stability*. We take the action of S_n into account and prove the description of $H_i(\mathrm{PConf}_n(\mathbb{C}); \mathbb{Q})$ as an S_n–representation stabilizes. More recently I proved that $H_i(\mathrm{PConf}_n(M); \mathbb{Q})$ is representation stable for *any* manifold. This implies that $H_i(\mathrm{Conf}_n(M); \mathbb{Q})$ satisfies homological stability, previously known only for open manifolds.

I will conclude with some arithmetic applications of representation-stable homology with J. Ellenberg and B. Farb. For example, thinking of Conf_n as a scheme, the space of degree–n squarefree polynomials over $\mathbb{F}_q$ is exactly $\mathrm{Conf}_n(\mathbb{F}_q)$, and certain counting problems can be solved in terms of the multiplicities of irreducible representations in $H_i(\mathrm{PConf}_n(\mathbb{C}); \mathbb{Q})$. (Received September 14, 2010)

58 ► Global analysis, analysis on manifolds

1064-58-15 **E Cabral Balreira*** (ebalreir@trinity.edu), One Trinity Place, Department of Mathematics, San Antonio, TX 78212. *A Generalization of the Fujisawa-Kuh Global Inversion Theorem.*

We discuss the global invertibility of nonlinear maps defined on the finite dimensional Euclidean space. Using differential tests of ratio conditions on the Jacobian matrix of the map, we provide a generalization of the Fujisawa-Kuh Global Inversion Theorem. We also introduce a generalized ratio condition to establish when the pre-image of a certain class of linear manifolds is non-empty and connected. In particular, we provide conditions to detect global injectivity. (Received July 26, 2010)

1064-58-308 **Eugene Lerman***, Department of Mathematics, University of Illinois, Urbana, IL 61801, and **Yael Karshon**. *Non-compact symplectic toric manifolds.*

The paradigmatic result in symplectic toric geometry is the paper of Delzant that classifies compact connected symplectic manifolds with effective completely integrable torus actions, the so called (compact) symplectic toric manifolds. The moment map induces an embedding of the quotient of the manifold by the torus action into the dual of the Lie algebra of the torus; its image is a simple unimodular ("Delzant") polytope. This gives a bijection between simple unimodular polytopes and isomorphism classes of compact symplectic toric manifolds. For a non-compact symplectic toric manifold the image of the moment map need not be convex and the induced map of the quotient need not be an embedding. Moreover, even when the map of the quotient is an embedding, its image no longer determines the symplectic toric manifold; a degree two characteristic class makes an appearance. None the less there is a classification of non-compact symplectic toric manifolds and I will explain what it is. (Received September 13, 2010)

1064-58-371 **Ryan E. Grady*** (rgrady@nd.edu), 255 Hurley Hall, Notre Dame, IN 46628. *Chern-Simons Theory and the Todd Genus.* Preliminary report.

Building on work of Costello, we show how the Todd genus of a manifold X arises in the rigorous analysis of a certain one dimensional perturbative field theory with target X. A key step in this one dimensional Chern-Simons theory is encoding the geometry of the manifold X as an L_∞-algebra. (Received September 14, 2010)

60 ► Probability theory and stochastic processes

1064-60-33 **Di Liu*** (richardl@math.msu.edu), D217 Wells Hall, East Lansing, MI 48824. *Numerical methods for stochastic bio-chemical reacting networks with multiple time scales.*

Multiscale and stochastic approaches play a crucial role in faithfully capturing the dynamical features and making insightful predictions of cellular reacting systems involving gene expression. Despite their accuracy, the standard stochastic simulation algorithms are necessarily inefficient for most of the realistic problems with a multiscale nature characterized by multiple time scales induced by widely disparate reactions rates. In this talk, I will discuss some recent progress on using asymptotic techniques for probability theory to simplify the complex networks and help to design efficient numerical schemes. (Received August 16, 2010)

1064-60-68 **Sivaditya Kaligotla*** (kaligotl@usc.edu), 3620 South Vermont Ave., KAP 108, los angeles, CA 90089, and **Sergey V Lototsky** (lototsky@usc.edu), 3620 South Vermont Ave., KAP 108, los angeles, CA 90089. *Wick Product in Stochastic Burgers Equation: A Curse or a Cure?*

It has been known for a while that a nonlinear equation driven by singular noise must be interpreted in the re-normalized, or Wick, form. For the stochastic Burgers equation, Wick non-linearity forces the solution to be a generalized process no matter how regular the random perturbation is, whence the curse. On the other hand, certain multiplicative random perturbations of the deterministic Burgers equation can only be interpreted in the Wick form, whence the cure. The analysis is based on the study of the coefficients of the chaos expansion of the solution at different stochastic scales. (Received August 25, 2010)

1064-60-124 **Igor Cialenco*** (igor@math.iit.edu), 10 West 32nd Str, Bld E1, Room 208, Chicago, IL 60616, and **Nathan Glatt-Holtz** (negh@indiana.edu), 303 Swain East, Bloomington, IN 47405. *Statistical inference for nonlinear Stochastic PDEs.*

While the general form of a model is commonly derived from the fundamental properties of a physical process under study, frequently parameters arise in the formulation which need to be specified or determined on the basis of empirical observation. Given in particular the growing significance of nonlinear stochastic partial differential equations (SPDE) in applications there is a clear need to develop the theory of parameter estimation for such systems. Under the assumption that a phenomenon of interest follows the dynamics of such an SPDE, and given that some realizations of this process are measured, we wish to find these unknown parameters appearing in the model, such that the equations fit or predict as much as possible this observed data. In this work we discuss some recent results concerning the estimation of the 'drift' parameter for a general class of nonlinear SPDE, based on the first N Fourier modes of a single sample path observed on a finite time interval. In particular, we exhibit specific estimators for the viscosity coefficient for the 2D stochastic Navier-Stokes equations, and study asymptotic properties of these estimators.

This talk is based on recent joint work with Nathan Glatt-Holtz. (Received September 02, 2010)

1064-60-171 **David F. Anderson*** (anderson@math.wisc.edu), Mathematics Department, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706. *Numerical methods for stochastic models of biochemical reaction networks.*

This talk will focus on stochastically modeled biochemical reaction networks, and will have a special emphasis on a pathwise representation for such models usually termed the "random time change representation." Such a representation is incredibly useful in that it allows us to (i) see the natural algorithms that can be used to simulate the processes and (ii) perform error analyses that can, in a rigorous manner, tell us what the algorithms are doing.

While exact simulation methods exist for discrete-stochastic models of biochemical reaction networks, they are oftentimes too inefficient for use because the number of computations scales linearly with the number of reaction events; thus, approximate algorithms have been developed. However, stochastically modeled reaction networks often have "natural scales" and it is crucial that these be accounted for when developing and analyzing numerical approximation methods. I will show that conducting such a non-standard error analysis leads to fundamentally different conclusions than previous analyses. (Received September 07, 2010)

1064-60-280 **Hakima Bessaih*** (bessaih@uwyo.edu), DEPT. 3036, 1000 East University Avenue, Laramie, WY 82071, and **Annie Millet**. *Inviscid Large Deviation Principle and the 2D Navier-Stokes Equations with a free boundary condition.* Preliminary report.

Using a weak convergence approach, we prove a LDP for the solution of the 2D stochastic Navier-Stokes equations with a free boundary condition, when the viscosity converges to zero and the noise intensity is multiplied by the

square root of the viscosity. Unlike previous results on LDP for hydrodynamical models, the weak convergence is proven by tightness properties of the distribution of the solution in appropriate functional spaces. (Received September 12, 2010)

62 ► Statistics

1064-62-110 **Sonja Petrovic*** (petrovic@math.uic.edu), Department of Mathematics, Statistics, and CS, 322 Science and Engineering Offices (M/C 249), 851 S. Morgan Street, Chicago, IL 60607-7045. *A computational challenge in algebraic statistics.*

Algebraic statistical models are real positive parts of algebraic varieties. Many of the fundamental questions about these models require heavy computation at the interface of statistics algebraic geometry.

Maximum likelihood estimation and parameter identifiability are two of the prominent problems in which algebraic methods have been effective. However, due to the size and complexity of the computations, numerical methods need to be used.

This talk will survey these problems for certain graphical models, and discuss the results of using numerical algebraic geometry to solve them. An important wealth of examples is provided by phylogenetic models in algebraic biology. (Received September 01, 2010)

65 ► Numerical analysis

1064-65-29 **Wenrui Hao*** (whao@nd.edu), Math department, Notre Dame, IN 46556. *Homotopy continuation and tumor growth.*

This talk will describe some of the recent work of Jonathan Hauenstein, Bei Hu, Yuan Liu, Andrew Sommese, Yong-Tao Zhang and myself.

Most of mathematical models of tumor growth, which consider the tumor tissue as a collection of proliferating cells, discuss the case of radially symmetric tumors. Since tumors grown in vitro have a nearly spherical shape, it is important to determine whether these radially symmetric tumors are asymptotically stable, and it is also important to understand bifurcation to non-radially symmetric solutions.

The tumor model we study is a free boundary problem with a parameter μ, which is tumor aggressiveness factor. To demonstrate the ability of numerical computational methods applied to free boundary problem, we setup a polynomial system to compute μ_2 and track along the solution branch of non-radially symmetric solutions in the steady-state system. Moreover, we also study the nonlinear stability of these solutions. (Received August 12, 2010)

1064-65-41 **Shuwang Li*** (sli@math.iit.edu), Room 208, Engineering 1 Bldg, 10 West 32nd Street, Chicago, IL 60616. *A boundary integral method for simulating the dynamics of an epitaxial island.*

We present a boundary integral method for computing the quasi-steady evolution of an epitaxial island. The problem consists of an adatom diffusion equation (with desorption) on terrace and a kinetic boundary condition at the step (island boundary). The normal velocity for the step motion is determined by a two-sided flux. The boundary integral formulation of the problem yields a Fredholm type integral equation including both double and single layer potentials. Numerical tests on a growing/shrink circular island are in excellent agreement with the analytical solution and demonstrate that the method is stable, efficient and spectrally accurate in space. Nonlinear simulations for perturbed circular islands show that sharp tips and facets will form during growth instead of the usual tip-splitting events for isotropic Laplacian growth. The numerical techniques presented here can be applied generally to a class of free/moving boundary problems in physical and medical science. (Received August 18, 2010)

1064-65-75 **Tianran Chen**, **Tsung-Lin Lee** and **T.Y. Li*** (li@math.msu.edu), Department of Math, Michgan State University, East Lansing, MI 48824. *Parallel computation of the mixed volume.*

Calculating mixed cells which produces mixed volume as a by-product is the vital step in solving systems of polynomial equations by the polyhedral homotopy methods. Our original algorithm for this purpose, implemented in MixedVol-2.0, is highly serial. In this talk, we propose a reformulation of our algorithm, making it much more fine-grained and scalable. It can be readily adapted to both distributed and shared memory computing systems. Remarkably, very high speed-ups were achieved in our numerical results, and we are now able to compute mixed

cells of polynomial systems of very large scale, such as "VortexAC6" system with mixed-volume 27,298,952 and total degree 2^{30} (around 1 billion). (Received August 27, 2010)

1064-65-104 **Frank Sottile*** (sottile@math.tamu.edu), Department of Mathematics, Texas A&M University, TAMU-3368, College Station, TX 77843, and **Jonathan D Hauenstein**. *alphaCertified: Software for certifying solutions to polynomial systems.*

Smale's α-theory provides computable certificates that, for a square system of polynomial equations, Newton iterations beginning at a given point will converge quadratically, doubling the precision at each step, to a solution to the system. In theory, this may be used to certify the output of a numerical solver, including certifying that all solutions have been found, that two numerically computed solutions are distinct, and that a numerically computed solution is real.

alphaCertified is a stand-alone software package with a MAPLE interface that uses α-theory to compute certificates for solutions to systems of polynomial equations.

This talk will briefly recall the main points of Smale's α-theory, and describe the functionality of alphaCertified. It will also include some examples of the application of these algorithms to questions that arise in our research, for alphaCertified was written as a tool for our work. (Received September 09, 2010)

1064-65-108 **Jan Verschelde** (jan@math.uic.edu), University of Illinois at Chicago, Dept of Math, Stat & CS (m/c 249), 851 S. Morgan Street, Chicago, IL 60607-7045, and **Genady Yoffe*** (gyoffe2@uic.edu), University of Illinois at Chicago, Dept of Math, Stat & CS (m/c 249), 851 S. Morgan Street, Chicago, IL 60655. *Multiprecision Path Tracking on Multicore Workstations.* Preliminary report.

We investigate the parallel implementation of polynomial continuation or path tracking on a multicore workstation. For tracking paths at higher precision, the quad double library QD-2.3.9 (developed by Y. Hida, X.S. Li, and D.H. Bailey) is integrated into PHCpack. To compensate for the overhead caused by the quad double arithmetic, our parallel implementation uses multiple threads for tracking a single path. In our experiments, we double the accuracy in less than double the time for the stages of Newton's method on a machine with eight cores for polynomial systems of sufficiently large size. We also observe good speedups for systems with a moderate number of variables and/or smaller degrees. (Received September 01, 2010)

1064-65-109 **Danko Adrovic** (adrovic@math.uic.edu), University of Illinois at Chicago, Dept of Math, Stat & CS (m/c 249), 851 S. Morgan Street, Chicago, IL 60607-7045, and **Jan Verschelde*** (jan@math.uic.edu), University of Illinois at Chicago, Dept of Math, Stat & CS (m/c 249), 851 S. Morgan Street, Chicago, IL 60607-7045. *Developing Solution Sets with Polyhedral Methods.* Preliminary report.

Numerical algebraic geometry has given us tools to manipulate positive dimensional solution sets of polynomial systems. Paths defined by polyhedral homotopies originate at the first coefficient of a Puiseux series expansion. Recently we extended this polyhedral approach to a preprocessing algorithm to compute common factors of two polynomials. This approach is promising to exploit permutation symmetry: initial form systems in the same orbit are solved only once. Developing polyhedral algorithms for more than one dimensional solution sets gives insight in the structure of the pretropical variety. We illustrate our developments with computational results on benchmark problems. (Received September 01, 2010)

1064-65-113 **Wenyuan Wu** and **Zhonggang Zeng*** (zzeng@neiu.edu), Department of Mathematics, Northeastern Illinois Univeristy, Chicago, IL 60625. *The Numerical Irreducible Factorization of Multivariate Polynomials.* Preliminary report.

Computing the irreducible factorization of a multivariate polynomial is an ill-posed problem whose solution is high sensitive to data perturbations. With a proper formulation, however, the numerical irreducible factorization becomes well posed and suitable for approximate computation. In this talk present the regularization theory, convergence theorems, and a two-staged algorithm for accurate computation of the numerical irreducible factorization in the presence of data errors. (Received September 01, 2010)

1064-65-127 **Jonathan D Hauenstein*** (jhauenst@math.tamu.edu), Texas A&M University, Department of Mathematics, Mailstop 3368, College Station, TX 77845-3368, and **Andrew J Sommese** (sommese@nd.edu), University of Notre Dame, Applied & Computational Math. and Stat., Notre Dame, IN 46556. *Witness sets of projections.*

Elimination is a basic algebraic operation which geometrically corresponds to projections. The tools in numerical algebraic geometry allow us to compute a witness set for the image of an algebraic set under any linear map, in

particular, a projection. This talk will illustrate this idea as well as apply it to problems which are intractable using other methods. This is joint work with Andrew Sommese. (Received September 03, 2010)

1064-65-180 **Nicholls David*** (nicholls@math.uic.edu), Dept of Math, Stat, & CS (MC 249), University of Illinois at Chicago, 851 South Morgan Street, Chicago, IL 60607, and **Reitich Fernando**. *High-Order Integral Equations Methods for High-Frequency Scattering by Diffraction Gratings.*

In this talk we present a new high-order Integral Equation algorithm for the simulation of high-frequency scattering returns by diffraction gratings. For shallow gratings (those for which Geometric Optics indicates that there will be no multiple reflections) the method amounts to a phase-extraction technique resulting in a slowly-varying amplitude as unknown which requires only a small number of degrees of freedom to resolve. For deeper gratings we follow the work of Bruno, Reitich, and collaborators (e.g., Phil. Trans. Roy. Soc. London A 362, 2004) who utilize Geometric Optics corrections to iteratively update the rapidly varying amplitude which consists of many slowly-varying components. Our current contribution shows that the iterative update scheme can be eliminated and replaced with a simultaneous solution procedure. While our central ideas can be extended to the full vector electromagnetic time-harmonic Maxwell equations, we focus upon the case of two-dimensional linear acoustics for simplicity. (Received September 08, 2010)

1064-65-234 **Catalin Turc***, 10900 Euclid Ave Yost 220, Cleveland, OH 44106, and **Oscar Bruno** and **Akash Anand**. *Well posed integral equation formulations for the solution of three dimensional scattering problems in Lipschitz domains.* Preliminary report.

We present several well posed frequency domain integral equation formulations for the solution of three dimensional scattering problems in domains with edges and corners. We show that these formulations discretized using a novel Nystrom method based on non-overlapping patches and Chebyshev grids deliver rapidly convergent solutions for acoustic and electromagnetic scattering problems in domains with edges and corners. (Received September 10, 2010)

1064-65-304 **Luoding Zhu***, Department of Mathematical Sciences, 402 N. Blackford St., LD270, Indianapolis, IN 46202. *A lattice-Boltzmann based immersed boundary method in three dimensions with application.*

The immersed boundary (IB) method originated by Charles Peskin has been popular in modeling and simulating problems involving the interaction of a flexible solid structure and a viscous incompressible fluid. The Navier-Stokes equations in the IB method are usually solved by numerical methods such as FFT or projection methods. Here in our work the N-S equations are solved by an alternative approach, the lattice Boltzmann method (LBM). Compared to many conventional N-S solvers, the LBM is relatively easier to implement and more convenient to model additional physics in a problem. This alternative approach adds extra versatility to the immersed boundary method. In this talk we will briefly introduce the IB method and the lattice Boltzmann method, discuss the use of a 3D lattice Boltzmann model (D3Q19) in the IB method, implementation of the hybrid method (both explicit and implicit), and application of the method in simulation of a viscous flow past a flexible sheet tethered at its middle-line or upstream-edge in a three dimensional channel. (Received September 13, 2010)

1064-65-328 **Yassine Boubendir*** (boubendi@njit.edu), New Jersey Institute of Technology, Math dept. Univ. Height, 323 Dr. M. L. King Jr. Blvd, Newark, NJ 07102, and **Xavier Antoine** and **Christophe Geuzaine**. *Quasi-Optimal Convergence of Non Overlapping Domain Decomposition Method: the Helmholtz Equation.*

In this talk, we present a new non overlapping domain decomposition method where the transmission conditions are defined using suitable representation of Dirichlet to Neumann operator. Following a general overview of the method, we explain the approximation procedure of these operators and discuss convergence properties of the iterative method. Numerical results, both in 2D and 3D, are presented and show that the effective convergence is quasi-optimal. (Received September 13, 2010)

1064-65-350 **Misun Min*** (mmin@mcs.anl.gov), 9700 S. Cass Ave, Argonne, IL 60439, and **Paul Fischer**. *An efficient high-order time-integration method based on Krylov appraoximations for electromagnetic modeling.*

We present efficient algorithms and practical implementation of an explicit-type high-order timestepping method based on Krylov subspace approximations, with a motivation for possible application to large-scale engineering problems in electromagnetics, specifically accelerator modleing and nanophotnics applications. We consider a

semi-discrete form of the Maxwell's equations resulting from spectral-element discontinuous Galerkin discretizations in space whose solution can be expressed analytically by a large size matrix exponential of dimension n x n. We project the matrix exponential into a small Krylov subspace by Arnoldi process and perform matrix exponential operation with a much smaller matrix of dimension m x m (m ¡¡ n), whose convergence is generally the order of (m-1) in time. This method allows to take larger timestep sizes as m increases so that total simulation time can be reduced. We demonstrate CPU time reduction in comparison to the results by the the 4th-order Runge-Kutta method. Parallel implementation and efficiency at large scale will be also discussed. (Received September 14, 2010)

1064-65-354 **Thomas Hagstrom*** (thagstrom@smu.edu), Department of Mathematics, PO Box 750156, Dallas, TX 75275-0156, and **Seungil Kim**, **Kurt Stein** and **Timothy Warburton**.
Complete Radiation Boundary Conditions on Rectangular Domains.

The solution of time-domain scattering problems using pde formulations requires near-field radiation boundary conditions which can provide any specified accuracy at reasonable cost and be applied in convenient computational domains. Complete radiation boundary conditions (CRBCs) for isotropic wave systems meet both of these requirements. CRBCs are local boundary condition sequences which interpolate exact conditions along a Laplace inversion contour $\Re s = T^{-1}$ where T is the simulation time. Assuming a separation δ of sources from the boundary, we prove that q nodes can be chosen to guarantee an error less than ϵ with

$$q \propto \ln \frac{1}{\epsilon} \cdot \ln \frac{cT}{\delta}$$

To implement the conditions we evolve a hyperbolic system of $O(q)$ boundary variables. On domains with corners, we must close the boundary system with appropriate compatibility relations. These are derived for smooth solutions by extending the boundary variables, leading to sparse but implicit systems of differential equations for a set of corner variables. Energy estimates establish the uniqueness of solutions with high regularity in domains with corners. Numerical experiments demonstrate the method's accuracy and efficiency. (Received September 14, 2010)

1064-65-375 **Timothy M McCoy*** (tmccoy@nd.edu), 262 Hurley Hall, Notre Dame, IN 46556.
Extensions of Filtering Techniques and Applications to Zebrafish. Preliminary report.

Discretizations of PDEs arising from models of interest in science and engineering often yield polynomial systems. Homotopy continuation methods offer a means of computing all solutions to such systems without any a priori expectations. However, the relative number of solutions of physical significance is typically small, so many CPU cycles are wasted on discarded solutions. For problems on large grids, this can lead to impractical computation time. Filtering is a technique for reducing this inefficiency by first solving on a smaller, tractable grid. This talk will look at recent refinements to filtering, with specific applications to a model of dorsal-ventral patterning in zebrafish. (Received September 14, 2010)

1064-65-400 **Nilima Nigam***, Dept. of Mathematics, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 2S6, Canada, and **Simon Gemmrich**. *Boundary integral equations on the sphere- discretization and applications.*

The study of PDEs evolving on surfaces has attracted much attention recently, particularly for applications in atmospheric and oceanic sciences, pattern formation and computational graphics. The resulting models lead to boundary value problems on the submanifolds with specified boundary data. In this talk we present recent work on integral equation reformulations of model boundary value problems on the sphere. Integral equations possess advantages over PDE descriptions of such models, including dimension reduction or when the boundary curve or data is highly irregular.

The double layer operator for the Laplace-Beltrami boundary value problem possesses properties which are analogous, but not identical, to the double layer operator for the Laplacian on the plane. Lipschitz curves need particular consideration in both cases. We elucidate some of these similarities and differences. We then present Galerkin discretization strategies and some preliminary results for integral equations arising in other application areas which lead to related PDE. (Received September 14, 2010)

68 ► Computer science

1064-68-129 **Yang Cao*** (ycao@cs.vt.edu), 2160L Torgerson Hall, Computer Science Department (0106), Virginia Tech, Blacksburg, VA 24061. *Multiscale Challenges in Stochastic Simulation of Biochemical Systems.*

Random effects in cells have been a concern in systems biology in recent years due to low copy numbers of DNAs, RNAs and proteins in a single cell. Stochastic simulation algorithms have been developed to simulate biochemical models. In these biochemical models, they often contain species and reaction channels across a large scale range. A system could have species with populations of a million and species with population around a dozen. Some reactions will fire orders of magnitude faster than others. These features characterize the computational challenges we face when designing stochastic simulation methods for biochemical systems. In this talk I will give a review for the current progress in the development of stochastic simulation algorithms and discuss different efforts to answer the multiscale challenges. (Received September 03, 2010)

76 ► Fluid mechanics

1064-76-237 **C. Foias** and **M. S. Jolly*** (msjolly@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405, and **R. Kravchenko**. *A determining form for the 2-D Navier-Stokes equations.*

The determining modes for the incompressible Navier-Stokes equations (NSE) are shown to satisfy a differential equation which preserves the solutions of the NSE. This new infinite-dimensional system is shown to be dissipative; an estimate for the radius of an absorbing ball is derived in terms of the number of modes and the Grashof number. (Received September 10, 2010)

1064-76-302 **Suncica Canic***, University of Houston, Department of Mathematics, 651 PGH, Houston, TX 77204. *Mathematical Methods in Cardiovascular Applications.*

Mathematical modeling, analysis and numerical simulation provide a powerful tool to study various aspects of cardiovascular treatment. This talk will address two examples: a mathematical study of fluid-structure interaction with a clinical application to 2D and 3D Doppler assessment of mitral regurgitation, and a novel multi-scale approach to modeling coronary stents as 3D meshes of 1D curved rods (3D network of 1D hyperbolic conservation laws). An overview of the basic mathematical ideas underlying this research and several applications to cardiovascular treatment will be presented. This talk will be accessible to a wide scientific audience. The work reported in this talk has been performed together with medical collaborators Dr. W. Zoghbi, Dr. S. Little and Dr. D. Paniagua of the Texas Medical Center in Houston and with mathematicians Prof. J. Tambaca (University of Zagreb, CRO), Prof. R. Glowinski, Prof. G. Guidoboni, post-doc A. Quaini, and graduate students M. Bukac, M. Kosor and T.B. Kim (UH). (Received September 13, 2010)

1064-76-355 **Roman Shvydkoy*** (shvydkoy@math.uic.edu), 851 Morgan St, MC 249, Chicago, IL 60607. *On scaling laws of fully developed turbulence.* Preliminary report.

This talk will focus on a possibility of deriving the classical scaling laws of turbulence for Leray-Hopf weak solutions to the NSE. Although the results of this kind are not new we will present some sharper estimates on the second order structure function, as predicted by the similarity and refined similarity hypotheses, as well as properly defined energy spectrum of the solutions. A distinctive feature of the upper estimates is that they don't require the use of the Navier-Stokes equations and are sharp in the vicinity of the dissipation wavenumber. This is a part of an ongoing joint work with A. Cheskidov. (Received September 14, 2010)

1064-76-381 **Philippe Sucosky***, 143 Multidisciplinary Research Building, Department of Aerospace and Mechanical Engine, University of Notre Dame, Notre Dame, IN 46556. *Modeling of Heart Valve Disease: State-of-the-Art and Future Directions.*

As the underlying cause of 44,000 deaths in the US, calcific aortic stenosis has significant societal impact. This condition characterized by an accumulation of calcium on aortic valve leaflets leads to the obstruction of the left ventricular outflow and ultimately heart failure. Although tremendous progress has been achieved in the design of valve implants, valve replacements still pose significant challenges related to surgical risks and implant durability. The development of novel methods enabling the early detection of the disease and its non-invasive management has been hampered by the lack of understanding of valvular pathobiology. Although the onset of valvular disease was attributed for years to risk factors and genetic predisposition, recent developments suggest that abnormal mechanical stresses may also cause tissue calcification. The complexity of valvular hemodynamics along with the

paucity of information on valvular biology provide an intriguing system to investigate the mechanobiological root of valvular disease and to utilize this knowledge toward the design of patient-specific models of disease progression. This presentation describes the state-of-the-art in valvular flow techniques, ex vivo mechanobiological studies and valvular disease progression modeling. (Received September 14, 2010)

78 ► Optics, electromagnetic theory

1064-78-9 **Sergey V Petropavlovsky** and **Semyon V Tsynkov*** (tsynkov@math.ncsu.edu), Department of Mathematics, North Carolina State University, Box 8205, Raleigh, NC 27695-8205. *A Non-Deteriorating Algorithm for Computational Electromagnetism Based on Quasi-Lacunae of Maxwell's Equations.*

The performance of many well-known methods used in computational electromagnetism for the treatment of outer boundaries may deteriorate over long time intervals. The methods found susceptible to this undesirable phenomenon include some local low order artificial boundary conditions , as well as perfectly matched layers. We propose a universal algorithm for correcting this problem. It works regardless of either why the deterioration occurs in each particular instance, or how it actually manifests itself (loss of accuracy, loss of stability, etc.). Our algorithm relies on the Huygens' principle in a generalized form, when a non-zero electrostatic solution can be present behind aft fronts of the propagating waves, i.e., inside the lacunae of Maxwell's equations. In this case, we refer to quasi-lacunae as opposed to conventional lacunae, when the solution behind aft fronts is zero. The use of quasi-lacunae allows us to overcome a key constraint of the previously developed version of the algorithm that was based on genuine lacunae. Namely, the currents that drive the solution no longer have to be solenoidal. Another important development is that we apply the methodology to general non-Huygens' problems. (Received July 09, 2010)

1064-78-378 **Michael C Haslam*** (mchaslam@mathstat.yorku.ca), Department of Mathematics and Statistics, York University, 4700 Keele St., Toronto, Ontario M3J 1P3. *High Order Solvers for Large Driven Wire Arrays.*

We discuss our recent work concerning the evaluation of the current induced on an arbitrarily large array of non-intersecting wire segments with a current source located on an array element. In this work the source model is taken to be the widely-used delta-gap generator in which a finite voltage is maintained across an infinitesimally small distance. This idealized driving source produces a delta function in the source terms of the Pocklington integro-differential equation for the current; specialized treatment of these terms is required to maintain the high-order convergence of our algorithms. We illustrate the performance of our solvers by considering an array of several hundred wire elements. Near and far-field results are efficiently extracted along with other quantities of interest such as the antenna gain. With Oscar Bruno, Caltech. (Received September 14, 2010)

80 ► Classical thermodynamics, heat transfer

1064-80-251 **Kishor Ramrao Gaikwad*** (kishor_1944@yahoo.co.in), Dept. of Mathematics, Savitribai Phule Womens Engineering college, Aurangabad, 431004, India, and **Kirtiwant P Ghadle** (drkp.ghadle@yahoo.com), Dept. of Mathematics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, 431004, India. *A note of quasi-static thermal deflection in a thin circular plate.*

The aim of this work is to determine the quasi-static thermal deflection in a thin circular plate subjected to an arbitrary heat flux on the upper surface under a un-steady state field is considered. The fixed circular edge thermally insulated and the temperature of a lower surface is kept at zero. The governing heat conduction equation has been solved by using Laplace transform technique. The results are obtained in series form in terms of Bessel's functions. The results for temperature and deflection have been computed numerically and illustrated graphically. (Received September 11, 2010)

81 ► Quantum theory

1064-81-13 **Stephen F Sawin*** (ssawin@fairfield.edu), 1073 N. Benson Road, Bannow 105, Fairfield, CT 06824, and **Dana Fine** (dfine@umassd.edu). *Supersymmetric Quantum Mechanics, Infinite-Dimensional Matthai-Quillen, and the Gauss-Bonnet-Chern Theorem.* Preliminary report.

An interpretation of the path integral representation of the propagator of $N = 1$ imaginary time Supersymmetric Quantum Mechanics in curved space-time is offered which is sufficiently robust that it can be proven to yield the heat kernel of the Hodge-Laplace operator and also to be approximated by the steepest descent approximation for both small time and small $\hbar$ (in real time this would correspond to the stationary phase approximation). These tools allow one to make the proof of the Gauss-Bonnet-Chern Theorem suggested by Witten and made precise by Alvarez-Gaumé and Friedan and Windey rigorous essentially as is (they work with the Index Theorem, but for simplicity we restrict attention to the special case of the GBC Theorem). (Received July 22, 2010)

1064-81-334 **Andreas Malmendier*** (andreas.malmendier@colby.edu), 5835 Colby College, Waterville, ME 04901, and **Ken Ono** (ono@mathcs.emory.edu), Department of Mathematics, Mathematics and Science Center, Suite W410, Atlanta, GA 30322. *Supersymmetric gauge theory in four dimensions and mock modular forms.*

The moduli space of vacua for the topological $\mathcal{N} = 2$ supersymmetric pure gauge theories with gauge group SU(2) or SO(3) is the universal elliptic curve for the modular group $\Gamma(2) \subset \mathrm{SL}(2;\mathbb{Z})$. Moreover, the supersymmetric gauge theory associates a not necessarily holomorphic modular form of weight $(\frac{1}{2}\, b_2^+ + 1, \frac{1}{2}\, b_2^-)$ to each four-manifold.

In the case $b_2^+ = 1$ the contributions of this function at the cusps of $\mathbb{H}/\Gamma(2)$ are interesting (almost) topological invariants of the manifold. To evaluate the cusp contributions, also called the u-plane integral, one can use nonholomorphic modular forms or Mock theta functions. In the case of the SO(3)-gauge theory on $\mathbb{C}\mathrm{P}^2$ we prove using a particular Mock theta function that the cusp contribution from $\tau = i\infty$ is closely related to the Donaldson invariants of $\mathbb{C}\mathrm{P}^2$, a conjecture made by Moore and Witten. (Received September 14, 2010)

1064-81-390 **Jens Koeplinger*** (jens@prisage.com), 105 E Avondale Dr, Greensboro, NC 27403, and **Vladimir Dzhunushaliev** (vdzhunus@krsu.edu.kg), Kyrgyz-Russian Slavic University, Dept. Phys. and Microel. Eng., Kievskaya Str. 44, 720021 Bishkek, Kyrgyzstan. *Notes towards a nonassociative quantum theory.* Preliminary report.

This talk briefly sketches two proposed approaches where nonassociativity is used to model observable properties of a physical quantum system. The first approach aims at understanding strongly coupled fields, such as the strong force of the Standard Model, which is modeled through unobservable interaction partners and has a limited interaction radius. The second approach investigates algebraic properties of exponentiation in the complex numbers, for a proposed generalization of Born's rule in quantum mechanics when using octonions. (Received September 14, 2010)

82 ► Statistical mechanics, structure of matter

1064-82-388 **Tian Ma**, Chendgu, Sichuan , Peoples Rep of China, and **Shouhong Wang*** (showang@indiana.edu), Bloomington, IN 47405. *Dynamic Transition Theory and its Application to Gas-Liquid Phase Transitions.*

Gas-liquid transition is one of the most basic problem to study in equilibrium phase transitions. In the pressure-temperature phase diagram, the gas-liquid coexistence curve terminates at a critical point C, also called the Andrews critical point. It is, however, still an open question why the Andrews critical point exists and what is the order of transition going beyond this critical point. To answer this basic question, using the Landau's mean field theory and the Le Chatelier principle, for the first time, a dynamic model for the gas-liquid phase transitions in a PVT system is established. With this dynamic model, we are able to derive a theory on the Andrews critical point C: 1) the critical point is a switching point where the phase transition changes from the first order with latent heat to the third order, and 2) the liquid-gas phase transition going beyond Andrews point is of the third order. This clearly explains why it is hard to observe the liquid-gas phase transition going beyond the Andrews point. In addition, the study suggest an asymmetry principle of fluctuations, which appears also in phase transitions in ferromagnetic systems. This example demonstrates a symbiotic interplay between advanced mathematics and nonlinear sciences. (Received September 14, 2010)

92 ► Biology and other natural sciences

1064-92-32 **Richard Yamada*** (yryamada@umich.edu), 530 Church Street, 2074 East Hall, Ann Arbor, MI 48109-1043. *What can noise do for you? Understanding the role of molecular noise in mammalian time-keeping.*

Biological cells can best be described as a complex machine; the cell's survival depends on regulating many processes and transporting materials with exacting precision. Each of these individual cells contain a wide array of macromolecules, including proteins and messenger ribo-nucleotide triphosphates (mRNA). However, the specific number of particular proteins (such as activators and repressors) and mRNA molecules is hypothesized to be small. Thus, fluctuations in molecular number (i.e. molecular noise) may play an important role in affecting cellular physiology, such as transcription regulation and post-translational modifications.

In this talk, we discuss the effect of noise on an important physiological process: cellular time-keeping. Specifically, we explore the role of molecular noise at both the intra-cellular and inter-cellular level. We will see that biological phenomena presents us with interesting questions that can be further simplified (as 'toy models') for mathematical analysis. We then conclude with a brief discussion of the mathematical tools that must be developed in order to properly understand the results from these models. (This talk is joint work with Joseph Takahashi, Caroline Ko, David Welsh, Kara Fulton, and Danny Forger.) (Received August 15, 2010)

1064-92-36 **Yangjin Kim*** (yangjink@umd.umich.edu), 2078 CASL Building, 4901 Evergreen Road, Dearborn, MI 48128, **Hans G. Othmer** (othmer@math.umn.edu), 270A Vincent Hall, 206 Church St. SE, Minneapolis, MN 55455, and **Magdalena A. Stolarska** (mastolarska@stthomas.edu), 2115 Summit Avenue, Saint Paul, MN 55105. *A multi-scale mathematical model of tumor-microenvironment interactions.*

Mathematical modeling holds great promise for medicine to predict tumor growth and therapeutic drug response. Fibroblasts and myofibroblasts near the tumor microenvironment are important players in tumor growth and metastasis because of their unique ability to coordinate events which increase cell proliferation especially in breast cancer. It has been experimentally shown that fibroblasts play an important role in promoting tumor growth in vitro. A multi-scale model of this interaction between stroma and transformed epithelial cells near breast duct will be presented. EGF-TGFbeta signal pathway controls these interactions and our multi-scale model describes these phenomena at different time and spatial time scales, i.e., intracellular dynamics, cell dynamics at cellular level, and mechanical interaction between tumor cells and stromal tissue (continuum). (Received August 16, 2010)

1064-92-37 **Ching-Shan Chou*** (chou@math.ohio-state.edu), 412 Math Tower, 231 W. 18th Ave, Columbus, OH 43210, and **Qing Nie** and **Tau-Mu Yi**. *Noise Filtering in Spatial Gradient Sensing and Response during Yeast Cell Polarization.*

Cells sense chemical spatial gradients and respond by polarizing internal components. This process is disrupted by gradient noise caused by fluctuations in chemical concentration. In this talk, I will discuss how gradient noise affects spatial sensing and response. In our study, we discovered that a combination of positive feedback, multiple signaling stages, and time-averaging produced good results. There was an important tradeoff, however, because filtering resulted in slower polarization. Using both modeling and experiments, we showed that yeast cells likely also combine the above three filtering mechanisms to achieve impressive spatial-noise tolerance, but with the consequence of a slow response time. (Received August 17, 2010)

1064-92-42 **Abbas Shirinifard*** (ashirini@indiana.edu), Simon Hall MSB1, 047, 212 S. Hawthorne Drive, Bloomington, IN 47405, and **James Alexander Glazier** (glazier@indiana.edu), Simon Hall MSB1, 047, 212 S. Hawthorne Drive, Bloomington, IN 47405. *3D Multi-Cell Simulation of Angiogeneis and Its Application in Tumor Growth and Choroidal Neovascularization.*

Angiogenesis is the adaptive formation of new blood vessels in both embryonic and adult tissues. It can both cure and cause diseases depending on the vessels' interaction with their micro-environment. The underlying mechanisms controlling growth and patterning of capillaries are multi-scale and stochastic and thus require appropriate stochastic mathematical description. We introduce a 3D simulation of angiogenesis using the Glazier-Graner-Hogeweg model (GGH), a multi-cell, lattice-based, stochastic model which describes biological cells and their interactions. We use our simulation to investigate the interaction of a growing micro-tumor with neighboring capillary vasculature and the morphological and kinetic differences between vascular and avascular tumors. We also use our 3D angiogenesis simulation to simulate choroidal neovascularization (CNV), the leading cause of adult blindness in industrialized societies. We identify failures in particular types of inter-component adhesion as

the causes of specific types of CNV. In both cases, stochastic multi-cell studies of angiogenesis effectively capture the complex interactions between capillaries and their micro-environment and make meaningful, experimentally testable predictions. (Received September 06, 2010)

1064-92-44 **Mark Alber*** (Albemark@gmail.com), Department of Applied and Computational, Mathematics and Statistics, 255 Hurley, Building, University of Notre Dame, Notre Dame, IN 46656, **Pavel Lushnikov**, Department of Mathematics and Statistics, University of New Mexico, Albuquerque, NM 87131, and **Richard Gejji**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall, 3rd Floor, Columbus, OH 43210. *Macroscopic model of self-propelled bacteria swarming with regular reversals.*

Periodic reversals of the direction of motion in systems of self-propelled rod shaped bacteria enable them to effectively resolve traffic jams formed during swarming and maximize their swarming rate. In this talk, a connection will be presented between a microscopic one dimensional cell-based stochastic model of reversing non-overlapping bacteria and a macroscopic non-linear diffusion describing dynamics of cellular density. Boltzmann-Matano analysis is used to determine the nonlinear diffusion equation corresponding to the specific reversal frequency. Combination of microscopic and macroscopic models are used for studying swarming rates of populations of bacteria reversing at different frequencies. It is shown that cell populations with high reversal frequencies are able to spread out effectively at high densities. If the cells rarely reverse then they are able to spread out at lower densities but are less efficient at spreading out at higher densities. (Received August 20, 2010)

1064-92-54 **Hans G Othmer*** (othmer@math.umn.edu), School of Mathematics, University of Minnesota, 206 Church St S E, Minneapolis, MN 55455. *Multi-scale analysis of stochastic reaction networks.* Preliminary report.

In many complex reaction networks the reactions occur on vastly different time scales, but the usual form of the evolution equations does not lend itself to identification of slow and fast variables. In this talk we first show how they can be identified in deterministic systems, and we then discuss recent work on stochastic multi-scale analysis of reaction networks. (Received August 23, 2010)

1064-92-67 **Yuan Lou*** (lou@math.ohio-state.edu), Department of Mathematics, Ohio State University, Columbus, OH 43210. *Ideal free distribution and evolution of dispersal.*

A dispersal strategy, which results in the ideal free distribution of a single population at equilibrium, was found in Cantrell et al. (Math Bios. Eng., Vol 7 (2010) 17-36). It was shown by Cantrell et al. that this special dispersal strategy is a local evolutionarily stable strategy when the random diffusion rates of the two species are equal, and here we show that it is a global evolutionarily stable strategy for arbitrary random diffusion rates. The conditions in Cantrell et al. for the coexistence of two species are substantially improved. We show that this special dispersal strategy is not globally convergent stable for certain resource functions, in contrast with the result from Cantrell et al., which roughly says that this dispersal strategy is globally convergent stable for any monotone resource function. This is based upon a joint work with Isabel Averill and Dan Munther. We will also report some further progress on the convergent stability of this ideal free dispersal strategy in the more general context of the evolution of two traits, based upon a joint work with Richard Gejji, Dan Munther, and Justin Peyton. (Received August 25, 2010)

1064-92-84 **Ruijun Zhao*** (rzhao@purdue.edu), 305 North University Street, Purdue University, Department of Computer Science, West Lafayette, IN 47907, and **Fabio A. Milner**. *An Epidemic S-I-R Model with Directed Spatial Diffusion.*

We study an epidemic S-I-R model with spatial structure in which the susceptible move away from infection and total population avoid overcrowding. In particular, the model is analyzed in two extreme cases–moving in avoidance of infection only and overcrowding only. We show existence of a finite time blow-up solution for the case of avoiding infection only. Challenge of solving this type of problems is discussed. Some numerical results using a scheme based on Runge-Kutta Discontinuous Galerkin method are presented. (Received August 30, 2010)

1064-92-97 **David Gurarie*** (dxg5@case.edu), Math. dep., CWRU, Cleveland, OH 44106. *Stochastic within-host models of malaria infection: calibration and Agent-Based Communities.*

Agent-based modeling of malaria infection offers an attractive alternative to the conventional population-based methodology. It allows to accommodate heterogeneous 'host-vector-parasite' populations and realistic transmission environment. To build such community model one need a suitable within-host model (agent) that accounts for host immunity and parasite regulation. Immune response involves a complex array of multiple cell-types, signaling/effector proteins and cascading processes. Other complexities arise from immune-evasion strategies

by many parasites, like malaria P-falciparum. Stochastic processes are useful for representing such complex dynamics. We outline several within models ranging from a simple 3-state system, to more detailed versions. All of them can be efficiently manipulated (mathematically and computationally) to allow numeric experiments with large host ensembles' and communities'. Some of these models were calibrated using malaria-therapy data. We explain the details of calibration. The resulting choices of within-host' parameters provide us the basic building blocks for Agent-based Communities (ABC). We demonstrate a few examples of such ABC, and look in particular at the effect of transmission intensity on the resulting patterns of parasitemia. (Received August 31, 2010)

1064-92-136 **Evgeniy Khain*** (khain@oakland.edu), 2200 N. Squirrel Road, Oakland University, Rochester, MI 48309. *Migration and clustering of glioma cells.*

We investigate clustering of malignant glioma cells [1]. In vitro experiments in collagen gels identified a cell line that formed clusters in a region of low cell density, whereas a very similar cell line (which lacks an important mutation) did not cluster significantly [2,3]. We hypothesize that the mutation affects the strength of cell-cell adhesion. We investigate this effect in a new experiment [1], which follows the clustering dynamics of glioma cells on a surface. We interpret our results in terms of a stochastic model and identify two mechanisms of clustering. First, there is a critical value of the strength of adhesion; above the threshold, large clusters grow from a homogeneous suspension of cells; below it, the system remains homogeneous, similarly to the ordinary phase separation. Second, when cells form a cluster, we have evidence that they increase their proliferation rate. We have successfully reproduced the experimental findings [1] and found that both mechanisms are crucial for cluster formation and growth.

[1]. E. Khain et al, EPL 88, 28006 (2009). [2]. E. Khain and L.M. Sander, Phys. Rev. Lett. 96, 188103 (2006). [3]. A. M. Stein et al, Biophys. J. 92, 356 (2007). (Received September 03, 2010)

1064-92-217 **Qing Nie*** (qnie@math.uci.edu), Department of Mathematics, Department of Biomedical Engineering, University of California, Irvine, Irvine, CA 92697-3875. *Noise attenuation and computational tools for biological systems.*

In this talk, I will first discuss noise attenuation in biological systems with feedbacks. I will present a new critical quantity, called Signed Activation Time (SAT) and its relationship with noise amplification. In the second part of the talk, I'll present a new class of efficient numerical algorithms for stiff PDEs that have applications to solving models for spatial dynamics of complex biological systems. (Received September 09, 2010)

1064-92-312 **Alex Capaldi*** (alex.capaldi@valpo.edu), 1900 Chapel Drive, Valparaiso, IN 46383. *Model Selection for an Outbreak of Influenza in a Boarding School.*

Epidemiologists often strive to calculate the basic reproductive number, R_0, for an outbreak to use as a summary of the strength of the infection. This is frequently done indirectly by fitting a model to data. However, choosing an appropriate model to fit to the data is a non-trivial step in the modeling process. In this presentation, we apply the Akaike information criterion to select a model from a series of ODE and PDE epidemic models fitted to an outbreak of influenza in a boys' boarding school in England. We find that an uncommonly used epidemic model, a Susceptible-Infective-Confined-Recovered (SICR) model, is the best fitted, most parsimonious model and produces an estimate of R_0 of 4.25. (Received September 13, 2010)

1064-92-346 **Kimberly D Kendricks*** (kkendricks@centralstate.edu), 144 Henderson Hall, Central State University, 1400 Brush Row Rd., Wilberforce, OH 45384, **Ronald F Tuttle** (ronald.tuttle@afit.edu), Air Force Institute of Technology, Bldg. 640, Rm. 207, 2950 Hobson Way, WPAFB, OH 45433, and **Adam M Fullenkamp** (adam.fullenkamp@wpafb.af.mil), Air Force Research Laboratory, WPAFB, 711 HPW/RHPAA, 2800 Q. Street, WPAFB, OH 45433. *Results from a Groebner Basis Study in Gait Analysis.* Preliminary report.

In the gait cycle, two important indicators: wrist and foot placement, when isolated, provide key information about future behaviors in the gait cycle. To determine the placement of the wrist and foot in the gait cycle, an inverse kinematic model was derived for the upper and lower extremities in the sagittal plane using a Groebner basis. This model was used to predict wrist and foot placement at one hundred points of the gait cycle for twenty human subjects. The results of the study will be presented as well as future projects in gait analysis. (Received September 14, 2010)

1064-92-366 **Leonard M Sander*** (lsander@umich.edu), 450 Church St., Ann Arbor, MI 48109-1040.
Fluctuations and stability in front propagation.

Propagating fronts arising from bistable reaction-diffusion equations are a purely deterministic effect, and are important in many contexts in cell biology. However, within cells, populations are small, and fluctuations are important. Stochastic reaction-diffusion processes also show front propagation which coincides with the deterministic effect in the limit of small fluctuations (large populations). However, for larger fluctuations propagation can be affected.

We give an example where the direction of wave propagation, i.e., the relative stability of two phases, can be *reversed* by fluctuations.

With E. Khain and Y. T. Lin (Received September 14, 2010)

1064-92-380 **Peter J Thomas*** (pjthomas@case.edu), 10900 Euclid Avenue, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, OH 44106, and **Stephen J Fleming** (pjt9@case.edu), Cleveland, OH 44106. *Gradient Sensing as a Statistical Estimation Problem: Comparison with Experimental Data.*

A eukaryotic cell performing chemotaxis must estimate the external gradient direction from the signal available from a population of $N \gtrsim 10,000$ receptors distributed across the cell surface. We treat each receptor as an independent two-state Markov process with one transition rate (binding) proportional to the local signal concentration and another transition (release) that is constant, and study the distribution of an ideal observer's estimate of gradient direction based on maximum likelihood analysis of samples from the equilibrium distribution of receptor states in a 2D geometry. We find the accuracy of chemotaxis predicted for a 2D model better matches that observed experimentally than that predicted by one-dimensional models. However, when taking into account sampling over extended times, the accuracy of chemotaxis possible for the ideal observer is orders of magnitude finer than that observed in real cells. (Received September 14, 2010)

1064-92-399 **Sima Setayeshgar*** (simas@indiana.edu), Department of Physics, 727 E. Third St., Bloomington, IN 47401, and **Lin Wang**. *Information Processing by the* E. coli Chemotaxis Network.

Biochemical signal transduction, broadly defined as the conversion of the concentration of an input signal to an output response by networks of reacting proteins, is the most basic level of biological information processing. The biochemical reactions comprising these networks are inherently stochastic, inevitably affecting the faithful transmission of information. A major challenge is posed by the fact that input signals often possess dynamical and widely varying properties, and signaling networks are required to detect and process information under a broad range of environmental conditions. In this work, we investigate information processing by the *E. coli* chemotaxis network using a realistic, stochastic network model. We compute the dominant filters employed by the network in processing time-varying input ligand concentrations. We show that the input-output relation of the network adapts to the statistical properties of the input signal. We demonstrate that the rescaling property of input-output relation is to maintain the information transmitted about the stimulus by the chemotaxis network. (Received September 14, 2010)

97 ► Mathematics education

1064-97-10 **Michael Livshits*** (michaelliv@gmail.com), Michael Livshits, 36 Linnaean Street, Apt. 14, Cambridge, MA 02138. *Rethinking Calculus.*

Most people consider calculus a finished piece of mathematics, based on the late 19th century classical analysis. Many computer programs that help people learn it have been written. On the other hand, little has been done to simplify and clarify the fundamental concepts of calculus, in fact, many claim that it is impossible, since calculus is already perfect. I will challenge this point of view and discuss some recent progress, done by Hermann Karcher, Karl Dovermann, Peter Lax, Mark Bridger, Qun Lin and myself. I will start with differentiating polynomials by factoring $p(x) - p(a)$ through $x - a$, and show how calculus can be developed directly and naturally, with no use of limits and continuity, and hardly any use of real numbers. Some of the material for this talk is discussed in my preprint at http://arxiv.org/abs/0905.3611 and references there. My purpose is to convince the audience that calculus is rather elementary, that it can be understood without wading through unnecessary mathematical abstractions, that learning and teaching it can be made more satisfying for students and teachers alike. (Received July 14, 2010)

1064-97-38 **Paul E. Becker*** (peb8@psu.edu), School of Science, Penn State Erie, Erie, PA 16563, and **Mark Medwid**. *Matrix Representations in Group Theory and Geometry.*

Computer algebra systems are now widely available. We discuss one aspect of this new reality: Cayley's theorem as an instructional tool connecting abstract algebra, linear algebra, and geometry. The theorem may be broadly stated: each group with n elements is isomorphic to at least one group of permutation matrices. Most small groups are isomorphic to groups of block-diagonal permutation matrices with dimension much less than (n x n). With the aid of computer algebra systems, group theory can be treated as a continuation of introductory linear algebra. Students use the software to create and manipulate matrix groups. The block-diagonal structure provides a simple visual model of underlying subgroup structure. Undergraduates develop fundamental group theory concepts through experimentation. We present Maple worksheets developing the basic definitions of group, subgroup, homomorphism, isomorphism, etc. Further worksheets direct students toward normal subgroups, direct products, and semi-direct products. This approach allows immediate and frequent introduction of group actions. Every matrix group is inherently a group of functions, acting on vectors by multiplication. We conclude by describing a current geometry course which utilizes this approach. (Received August 18, 2010)

1064-97-96 **R. Michael Range*** (range@math.albany.edu), Department of Mathematics and Statistics, University at Albany, SUNY, Albany, NY 12222. *Derivatives without Limits: Do We Need to Rethink Elementary Calculus?*

I will discuss an elementary algebraic method to introduce derivatives, whose roots go back to Descartes and van Schooten in the 17th century, and which was recently resuscitated and extended to cover all algebraic functions. This simple approach avoids infinitesimals, differentials, and similar vague concepts, and most importantly, it does not require any limits. Furthermore, it naturally leads to continuity and to the modern definition of differentiability—in an elegant formulation introduced by C. Carathéodory—which needs to be considered when studying the elementary transcendental functions. This approach might provide an easier and more direct introduction to calculus for students in the 21st century than the standard 20th century approach which emphasizes limits early on. (Received August 31, 2010)

1064-97-111 **Diane L Herrmann*** (diane@math.uchicago.edu), 5734 South University Avenue, Chicago, IL 60637. *The Old Family Recipe.*

What is it that draws talented high school students to a department where the courses are challenging, the work load is heavy, and proofs are expected of every student? Many factors contribute to the success of the University of Chicago undergraduate mathematics program. This talk will address what we do to encourage high performing high school students to take an introductory honors sequence in calculus, and how we recruit our senior faculty to teach the course. The inclusion of an Inquiry Based Learning section and its continued success will also be discussed. (Received September 01, 2010)

1064-97-123 **Morteza Shafii-Mousavi*** (mshafii@iusb.edu), Mathematical Sciences, 1700 Mishawaka Ave., PO BOX 7111, South Bend, IN 46634-7111, and **Paul Kochanowski** (pkochano@iusb.edu), School of Business and Economics, 1700 Mishawaka Ave., PO Box 7111, South Bend, IN 46634-7111. *Using Service-Learning to Connect Mathematics Content to the World beyond the Classroom.*

In this article, we discuss service-learning in the mathematics classroom through the use of client-driven projects posed by business, government, and non-profit organizations and based upon real problems facing these organizations. Although client-driven projects have long been used in business and engineering education, their use in mathematics is rare. Service-learning represents authentic connection between some standard mathematics content and the world beyond the classroom, but their use as tools for teaching mathematics also raises many curricular and pedagogical issues. We discuss how service-learning seems to have a positive impact on students' attitudes, motivation, and actual learning. We share our seven-year experience of several facets of service-learning in teaching a non-major first-year mathematics course including, the acquiring of projects, the dynamics of the teams, assessment of students' work, the use of technology, and lessons we have learned in dealing with the practice of mathematics outside of academia. Furthermore, we briefly discuss projects used in our team-teaching over seven years along with the mathematical techniques applied in each project. (Received September 02, 2010)

1064-97-128 **Paul Kochanowski*** (pkochano@iusb.edu), School of Business and Economics, 1700 Mishawaka Ave., PO BOX 7111, South Bend, IN 46634-7111, and **Morteza Shafii-Mousavi** (mshafii@iusb.edu), Mathematical Sciences, 1700 Mishawaka Ave., PO Box 46634, South Bend, IN 46634-7111. *Mathematical Preparation for First Statistics Courses.*

In this presentation, we will discuss how the IUSB linked courses, Mathematics in Action: Social and Industrial Problems, and Introduction to Computing satisfy statisticians' articulated goals for prerequisites: 1) emphasize multiple presentations of mathematical objects; 2) multiple approaches to problem solving; 3) adopt learning-centered instruction and address students' different learning styles by employing multiple pedagogies; 4) insist that students communicate in writing and learn to read algebra for meaning; 5) use real, engaging applications through which students can learn to draw connections between the language of math and the context of the application; 6) instill appreciation of the power of technology and develop skills necessary to use appropriate technology to solve problems, develop understanding, and explore concepts; and 7) align assessment strategies with instructional goals. We will present project examples, lessons plans, descriptions of course structures illustrating how students in these linked classes learn mathematics, data generation, technological tools and applications. Further, the presentation will include examples of student team work, writing, discussion, and connections between the language of mathematics and the context of the application. (Received September 03, 2010)

1064-97-207 **David A. Smith*** (das@math.duke.edu), 1408 Shepherd St., Durham, NC 27707. *Changing the Culture: A 20th Century Vision Delayed.*

In the late 20th Century, many mathematics teachers shared a shift in primary objective from "reproducing our own kind" to "mathematical understanding for all". Educational research conducted around the world told us (if we were paying attention) what changes in classroom practice would be necessary if we were to achieve that objective. For many reasons, not the least of which is inertia, those changes have not been implemented widely at the collegiate level, so "mathematical understanding for all" has necessarily become a vision for the 21st Century. In this talk, I will survey briefly what we know about the art of changing students' brains positively for mathematical understanding. (Received September 09, 2010)

1064-97-264 **Mike May*** (maymk@slu.edu), SLU, Dept of Math & CS, 220 N Grand Blvd, St Louis, MO 63103. *Technology in the classroom: From slide rules to graphing calculators to computer applets.* Preliminary report.

The last third of the 20th century saw a shift in technology for the typical mathematics classroom, going from slide rules to graphing calculators, for the most part skipping over the scientific calculator in the process. As computers and computer like devices have become a standard part of the collegiate environment it is worthwhile asking what leads a technology to be skipped or routinely incorporated into a classroom. In this talk I will address how I see computers being incorporated into a standard classroom with a focus on applets over CAS. Pedagogical issues that accompany any shift in technology will also be addressed. Some time will be devoted to other approaches to incorporating computers into the mathematics classroom. (Received September 12, 2010)

1064-97-271 **Barbara E Reynolds, SDS*** (breynolds@stritch.edu), Department of Mathematics & Computer Science, Cardinal Stritch University, 6801 N. Yates Road, Milwaukee, WI 53217. *Engaging Digital Students: A 21st Century Challenge.*

A critical skills survey conducted for the American Management Association found that skills needed for work-force preparedness include critical thinking and problem solving, effective communication, collaboration and team building, creativity and innovation. Increasingly students arrive expecting to use cell phones, laptops, iPods, and other devices during class. Technology available to 21st century students was the stuff of science fiction not many years ago. Yet I notice paradoxes in student behaviors: web-savvy students shy away from on-line resources for course work, students surf the web for quick answers rather than reading for depth, and students who, when presented with a challenging problem, would rather find someone else's solution than figure it out on their own. Teaching in a technologically-rich classroom where I engage students in small-group activities, I constantly look for ways to unplug students from technology for entertainment and quick answers, and engage them in explorations leading to deeper thinking. My goal is to help students develop skills for life beyond the classroom. How can I wean students from a mentality that all important answers can be found on the web or in the back of the book? (Received September 12, 2010)

1064-97-273 **Steven Broad*** (sbroad@saintmarys.edu), 343 Madeleva Hall, Saint Mary's College, Notre Dame, IN 46556. *When students choose their own technology.* Preliminary report.

Mathematics educators have debated the use and methodologies for using computing tools in mathematics and statistics courses. Graphing calculators, computer algebra systems, numerical programming packages and statistical software packages have made inroads into a wide variety of classroom settings, usually as required by the instructor. Three new technology tools may change the ways that technology enters the mathematical learning experience, especially when even beginning students choose to use these tools independent of the instructor. We will focus on the use and impact on mathematics learning of the new "answer engine" Wolfram|Alpha, including how it can be used in instruction. (Received September 12, 2010)

1064-97-284 **Nahid A. Erfan*** (erfan.1@nd.edu), University of Notre Dame, First Year of Studies, 239 Coleman Morse Center, Notre Dame, IN 46556. *Supporting deep learning in mathematics outside the classroom.*

In this talk we will address issues of learning, academic environment and support services in an attempt to uncover ways in which universities can promote mathematical understanding for all by fostering deep learning. Deep learning involves analysis, synthesis and evaluation of learning, as opposed to mere memorization. Certain classroom environments, such as those that are more task oriented and collaborative, tend to promote deep learning. Additionally, courses in which assessments also require deep learning tend to encourage utilization of deep learning study strategies. At the same time, academic support services can facilitate deep learning through various programs. Considering the fact that students enter college with a variety of high-school math backgrounds, the Learning Resource Center (LRC) at the University of Notre Dame is supporting deep learning in mathematics outside the classroom through collaborative learning groups and by developing "just in time activities" to fill the gaps in students' mathematical background. The talk will conclude with a discussion about our experiences at LRC as we strive to create a learning environment that enables students to be more successful in their courses, but also ultimately help them be more successful beyond graduation. (Received September 13, 2010)

1064-97-288 **Michele Intermont***, Kalamazoo College, Dept of Mathematics, Kalamazoo, MI 49006. *Math is to English as Duck is to Water.*

Using writing projects in mathematics is not a new idea in pedagogical circles. However, our students still do typically perceive these two areas as completely distinct. I'll discuss my attempts at using writing in classes and I'll foster a discussion on a vision for the future: How we can move beyond the usual discretization of subjects and integrate mathematics into the fabric of our students' perceptions. (Received September 13, 2010)

1064-97-299 **Natalie Domelle*** (ndomelle@saintmarys.edu), 39 Madeleva, Department of Mathematics, Saint Mary's College, Notre Dame, IN 46556, and **Bogdan Vajiac** (bvajiac@saintmarys.edu), 48 Madeleva, Department of Mathematics, Saint Mary's College, Notre Dame, IN 46556. *Assessing Attitudes in College Mathematics Courses.* Preliminary report.

Students' beliefs and attitudes toward mathematics is an underlying factor that affects a course, a series of courses, and/or overall a program design. In addition to teaching content, instructors may want to shift students' views towards mathematics. This is especially important in general education courses, and required math courses for non-majors. We designed a survey that measures students' attitude towards mathematics including their overall views of mathematics, personal belief in their mathematical ability, and also their mathematical anxiety. We also included a question on their perception of factors of a good mathematics course. Our data includes results of surveys from mid-semester Spring 2010 and early Fall 2010 semester. A combination of students in calculus courses, other introductory level courses, and pre-service elementary school teacher courses were selected for participation in the survey. Comparisons of students enrolled in different levels and types of courses will be presented utilizing a variety of measures. We will discuss how the survey will proceed and how it might be useful in affecting curricular change. (Received September 13, 2010)

1064-97-314 **Raju Hegde*** (rhegde@grcc.edu), 143 Bostwick Ave. NE, Grand Rapids, MI 49503, and **Yumi Watanabe** (ywatanab@grcc.edu), 143 Bostwick Ave. NE, Grand Rapids, MI 49503. *Mathematics Education at Community Colleges -Where we've been, where we are, where we need to go-.*

In July 2009, President Obama announced a 12 billion dollar initiative for community colleges, indicating the important role community colleges play in education and our economic recovery. This initiative was designed to boost graduation rates. Community colleges certainly offer opportunities to those who would not have a chance at higher education otherwise. In this talk, the drastic changes and associated challenges many community college

mathematics departments face are highlighted by focusing on course offerings, curriculum designs, enrollment data, and student population over the last decade. The talk will end with a discussion about the role that selective four year institutions can play in improving mathematics education at all levels. (Received September 13, 2010)

00 ► General

1065-00-17 **Annalisa Crannell*** (annalisa.crannell@fandm.edu), Department of Mathematics, Box 3003, Franklin & Marshall College, Lancaster, PA 17604-3003. *Reflections on Spheres.*

We give an analysis of the reflections of lines in a mirrored sphere, paying particular attention to the number and location of their vanishing points. We use this analysis to describe how to draw the images of boxes reflected in a mirrored sphere, providing an analogy of what, in linear perspective, would be one-point perspective drawings. In addition, we provide an analysis of two methods for computing viewing distance between the artist and the sphere for existing drawings of spherical reflections. One method uses distances between vanishing points; the other is an estimate that requires knowing a single small measurement from the "real world". (Received July 13, 2010)

1065-00-30 **B Lynn Bodner*** (bodner@monmouth.edu), Mathematics Department, Monmouth University, West Long Branch, NJ 07764. *Reconstructing Bourgoin's 14-Pointed Star Polygon Designs.*

Geometric Islamic art typically features highly-symmetric, infinitely-repeating patterns. Many of these designs are based on the construction of star-shaped polygons within regular n-gons, where n = 3, 4, 5, 6, 8, 10, & 12... These n-gons are constructible in the Euclidean sense; that is, they may be created using only a compass to make circles and a straightedge to connect points of intersection between path objects such as segments and circular arcs. For n = 7, 9, 11, 13, & 14..., the regular n-gons (and their corresponding regular n-star polygons) may be constructed only approximately using these tools. We will present a plausible recreation of 4, historical 14-pointed star polygon designs illustrated and analyzed in Plates 164 - 167 of Bourgoin's Arabic Geometrical Pattern and Design (1879). The creation of these designs all start with a cluster of four (14/6) stars, but the interstitial space between each cluster is filled differently. Bourgoin does not indicate how any of the designs may have been achieved. We seek to explore how the original designer of these patterns may have determined, without mensuration, the proportion and placement of the star polygons and also how the space between the stars may have been generated using compass-and-straightedge constructions. (Received July 29, 2010)

1065-00-39 **Leon Harkleroad***, Department of Mathematics, Bowdoin College, Brunswick, ME 04011. *The Musical Side of Wroński.* Preliminary report.

Of course, his namesake Wronskian represents Józef Maria Hoëné Wroński's primary claim to fame among mathematicians. However, he pursued many other interests, including a little mathematical music theory. His writings on music even exerted an influence on the noted composer Edgard Varèse. This talk will examine Wroński's contributions, with particular attention to the tuning system that he developed. (Received August 11, 2010)

1065-00-61 **Carolyn A. Yackel*** (yackel_ca@mercer.edu), 1400 Coleman Ave., Department of Mathematics, Macon, GA 31207-0001. *Counting and Illustrating Rep-Tiles.* Preliminary report.

We present results for the number of tiles used for reptiling–one quite general and one quite specific. We then illustrate special cases of each theorem via the ceramic model of the L-tile that inspired this investigation. (Received August 24, 2010)

1065-00-80 **Anne Burns*** (aburns@liu.edu), Department of Mathematics, C.W.Post Campus of Long Island University, 720 Northern Blvd., Brookville, NY 11548. *The Use of Color in Animating Dynamical Systems.*

In a simple dynamical system that depends on a single parameter the illusion of three dimensional growth can be created by the use of color. An increase in the number of parameters that define a dynamical system allows more variety in assigning color and value as functions of the parameters. As the parameters of a system change, the color assignments undergo changes as well, creating a sense of motion. For a dynamical system that depends on one or more complex parameters, since RGB color is a three dimensional space (four if we also use transparency), there is a seemingly endless number of color assignments. By making color assignments a function of time the illusion of motion can be speeded up or slowed down. A continuous change in parameters can transform one

system to another. Using color and value as functions of the parameters in a dynamical system allows a great deal of room for artistic expression. (Received September 01, 2010)

1065-00-87 **Thomas F. Banchoff*** (Thomas_Banchoff@brown.edu), 151 Thayer Street, Mathematics Department, Brown University, Providence, RI 02912. *Interactive Art and the Dimensions of Appreciation.* Preliminary report.

Viewers engage with art in dimensionally different ways, depending on the dimensions of the art objects themselves and the ability of the viewer to explore. Compare Rembrandt's "Night Watch" and Michaelangelo's "David" and Frank Lloyd Wright's "FallingWater" and "Surfaces Beyond the Third Dimension". What can we learn from the varying experiences of viewers about the creation and exhibition of works of art in all dimensions, in particular those only fully accessible through online interaction? (Received September 03, 2010)

1065-00-212 **Leslie D Hayes***, Department of Mathematics, Saint Joseph's University, Philadelphia, PA 19131. *An image is worth a thousand numbers: visual thinking in science.*

For better and for worse, visual thinking has been a recurring theme in the history of scientific thought and has often been applied to the conceptual development of scientific models. On the other hand, visualization has also been used as a practical means of resolving problems tied to difficult or intractable computations. Non-mathematicians such as Antonio Gaudí and Etiene-Jules Marey made use of visual tools to study what were essentially mathematical problems. Other examples from astronomy, architecture, and physiology will be presented. (Received September 13, 2010)

1065-00-213 **Rachel Wells Hall*** (rhall@sju.edu), Department of Mathematics, Saint Joseph's University, Philadelphia, PA 19131. *A Mathematician's Guide to Research in Mathematical Music Theory.*

Music theorists have used mathematics to solve musical problems for centuries. Mathematicians, too, have investigated musical questions. Some composers have turned to mathematics for inspiration. However, there has been a significant disconnect between these two fields since the eighteenth century. Mathematical music theory—a field still in its infancy—uses mathematics to describe and analyze musical structures such as rhythms, scales, chords, and melodies. In the past twenty-five years, questions have emerged in mathematical music theory that are appealing, nontrivial, and, in several cases, connected to other scientific fields. This talk aims to interpret current research in music theory in a manner that is accessible to mathematicians and to relate problems in music theory to questions that arise in diverse mathematical fields, including combinatorics, group theory, geometry, optimization, and category theory. (Received September 13, 2010)

01 ► History and biography

1065-01-71 **Frédéric Brechenmacher*** (frederic.brechenmachher@math.cnrs.fr), 72 rue Myrha, 75018, Paris, France. *Circulations of algebraic practices (1870-1940) : networks, communities and disciplines formations, evolutions and connections.*

Between 1870 and 1940, algebra took on various and changing identities depending on the communities, networks and disciplines in which "algebraic practices" were circulating. It is our aim to study how algebra circulated between and interacted with various disciplines which in turn will shed light upon the evolutions of these disciplines as algebra progressively took on a fundamental role in the organization of mathematical knowledge. In order to tackle these issues, this talk will focus on the circulation of certain practices of algebraic manipulations of "forms" between France and the United State. Although prominent algebraists such as Dickson made extensive references to papers published in France, and despite the roles played by algebra in the development of the American mathematical community, our knowledge of these works and authors is still very limited. We thus aim also to highlight some new sources in order to understand how they formed a part of various networks and communities in which these researches circulated. Instead of developing a global approach to the historical questions posed above, this talk will thus be devoted to a few relevant contexts in order to develop some detailed results as well as to highlight some methodological issues and open problems. (Received August 30, 2010)

1065-01-111 **Adrian Rice*** (arice4@rmc.edu), Department of Mathematics, Randolph-Macon College, Ashland, VA 23005. *"Splendidly isolated"? Some reflections on the transnationality of 19th-century British mathematics.* Preliminary report.

The phrase "splendid isolation" is often used to describe late 19th-century British foreign policy, which was characterized by a self-imposed aloofness from the affairs of mainland Europe. But could the same words be used to describe much of 19th-century British mathematics? After all, mathematics in 19th-century Britain

was typified by a certain insularity with regard to European mathematical developments, and the character and style of British mathematics differed considerably from that produced on the continent. Nevertheless, at the same time many British mathematicians were in touch with both European mathematical developments and European mathematicians, and several of the notable contributions made by British mathematicians during this period were well known on the continent. So was mathematical communication really impeded by the English Channel? To what extent did 19th-century British mathematical developments transcend national boundaries? In this talk, we will examine the extent of British mathematical "isolation" during the 19th century and attempt to reach some estimation of how "splendid" this status really was. (Received September 07, 2010)

1065-01-132 **Tatiana Roque*** (tati@im.ufrj.br). *The works of G.D. Birkhoff and the reception of Poincaré's researches on qualitative theory of differential equations in the USA.*

In his Semicentennial address of the American Mathematical Society, Birkhoff affirms that Americans begin to pay attention to Poincaré's works in 1906, when F.R. Moulton published an article about the three-body problem. In 1912, Birkhoff proves Poincaré's Last Geometric Theorem using a geometrical approach and shows that it would be impossible to understand its consequences with the method of analytic continuation. We have some testimonials that this work is responsible for Birkhoff's projection in the American mathematical community, as O. Veblen remarks in Birkhoff's biographical memoir.

Our intention in this communication is to analyze the reception of Poincaré's works in the USA during the period from 1906 to the 1920s. Some articles published by Birkhoff suggest that there have been reactions against the qualitative methods. We propose to investigate the role Birkhoff played in highlighting the innovative character of Poincaré's methods, as well as in advocating the legitimacy of the results they allow him to obtain. Special attention is given to the mathematical context in which Poincaré's Last Geometric Theorem was introduced. (Received September 10, 2010)

1065-01-137 **Patti Wilger Hunter*** (phunter@westmont.edu), Department of Mathematics and Computer Scienc, Westmont College, 955 La Paz Road, Santa Barbara, CA 93108. *Gertrude Cox in Egypt: A Case Study in Science Patronage and International Statistics Education during the Cold War.*

Gertrude Cox, first chair of North Carolina State University's Department of Experimental Statistics, worked as a consultant for the Ford Foundation to Cairo University's Institute of Statistical Studies and Researches in 1964. An analysis of this work provides a case study in the internationalization of the statistics profession and the systems of patronage available to scientists in the second half of the twentieth century. It highlights some of the complexities in the process of internationalization in science, showing that even when scientists cross national boundaries to promote their discipline, they may have as a goal the advancement of their own nationalistic interests, or those of their patrons. (Received September 10, 2010)

1065-01-205 **Nathan M. Selikoff*** (nselikoff@gmail.com), 800 22nd Street, Orlando, FL 32805. *The Confluence of Chaos and Computation in Generative Visual Art.* Preliminary report.

With the rise of accessible computation in the 1960s and 70s, practitioners of mathematics, statistics and physics were suddenly able to explore chaotic dynamical systems in new, powerful, and decidedly visual ways. At the same time, adventurous visual artists were adopting the computer as a new artistic tool in their repertoire, and from their ranks a few embraced chaos theory as a direct source of inspiration, imagery, and algorithms. I will discuss this confluence of mathematics and visual art and then illustrate its impact on my fine art practice. (Received September 13, 2010)

1065-01-221 **Maryam Vulis*** (mlv88@earthlink.net), 67-67 Burns st, Forest Hills, NY 11375. *The Discussion of two Schools of Mathematics in 19th century Russia.* Preliminary report.

This presentation will discuss the fundamental differences in approach to mathematics by two prominent Russian Schools of the 19th century. The Petersburg Mathematical School was heavily influenced by French mathematicians who saw the extreme importance of practical applications, especially to the army and navy. The Petersburg School of Mathematics followed the ideas of Peter the Great who back in the 17th wanted to bring the Western thought to Russia. On the contrary, the Moscow Mathematical School had different ideology which led to the conflict between the two schools. The French traditions of the Petersburg Mathematical School were in discourse with the Moscow mathematicians, or the "old-timers". In the 19th Century, the Moscow Mathematical Society was the backbone in mathematical studies, but the Moscow mathematicians of the time did not fully accepted the applied part of mathematics and was skeptical in achieving outstanding results if the goal of mathematics studies deviated from abstractionIn fact, the mysticism, superstition, and religious interpretation of mathematics

in the Moscow School deepened the discourse between the two approaches – one more western and progressive, and the other one is more prevalent in old Russia. (Received September 14, 2010)

1065-01-235 **Della D. Fenster*** (dfenster@richmond.edu), 28 Westhampton Way, Richmond, VA 23173, and **Joachim Schwermer**, , Austria. *"George Whaples: A Novice in Emil Artin's Mathematical Circle".* Preliminary report.

In this talk, we begin to explore how Emil Artin contributed to mathematical circles without formal publications. We focus on how Artin disseminated ideas about class field theory, and, in particular, how Artin began to work with George Whaples, a young American mathematician who had just completed his Ph.D. at the University of Wisconsin. (Received September 14, 2010)

1065-01-238 **Jean Dhombres*** (jean.dhombres@damesme.cnrs.fr), Pavillon Chevreul, 3rdbFloor, MNHN CP 25, 57 rue Cuvier, 75231 Paris, France. *What do we know about exchanges in mathematics in Europe under German control (1940-1944) ?*

A common knowledge from science studies asserts that wars accelerate progress in technology and in the physical sciences, but less is being claimed about mathematics, and particularly pure mathematics. In the case of the Second world war, due to nazi persecutions, another terrible factor occurred due to forced exile for Jews, and so destruction of active schools in Germany. But the Third Reich ruled over some European countries, and mathematicians had to adapt to the circumstances, under the complicated situation that quite often the most brilliant ones had been as post doc or similar positions to Göttingen or to other centers, even late in the Thirties. A typical case would be the Bourbaki seminar, as the first meetings were on operators on Hilbert spaces, a domain which was to be extraordinarily developed by von Neumann, then exiled in the States. The aim of this paper is to discuss what we may know for the epistemological situation in mathematics in France during the Vichy policy of collaboration with Germany (1940-1944), and to try to understand the reason towards a sort of excess of "pure" considerations, to avoid mixing with Vichy policies of applied mathematics. If time allows I would like to compare with the situation in the Netherlands. (Received September 14, 2010)

1065-01-247 **Joachim Schwermer*** (Joachim.schwermer@univie.ac.at), Faculty of Mathematics, University of Vienna, Nordbergstrasse 15, A 1090 Vienna, Austria, and **Della D. Fenster**. *Claude Chevalley's "elements ideaux" - a new concept in number theory.* Preliminary report.

In June 1935, in a letter to H. Hasse, Claude Chevalley laid out a new approach to local and global class field theory by introducing his concept of "elements ideaux". This letter marks the beginning of an important development in number theory. In this talk, we briefly discuss the impact of Chevalley's idea in the 1940's. (Received September 14, 2010)

05 ► Combinatorics

1065-05-42 **Donald Nelson**, **Michael Plummer**, **Neil Robertson** and **Xiaoya Zha*** (xzha@mtsu.edu), Department of Mathematical Sciences, Middle Tennessee State University, Murfreesboro, TN 37132. *On a conjecture concerning the Petersen Graph.* Preliminary report.

Robertson has conjectured that the only 3-connected internally-4-connected graph of girth 5 in which every odd cycle of length greater than 5 has a chord is the Petersen graph. We prove this conjecture in the special case where the graphs involved are also cubic. Moreover, this proof does not require the internal-4-connectivity assumption. An example is then presented to show that that the assumption of internal-4-connectivity cannot be dropped as an hypothesis in the original conjecture.

We then summarize our results aimed toward the solution of the conjecture in its original form. In particular, let G be any 3-connected internally-4-connected graph of girth 5 in which every odd cycle of length greater than 5 has a chord. If C is any girth cycle in G then $N(C)-V(C)$ cannot be an independent set, and if $N(C)-V(C)$ contains a path of length at least 2, then the conjecture is true. If the conjecture fails and H is a counterexample, then for any girth cycle C in H, $N(C)-V(C)$ consists of a matching M together with an independent set of vertices. Moreover, M can be partitioned into (at most) two disjoint non-empty sets where we can precisely describe how these sets are attached to cycle C. (Received September 14, 2010)

1065-05-43 **Ronald J. Gould*** (rg@mathcs.emory.edu), Department of Mathematics and Computer Scienc, Atlanta, GA 30322, **Kazuhide Hirohata**, Dept. of Electronic and Computer Engineering, Ibaraki, Japan, and **Paul Horn**, Department of Mathematics and Computer Scienc, Atlanta, GA 30322. *Independent cycles and chorded cycles in graphs.* Preliminary report.

A number of degree conditions guarantee the existence of a set of k independent cycles. Some are even strong enough to produce 2-factors. In this talk we consider a variation involving the cardinality of neighborhood unions of pairs of non-adjacent vertices. Two sharp results will be presented. The first guarantees the existence of k independent cycles, and answers a conjecture of J. Faudree and Gould. The second guarantees the existence of k independent chorded cycles. (Received August 13, 2010)

1065-05-44 **Yury J Ionin*** (yury.ionin@cmich.edu). *Binary Representations of Regular Graphs.*

For any 2-distance set X in the n-dimensional binary Hamming space H_n, let Γ_X be the graph with X as the vertex set and with two vertices adjacent if and only if the distance between them is the smaller of the two nonzero distances in X. The binary spherical representation number of a graph Γ, or $bsr(\Gamma)$, is the least n such that Γ is isomorphic to Γ_X where X is a 2-distance set lying on a sphere in H_n. It is shown that if Γ is a connected regular graph, then $bsr(\Gamma) \geq b - m$, where b is the order of Γ and m is the multiplicity of the least eigenvalue of Γ, and the case of equality is characterized. In particular, if Γ is a connected strongly regular graph, then $bsr(\Gamma) = b - m$ if and only if Γ is the block graph of a quasi-symmetric 2-design. (Received September 11, 2010)

1065-05-51 **Ryan Martin*** (rymartin@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50011, and **Tracy McKay**. *Recent results on the edit distance of graphs.*

In this talk, we will discuss the edit distance function, a function of a hereditary property $\mathcal{H}$ and of p, which measures the maximum proportion of edges in a density-p graph that need to be inserted/deleted in order to transform it into a member of $\mathcal{H}$. We will describe a method of computing this function and give some results that have been attained using this method. The edit distance problem has applications in property testing and evolutionary biology and is closely related to well-studied Turán-type problems. (Received August 19, 2010)

1065-05-52 **Hong-Jian Lai*** (hjlai@math.wvu.edu), 320 Armstrong Hall, Department of Mathematics, WVU, Morgantown, WV 26506-6310, **Yanting Liang** (lyt814@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506-6310, and **Ping Li** (liping@math.wvbu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506-6310. *Degree sequences and graphs with disjoint spanning trees.* Preliminary report.

A non-increasing sequence $d = (d_1, d_2, \cdots, d_n)$ is graphic if there is a simple graph G with degree sequence d. In this paper, it is proved that for a positive integer k, a graphic sequence d has a simple realization G which has k-edge-disjoint spanning trees if and only if either both $n = 1$ and $d_1 = 1$, or $n \geq 2$ and both $d_n \geq k$ and $\sum_{i=1}^{n} d_i \geq 2k(n-1)$. (Received August 20, 2010)

1065-05-54 **Seog-Jin Kim*** (skim12@konkuk.ac.kr), Department of Mathematics Education, Konkuk University, Seoul, 143-701, South Korea, **Alexandr Kostochka**, Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, **Douglas B. West**, Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, **Hehui Wu**, Department of Mathematics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, and **Xuding Zhu**, Department of Mathematics, Zhejiang Normal University, Jinhua, Peoples Rep of China. *Decomposition of Sparse Graphs into Forests and a Graph with Bounded Degree.* Preliminary report.

Say that a graph with maximum degree at most d is *d-bounded*. For $d > k$, we prove a sharp sparseness condition for decomposability into k forests and a d-bounded graph. Consequences are that every graph with fractional arboricity at most $k + \frac{d}{k+d+1}$ has such a decomposition, and (for $k = 1$) every graph with maximum average degree less than $2 + \frac{2d}{d+2}$ decomposes into a forest and a d-bounded graph. When $d = k+1$, and when $k = 1$ and $d \leq 6$, the d-bounded graph in the decomposition can also be required to be a forest. When $k = 1$ and $d \leq 2$, the d-bounded forest can also be required to have at most d edges in each component. (Received August 20, 2010)

1065-05-56 **Maria Axenovich*** (axenovic@iastate.edu), 412 Carver Hall, Ames, IA 50011, and **Joan Hutchinson** and **Michelle Lastrina**. *On list-coloring extensions for planar graphs.*

The famous theorem of Thomassen states that no matter how the lists of 5 colors are assigned to the vertices of a planar graph, there is always a way to choose a color for each vertex from its list such that the resulting coloring is proper (so that adjacent vertices receive distinct colors). Albertson conjectured that this theorem could be strengthened by allowing some distant vertices to have lists of size one, i.e., being pre-colored. We prove this conjecture for a wide class of planar graphs. (Received August 22, 2010)

1065-05-59 **R Luo** (rluo@mtsu.edu), Department of Mathematical Sciences, Middle Tennessee State University, Murfreesboro, TN 37132, and **Nick Zhao*** (yzhao@mail.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Vizing's independence number conjecture on edge chromatic critical graphs.*

In 1968, Vizing proposed the following conjecture which claims that the independence number of edge chromatic critical graphs with n vertices is at most $\frac{n}{2}$. The first result about this conjecture appeared in 2000 which proves that the independence number of edge chromatic critical graphs with n vertices is at most $\frac{2n}{3}$. In this talk, we will present some new results about this conjecture and show that the independence number of edge chromatic critical graphs with n vertices is at most $\frac{5n}{8}$. (Received August 24, 2010)

1065-05-73 **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, **Zhiquan Hu**, Faculty of Mathematics and Statistics, Central China Normal University, Wuhan, Hubei , Peoples Rep of China, and **Yaping Wu**, Faculty of Mathematics and Statistics, Central China Normal University, Wuhan, Hubei , Peoples Rep of China. *A lower bound of circumferences involving connectivities and independence numbers of subgraphs.* Preliminary report.

Let G be a k-connected graph of order n and let α and $c(G)$ be *the independence number* of G and *the circumference* of G, respectively. If $\alpha \leq k$, Chvátal and Erdős showed that G is hamiltonian. For $\alpha \geq k \geq 2$, Fouquet and Jolivet in 1978 made the conjecture that $c(G) \geq \frac{k(n+\alpha-k)}{\alpha}$, which was recently confirmed by Suil O, D. B. West and H. Wu. Under the same condition, we obtained the following two results:

(1) $c(G) \geq \min\left\{n, \max\left\{\frac{k(n+\alpha-k)}{\alpha}, k\left\lfloor\frac{n+2\alpha-2k}{\alpha}\right\rfloor\right\}\right\}$;

(2) For every nonempty induced subgraph H, there is a cycle C in G such that $|V(C) \cap V(H)| \geq \min\left\{|H|, k\left\lfloor\frac{|H|+\alpha(H)-k}{\alpha(H)}\right\rfloor\right\}$.

Set $f(G) := \min\left\{|G|, \max\left\{\frac{k(|G|+\alpha(G)-k)}{\alpha(G)}, k\left\lfloor\frac{|G|+2\alpha(G)-2k}{\alpha(G)}\right\rfloor\right\}\right\}$. Notice that $f(G)$ is not monotonic according to the inclusion order of subgraphs. We further improve the first result by showing that

$$c(G) \geq \max\{f(H) : H \text{ is any nonempty induced subgraph of } G\}.$$

(Received August 30, 2010)

1065-05-95 **Geir Agnarsson*** (geir@math.gmu.edu), George Mason University, Department of Mathematics, 4400 University Drive, MS:3F2, Fairfax, VA 22030. *On Minkowski sum of simplices and their flags.* Preliminary report.

We consider a Minkowski sum of k standard simplices in $\mathbb{R}^r$ and its chains of faces, for given $k, r \in \mathbb{N}$. We define its *flag polynomial* in a direct and canonical way in terms of the *k-th master polytope* $P(k)$. This polynomial is related to the well-known flag vector, and it has some nice algebraic properties that one can use to obtain explicit formulae for the number of chains of faces of fixed dimensions and height. (Received September 04, 2010)

1065-05-127 **John B. Polhill*** (jpolhill@bloomu.edu), Department of Math/CS/Stat, 237 Ben Franklin, 400 East Second Street, Bloomsburg, PA 17815. *Partial Difference Sets and Association Schemes.*

A regular partial difference set is a subset of a finite group G whose corresponding Cayley graph is strongly regular. As a result, a partial difference set and its complement form a 2-class association scheme. In this talk, we will investigate additional relationships between association schemes and partial difference sets. Along the way, we will construct some new examples. (Received September 09, 2010)

1065-05-131 **Zi-Xia Song***, Department of Mathematics, University of Central Florida, Orlando, FL 32816. *A Variation of the Classical Turán Type Problem.*

Let $D = (d_1, d_2, \ldots, d_n)$ be an integer sequence with $d_1 \geq d_2 \geq \cdots \geq d_n \geq 0$. We say that D is *graphic* if there is a graph G with D its degree sequence. In those circumstances, G is called a *realization* of D. We consider an extremal problem for graphs as introduced by Erdös, Jacobson and Lehel in 1991. That is to find

the minimum even integer t such that every graphic sequence $D = (d_1, d_2, \ldots, d_n)$ with $\sum_{i=1}^{n} d_i$ at least t has a realization containing K_k as a subgraph. They conjectured that $t = (k-2)(2n-k+1)+2$. In this talk, we will survey the methods on solving this conjecture and recent results in this area on K_k-graphic sequences. (Received September 09, 2010)

1065-05-134 **Jennifer Vandenbussche*** (jvandenb@spsu.edu), Southern Polytechnic State University, Department of Mathematics, 1100 S. Marietta Pkwy, Marietta, GA 30060, and **Douglas B. West** (west@math.uiuc.edu). *Extending subgraphs to 2-factors in regular bipartite graphs.*

It is currently unknown whether all (not necessarily perfect) matchings in hypercubes are contained in a 2-factor. Motivated by this question, we discuss conditions under which a subgraph of a regular bipartite graph extends to a 2-factor. We discuss two results closely related to previous work done by other authors, and apply them to show that every matching in Q_5 is contained in a 2-factor. (Received September 10, 2010)

1065-05-140 **Cun-Quan Zhang*** (cqzhang@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506-6310. *On cycle double cover conjecture.* Preliminary report.

The Cycle Double Cover Conjecture (CDC Conjecture) was proposed independently by G. Szekeres (1973), A. Itai and M. Rodeh (1978), and P.D. Seymour (1979). The conjecture is easy to state: *For every 2-connected graph, there is a family $\mathcal{F}$ of circuits such that every edge of the graph is covered by precisely two members of $\mathcal{F}$.* As an example, if a 2-connected graph is properly embedded in a surface (without crossing edges) in such a way that all faces are bounded by circuits, then the collection of the boundary circuits will "double cover" the graph. The CDC conjecture (and its numerous variants) is considered by most graph theorists to be one of the major open problems in the area. This survey will present some progresses during last 30 years to this open problem. The conjecture has been verified for many families of graphs, most of them are 3-edge-colorable, or "almost" 3-edge-colorable. In this talk, we will discuss some promising techniques, with which we are able to reach families of graphs that are beyond "almost" 3-edge-colorability (for example, weight decomposition, circuit extension, circuit chain, and their hybrid versions, etc.) (Received September 10, 2010)

1065-05-146 **Jordan D. Webster*** (jdwebster@midmich.edu), 1233 Buckingham Pl., Mount Pleasant, MI. *Reversible and DRAD difference sets via tiling structures.*

Difference sets with parameters $(4m^2, 2m^2-m, m^2-m)$ are known as Hadamard (or Menon) difference sets. In this talk, we will use rational idempotents in the group ring to develop a theory of tiles. We will show the usefulness of tiles by creating both reversible and DRAD difference sets in groups of the form $(C_{2^{2r}})^3$. We will also use tiling theory to give necessary conditions for both reversible and DRAD difference sets in abelian 2-groups. (Received September 11, 2010)

1065-05-150 **Wenliang Tang*** (victor_251@math.wvu.edu). *Edge Spectrum of Small Path.*

Let H be a simple graph, G is called an H-saturated graph if H is not a subgraph of G, but add any one edge e outside of G back will produce a copy of H. Denote by $SAT(n, H)$ the set of all H-saturated graph G with order of n. Then the saturation number $sat(n, H)$ is defined as $\min_{G \in SAT(n,H)} |E(G)|$, and extremal number $ex(n, H)$ is defined as $\max_{G \in SAT(n,H)} |E(G)|$. A natural question is whether we can find an H-saturated graph with m edges for any $sat(n, H) \leq m \leq ex(n, H)$. In this paper we investigate the edge spectrum for the case of small path P_5 and P_6. (Received September 12, 2010)

1065-05-153 **Ken W Smith*** (kenwsmith@shsu.edu), 335 Park Hill St., Huntsville, TX 77340. *Construction of circulant weighing matrices.*

An $n \times n$ circulant matrix A, with entries from $\{-1, 0, 1\}$ is a circulant weighing matrix of weight k (a $CW(n, k)$) if $AA^T = kI$. Viewing such a matrix as an element of a group ring over the cyclic group, we use rational idempotents to construct a CW(48,36). (It had been previously believed that a CW(48,36) did not exist.)

We examine other parameters and discuss the construction technique in some depth.

This is joint work with Bernhard Schmidt. (Received September 12, 2010)

1065-05-163 **Ronald Gould** and **Dong Ye*** (dye@math.wvu.edu), Department of Mathematics, West Virginia University, Morgantown, WV 26506, and **Cun-Quan Zhang**. *Edge-Spectrum of Saturated Graphs for Matchings.*

A graph G is H-saturated if G does not contain H as a subgraph but adding an edge to G will yield a copy of H in the the new graph. The edge spectrum of H is the set of sizes of all H-saturated graphs with n vertices.

In this talk, we present some results about the edge spectrum of tK_2-saturated graphs where tK_2 is the disjoint union of t complete graphs with two vertices. (Received September 12, 2010)

1065-05-164 **Yezhou Wu*** (yzwu@math.wvu.edu), 320 Armstrong, West Virginia University, Morgantown, WV 26505. *Mininum cardinality of feedback sets for line graphs.*

A subset of vertices (resp. arcs) of a graph G is called a feedback vertices (resp. arcs) set of G if its removal results in an acyclic subgraph.The problem to determine the minimum cardinality of the feedback sets is NP-hard for digraphs. the graph G. We will show the relations between the feedback vertices sets of graphs and the feedback arcs sets of their line graphs and give the exact minimum cardinality of the feedback vertices (resp. arcs) set of Kautz digraph $K(d, n)$ for $n \leq 7$ and a bound for $n \geq 8$. (Received September 12, 2010)

1065-05-169 **Fu Liu*** (fuliu@math.ucdavis.edu), One Shields Avenue, Davis, CA 95616. *Higher integrality conditions and volumes of slices.*

A polytope is integral if all of its vertices are lattice points. The costant term of the Ehrhart polynomial of an integral polytope is known to be 1. I generalize this result by introducing the definition of k-integral polytopes, where 0-integral is equivalent to integral. I will show that the Ehrhart polynomial of a k-integral polytope P has the properties that the coefficients in degrees of less than or equal to k are determined by a projection of P, and the coefficients in higher degrees are determined by slices of P. A key step of the proof is that under certain generality conditions, the volume of a polytope is equal to the sum of volumes of slices of the polytope. (Received September 12, 2010)

1065-05-174 **Stephen G. Hartke*** (hartke@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130, and **Tyler Seacrest** (s-tseacre1@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Balanced Bisections and Results Towards a Conjecture of Bollobás and Scott.* Preliminary report.

It is well known that every graph G contains a bipartite subgraph H with at least half the edges of G. The standard "pushing" argument shows that in fact the degree of each vertex in H is at least half its degree in G. A linearity of expectation argument also shows that a spanning balanced bipartite subgraph exists with at least half the edges. Can both properties be simultaneously obtained? That is, does there exist a spanning balanced bipartite subgraph H of G such that the degree of each vertex in H is at least half its degree (rounded down) in G? Bollobás and Scott have conjectured that this is in fact true. We will discuss partial results on this question, including probabilistic approaches and a potential version: for any degree sequence π, we show that there exists a realization G of π that has a bipartite subgraph H with (almost) the desired properties. (Received September 12, 2010)

1065-05-175 **Csaba D Toth*** (cdtoth@ucalgary.ca), Department of Mathematics and Statistics, MS 432, Calgary, Alberta T2N 1N4, Canada. *Convex subdivisions for point sets.*

A *convex subdivision* for a set S of n points in the plane is a planar straight line graph such that its vertex set contains S, the bounded faces are convex, and the outer face is the complement of the convex hull of S. This talk will survey recent extremal results for convex subdivisons and some applications. The results include upper and lower bounds for the minimum number of faces (with or without Steiner points), minimum total edge length, and the minimum size of a convex subdivision contained in a triangulation of n points in the plane. (Received September 12, 2010)

1065-05-178 **Walter D Morris*** (wmorris@gmu.edu), Department of Mathematical Sciences, MS 3F2, Fairfax, VA 22030. *Oriented matroids and intersection of simplices generated by a family of segments.* Preliminary report.

Let $\mathcal{S} = \{S_1, S_2, \ldots, S_d\}$ be a collection of segments in R^{d-1}. $\mathcal{S}$ has property P if every set of points $\{x_1, x_2, \ldots, x_d\}$, with $x_i \in S_i$ for all $i = 1, 2, \ldots, d$, is affinely independent. If, in addition, there is a point $p \in R^d$ so that $p \in int(conv\{x_1, x_2, \ldots, x_d\})$ whenever $x_i \in S_i$ for all $i \in \{1, 2, \ldots, d\}$, then $\mathcal{S}$ is said to have property K. We give some sufficient conditions for an oriented matroid analog of property K to hold. (Received September 12, 2010)

1065-05-185 **Mark Ellingham*** (mark.ellingham@vanderbilt.edu) and **Xiaoya Zha** (xzha@mtsu.edu). *Counting* $(3, 6)$*-fullerenes.*

$(3, 6)$-fullerenes are cubic plane graphs in which all faces are hexagons, except for four faces that are triangles. There is a standard way of representing these graphs by folding a plane hexagonal lattice onto a suitable tetrahedron. Fowler and Cremona showed how to determine the automorphism group from this representation, but the conditions are complicated. By using a slightly different representation we obtain simple conditions that

determine the automorphism group and provide other structural information. We use this to provide counting formulae for $(3,6)$-fullerenes, and also related classes such as isolated-pentagon-triple (IPT)-fullerenes, with a given number of vertices. (Received September 13, 2010)

1065-05-199 **Yong Lin** and **Linyuan Lu*** (lu@math.sc.edu), Department of Mathematics, University of South Carolina, 1523 Greene Street, Columbia, SC 29063, and **S.-T. Yau**. *Ricci Curvature of Graphs.*

We modify the definition of Ricci curvature of Ollivier of Markov chains on graphs to study the properties of the Ricci curvature of general graphs, Cartesian product of graphs, random graphs, and some special class of graphs. (Received September 13, 2010)

1065-05-200 **Tao Jiang*** (jiangt@muohio.edu), Dept. of Mathematics, Miami University, Oxford, OH 45056, and **Robert Seiver** (seiverrt@muohio.edu), Department of Mathematics, Miami University, Oxford, OH 45056. *Turan numbers of subdivided graphs.*

Given a positive integer n and a graph F, the Turán number $ex(n,F)$ is the maximum number of edges in an n-vertex graph that does not contain F as a subgraph. We prove a rather general result concerning Turán numbers.

Let F be a graph that is obtained from another graph H by subdividing its edges. For each $xy \in E(H)$, let $l_{x,y}$ be the length of the unique x,y-path in F that is internally disjoint from $V(H)$. Suppose that $l_{x,y}$ is even for all $xy \in E(H)$ and that $\min\{l_{x,y} : xy \in E(H)\} = 2m$. We show that $ex(n,F) = O(n^{1+\frac{8}{m}})$. This strengthes a recent result by Jiang and an old result by Kostochka and Pyber. (Received September 13, 2010)

1065-05-202 **Mark N Ellingham** and **Justin Z Schroeder*** (justin.z.schroeder@vanderbilt.edu), 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240. *A tripling construction for the genus of joins of complete and edgeless graphs.* Preliminary report.

Ellingham and Stephens have shown in several cases that the genus of $\overline{K_m} + K_n$ is the same as the genus of $K_{m,n}$, namely $\lceil (m-2)(n-2)/4 \rceil$. One of the methods utilized to obtain these minimum genus embeddings involves embeddings of K_n with all hamilton cycle faces. They use a doubling construction to get an infinite family of such embeddings when $n \equiv 2 \pmod 4$. In this paper we develop a tripling construction that provides embeddings of K_n with all hamilton cycle faces when $n \equiv 3 \pmod 4$. This leads to an infinite family of graphs for which $g(\overline{K_m} + K_n) = g(K_{m,n})$, the first known results for $n \equiv 3 \pmod 4$ and all $m \geq n-1$. To make this tripling construction work, some embeddings of $K_{n,n,n}$ with certain properties are given. (Received September 14, 2010)

1065-05-204 **Tao Feng*** (feng@math.udel.edu), 432 Ewing Hall, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, and **Qing Xiang** (xiang@math.udel.edu), 508 Ewing Hall, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Cyclotomic Strongly Regular Graphs.*

We will talk about cyclotomic strongly regular graphs Cay(Fq,D) in a broad sense(that is, D is a union of cosets of a subgroup of the multiplicative group Fq* of Fq, not just a single coset of a subgroup of Fq*). Many new infinite classes of strongly regular graphs are obtained in this way. This is a joint work with Qing Xiang. (Received September 13, 2010)

1065-05-217 **Peter Sin** (sin@ufl.edu), Gainesville, FL 32611, **Junhua Wu*** (jwu@lanecollege.edu), Jackson, TN , and **Qing Xiang** (xiang@math.udel.edu), Newark, DE 19716. *Dimensions of some binary codes arising from a conic in $PG(2,q)$.*

Let $\mathcal{O}$ be a conic in the classical projective plane $PG(2,q)$, where q is an odd prime power. With respect to $\mathcal{O}$, the lines of $PG(2,q)$ are classified as passant, tangent, and secant lines, and the points of $PG(2,q)$ are classified as internal, absolute and external points. The incidence matrices between the secant/passant lines and the external/internal points were used to produce several classes of structured low-density parity-check binary codes. In particular, the dimension formula for the binary code $\mathcal{L}$, which arises as the $\mathbb{F}_2$-null space of the incidence matrix between the secant lines and the external points to $\mathcal{O}$, was conjectured. In this talk, we present a proof for the conjecture on the dimension of $\mathcal{L}$ by using a combination of techniques from finite geometry and modular representation theory. (Received September 14, 2010)

1065-05-223 **Simone Severini***, Department of Physics & Astronomy, University College London, London, WC1E 6BT. *A role for the Lovász theta function in Quantum Mechanics: entanglement assisted capacity and noncontextuality.*

The mathematical study of how much information can be transmitted without error, the so-called zero-error capacities, was initiated by Shannon in the 50s. Only in 1979, Lovász solved the major open problem of Shannon concerned with this topic. The solution is based on a famous object called Lovász theta function, which greatly contributed to the developments of areas of Mathematics like semidefinite programming and extremal problems in combinatorics. The Lovász theta function is an upper bound to the zero-error capacity, however it is not always tight. I will show that the function is also an upper bound to the zero-error capacity when the parties can share certain physical resources, and that this quantity can be greater than the classical one. Additionally, I will propose a physical interpretation of the Lovász theta function as the maximum violation of certain noncontextual inequalities. This is joint work with Adan Cabello (Sevilla), Runyao Duan (Tsinghua), and Andreas Winter (Bristol/Singapore). (Received September 14, 2010)

1065-05-224 **Kevin G Milans*** (milans@math.sc.edu), Deptartment of Mathematics, 1523 Greene Street, University of South Carolina, Columbia, SC 29208, and **Daniel Schreiber** and **Douglas B West**. *Acyclic sets in k-majority tournaments.*

Given a set S of linear orders of a ground set X, the *majority digraph* of S is the directed graph on X where there is an edge from u to v when a majority of the orders in S rank u above v. For odd k, a *k-majority tournament* is a tournament that arises as the majority digraph of a set of k orders. When the orders in S are interpreted as a ranking of preferences among a set of alternatives X, acyclic sets in the majority tournament can be viewed as a consensus ranking of a subset of X. We study the maximum size of an acyclic set of vertices in k-majority tournaments.

Every n-vertex 3-majority tournament contains an acyclic set of size $n^{1/2}$; we present a family of 3-majority tournaments which have no acyclic sets of size larger than $2n^{1/2}$. We show that every n-vertex 5-majority tournament contains an acyclic set of size $n^{1/4}$. For general k, every k-majority tournament contains an acyclic set of $n^{f(k)}$, where $f(k) = 3^{-(k-1)/2}$. On the other hand, there are k-majority tournaments whose largest acyclic sets have size $n^{g(k)}$, where $g(k) = O(\log\log k/\log k)$. This is joint work with Dan Schreiber and Douglas B. West. (Received September 14, 2010)

1065-05-255 **D. Christopher Stephens*** (cstephen@mtsu.edu), Department of Mathematical Sciences, Middle Tennessee State University, 1301 East Main Street, Murfreesboro, TN 37132, and **Roi Krakovski** and **Xiaoya Zha**. *Subdivisions of K_5 in Graphs Embedded on Surfaces With Face-Width at least Five.*

We prove that if G is a 5-connected graph embedded on a surface Σ (other than the sphere) with face-width at least 5, then G contains a subdivision of K_5. This is a special case of a conjecture of P. Seymour, that every 5-connected non-planar graph contains a subdivision of K_5. Moreover, we prove that if G is 6-connected and embedded with face-width at least 5, then for every $v \in V(G)$, G contains a subdivision of K_5 whose branch vertices are v and four neighbors of v. (Received September 14, 2010)

1065-05-259 **Jeremy Dover**, **Keith Mellinger** and **Kenneth Wantz*** (kwantz@regent.edu), School of Undergraduate Studies, Regent University, 1000 Regent University Dr., Virginia Beach, VA 23464. *A family of blocking semiovals containing conics.* Preliminary report.

A blocking semioval is a set of points in a projective plane that is both a blocking set (every line meets the set, but the set contains no line) and a semioval (there is a unique tangent line at each point). A family of blocking semiovals in $PG(2, q^2)$ will be constructed where each blocking semioval consists of the points of a conic together with points from a related unital which are interior to the conic. An emphasis will be placed on the associated polarities, which commute. The potential for constructing blocking semiovals in non-Desarguesian planes using similar techniques will also be discussed. (Received September 14, 2010)

1065-05-260 **Andrew M. Zimmer*** (aazimmer@umich.edu). *Lower bounds for the minimum positive semidefinite rank via sign patterns.*

In this talk we develop a new lower bound for the minimum positive semidefinite rank. By construction, this new bound will always be greater or equal to a previously developed lower bound, the OS-number, and in many cases this new lower bound will be strictly greater than the OS-number. Our new lower bound is obtained by first constructing lower bounds on the rank of real positive semidefinite matrices with a given sign pattern. Then by minimizing this parameter over all sign patterns with a given zero-nonzero pattern we obtain a new lower bound for the minimum positive semidefinite rank. (Received September 14, 2010)

1065-05-267 **Edwin R. van Dam** (Edwin.vanDam@uvt.nl), PO Box 90153, 5000 LE, Tilburg, Netherlands, **William J. Martin*** (martin@wpi.edu), 100 Institute Rd, Worcester, MA 01609, and **Mikhail E. Muzychuk** (muzy@Netanya.ac.il), University St. 1, 42365 Netanya, Israel. *Linked systems of designs.*

Cameron introduced linked systems of symmetric designs. Restricting to the case where all pairwise parameters are the same, we consider a set X of size wv ($w \geq 2$) partitioned into w sets $X_1, X_2, \ldots$ each of size v and a graph G_1 on vertex set X with the following properties:

- no edge of G_1 has both ends in the same "fibre" X_i;
- between any X_i and X_j ($i \neq j$), the induced subgraph is the incidence graph of a symmetric (v, k, λ)-design;
- if $x \in X_i$ and $y \in X_j$ with $i \neq j$, then the number of common neighbors that x and y have inside any X_k ($k \neq i, j$) depends only on whether or not x and y are adjacent (in G_1) and not on the choice of x, y, nor i, j or k.

Only one infinite family of linked systems of symmetric designs is known with $w > 2$; these are the "Cameron-Seidel" schemes coming from Kerdock codes.

In this talk, we will explore these objects, as well as linked systems of strongly regular designs and, more generally, Q-antipodal association schemes. We will discuss the known examples, structural results, as well as upper bounds on the parameter w. (Received September 14, 2010)

1065-05-276 **Tobias Mueller*** (tobias@cwi.nl), centrum wiskunde & informatica, p.o. box 94079, 1090 GB amsterdam, Netherlands, and **Ross J Kang**. *Dot product representations of graphs.*

A graph G on n vertices is a k-dot product graph if there exist vectors $v_1, \ldots, v_n \in \mathbb{R}^k$ such that $v_i^T v_j \geq 1$ if and only if $ij \in E(G)$. The dot product dimension of G is the least k such that G is a k-dot product graph.

In this talk I will survey some results on dot product dimension, and sketch a proof that every planar graph has dot product dimension at most 4, and that there are planar graphs with dot product dimension equal to 4. This answers a question of Fiduccia et al. Time permitting, I will also sketch the proof that, for every $k \geq 2$ there are k-dot product graphs for which in every choice of vectors $v_1, \ldots, v_n \in \mathbb{R}^k$ exponentially many bits are needed to store these vectors in the memory of a computer. This answers a question of Spinrad.

(joint work with Ross J. Kang) (Received September 15, 2010)

06 ► Order, lattices, ordered algebraic structures

1065-06-181 **Jeremiah William Johnson*** (jwj10@psu.edu), Penn State Harrisburg, W-255 Olmsted, 777 W. Harrisburg Pike, Middletown, PA 17057. *Admissible Orders on Quotients of the Free Associative Algebra.*

An admissible order on a multiplicative basis of a noncommutative algebra is a term order satisfying additional conditions that allow for the construction of Gröbner bases. E. Hinson has used position-dependent weights encoded in so-called *admissible* arrays to partially order words in the free associative algebra in a way which produces a length-dominant admissible order on a particular quotient of the free algebra. The ideal by which the quotient is taken, the so-called *weight ideal*, is generated by pure homogeneous binomial differences and is determined by the array.

In this talk I will discuss the weight ideals associated to two families of admissible arrays. The weight ideals associated to an array in the first class is finitely generated and we can describe its generating set. The weight ideals associated to arrays in the second class may be trivial, may be nontrivial but finitely generated, or may not admit a finite generating set. (Received September 13, 2010)

11 ► Number theory

1065-11-1 **Matthew Baker*** (mbaker@math.gatech.edu), School of Mathematics, Georgia Tech, Atlanta, GA 30332-0160, and **Laura DeMarco**. *Preperiodic points and unlikely intersections.*

We combine complex-analytic and arithmetic tools to study the preperiodic points of one-dimensional complex dynamical systems. We show that for any fixed complex numbers a and b and any integer $d \geq 2$, the set of complex numbers c for which both a and b are preperiodic for $z^d + c$ is infinite if and only if $a^d = b^d$. This provides an affirmative answer to a question of Zannier, which itself arose from questions of Masser concerning

simultaneous torsion sections on families of elliptic curves. Using similar techniques, we prove that if rational functions $f, g \in \mathbf{C}(z)$ have infinitely many preperiodic points in common, then all of their preperiodic points coincide (and in particular the maps must have the same Julia set). This generalizes a theorem of Mimar, who established the same result assuming that f and g are defined over a number field. The main arithmetic ingredient in the proofs is an adelic equidistribution theorem for preperiodic points over number fields and function fields, with non-archimedean Berkovich spaces playing an essential role. (Received September 12, 2010)

1065-11-45 **David M Brown*** (david.m.brown.jr@gmail.com), 319 Van Vleck Hall, Madison, WI 53704. *Rigid Cohomology for Algebraic Stacks.*

Rigid cohomology is one flavor of Weil cohomology. This entails for instance that one can asociate to a scheme X over $\mathbb{F}_p$ a collection of finite dimensional $\mathbb{Q}_p$-vector spaces $H^i(X)$ (and variants with supports in a closed subscheme or compact support), which enjoy lots and lots of nice properties (e.g. functorality, excision, Gysin, duality, a trace formula – basically everything one needs to give a proof of the Weil conjectures).

Classically, the construction of rigid cohomology is a bit involved and requires many choices, so that proving things like functorality (or even that it is well defined) are theorems in their own right. An important recent advance is the construction by le Stum of an 'Overconvergent site' which computes the rigid cohomology of X. This site involves no choices and so it trivially well defined, and many things (like functorality) become transparent.

In this talk I'll explain a bit about classical rigid cohomology and the overconvergent site, and explain some new work generalizing rigid cohomology to algebraic stacks (as well as why one would want to do such a thing). (Received August 15, 2010)

1065-11-136 **Robert L. Benedetto*** (rlb@math.amherst.edu), Department of Mathematics, Amherst College, Amherst, MA 01002. *Attacking the Dynamical Uniform Boundedness Conjecture.*

Let K be a number field, and let f be a morphism from the projective line to itself, defined over K and of degree at least two. The 1994 Dynamical Uniform Boundedness Conjecture of Morton and Silverman claims, in dimension one, that the number of K-rational preperiodic points of f is bounded by a constant depending only on the degrees of f and K. In this talk, we will discuss certain non-archimedean methods used to make progress towards this conjecture both when f is a polynomial and when f is not a polynomial. (Received September 10, 2010)

1065-11-157 **Matthew Baker*** (mbaker@math.gatech.edu), School of Mathematics, Georgia Tech, Atlanta, GA 30332-0160. *Specialization of divisors from curves to graphs.*

I will discuss applications to tropical geometry and arithmetic algebraic geometry of a semicontinuity result concerning the specialization of divisors from curves to graphs. (Received September 12, 2010)

1065-11-167 **J. Brandt Kronholm*** (bkronholm@smcm.edu), Department of Mathematics, 18952 E. Fisher Rd, St. Mary's City, MD 20686-3001. *Ramanujan Congruence Properties of the Restricted Partition Function $p(n, m)$.*

Ramanujan-type congruences for the unrestricted partition function $p(n)$ are known and have been studied in great detail. $p(n, m)$ is the restricted partition function that enumerates the number of partitions of n into exactly m parts.

The relationship between $p(n)$ and $p(n, m)$ is clear:

$$p(n) = p(n, 1) + p(n, 2) + \cdots + p(n, n-1) + p(n, n).$$

Until recently, the existence of Ramanujan-type congruences have been virtually unknown for this function. Let ℓ be any odd prime. In this presentation we will establish explicit Ramanujan-type congruences for $p(n, m)$ for $2 \leq m \leq \ell$ modulo any power of that prime ℓ^α. (Received September 12, 2010)

1065-11-246 **Jennifer S. Balakrishnan*** (jenb@mit.edu). *Explicit iterated Coleman integration for hyperelliptic curves and the nonabelian Chabauty method.* Preliminary report.

Coleman's p-adic integration theory gives us explicit means of finding torsion and rational points on curves as well as computing p-adic regulators in K-theory. We describe an algorithm for computing Coleman integrals on hyperelliptic curves, including the natural generalization to iterated integrals. Specializing to the case of elliptic curves, we use our methods to study integral points via Kim's nonabelian Chabauty method. (Received September 14, 2010)

1065-11-265 **Xinyi Yuan*** (yxy@math.harvard.edu), 900 Davidson Road, Apt. 152, Piscataway, NJ 08854. *Monge-Ampere measures and Calabi-Yau theorem on Berkovich spaces.*

In this talk, I will review Chambert-Loir's construction of a measure on the Berkovich space from a metrized line bundle. Then we consider the non-archimedean analogue of the Calabi-Yau theorem. We prove the uniqueness part, which basically says the measure determines the metric up to constants. (Received September 14, 2010)

1065-11-268 **Ruochuan Liu*** (rliu@math.ias.edu), 338 Olden Lane, Princeton, NJ 08540. *On a conjecture of Rapoport and Zink.* Preliminary report.

In their book "Period spaces for p-divisible groups", Rapoport and Zink construct the rigid analytic period spaces for Fontaine's filtered φ-modules. They further conjecture the existence of certain local systems over some étale bijective coverings of the period spaces. We prove this conjecture by proposing some new constructions in Relative p-adic Hodge theory. This is a joint work with Kiran Kedlaya. (Received September 14, 2010)

12 ► Field theory and polynomials

1065-12-168 **Thomas J. Tucker*** (tjtucker@gmail.com), Math Department, University of Rochester, Rochester, NY 14610. *P-adic parametrization of orbits.*

Let $f : X \longrightarrow X$ be a morphism of varieties over a field of characteristic 0 and let x be a point on X. In many cases, one can show the orbit of x under f can be "p-adically parametrized"; that is, one can find a p-adic analytic map g from a disc in $\mathbb{C}_p$ to X such that $g(n) = f^n(x)$ for all n. The existence of such a parametrization allows one to solve the so-called "dynamical Mordell-Lang problem" for f, which states that, given a subvariety W of X, the set of n such that $f^n(x)$ is in W forms a finite union of arithmetic sequences. It also allows for the solution of various weak forms of a conjecture of Zhang on the existence of points with Zariski dense orbits. (Received September 12, 2010)

14 ► Algebraic geometry

1065-14-85 **Mohammad Ghomi** (ghomi@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, and **Ralph Howard*** (howard@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29205. *Tangent Cones and Regularity of Convex Sets.*

Let X be a locally closed subset of $\mathbf{R}^n$ so that all the tangent cones (in the sense of Federer), T_pX, are affine hypersurfaces of $\mathbf{R}^n$, the dependence on p is continuous, and the measure theoretic multiplicity at each point is at most $m < 3/2$. Then X is an embedded C^1 hypersurface of $\mathbf{R}^n$. This is used to show: (1) any convex real analytic hypersurface of $\mathbf{R}^n$ is C^1 and (2) if X is real algebraic, strictly convex, and unbounded, then it is a graph of a C^1 function over a hyperplane. (Received September 02, 2010)

1065-14-122 **Yifeng Liu*** (liuyf@math.columbia.edu), Room 509, MC4406, Department of Mathematics, Columbia University, 2990 Broadway, New York, NY 10027. *A non-archimedean Calabi-Yau theorem for totally degenerate abelian varieties.*

The theorem of Calabi-Yau is one of the most important results in complex geometry. In this work, we consider the similar question for a non-archimedean field in a special case. Let A be a totally degenerate abelian variety over $\mathbb{C}_p$ of dimension d, i.e., $A^{\mathrm{an}} \cong \left(\mathbb{G}_m^d\right)^{\mathrm{an}}/M$ for a complete lattice $M \subset \mathbb{G}_m^d(\mathbb{C}_p)$. We have an evaluation map $\tau_A : A^{\mathrm{an}} = \left(\mathbb{G}_m^d\right)^{\mathrm{an}}/M \to \mathbb{R}^d/\Lambda$ with a complete lattice $\Lambda \subset \mathbb{R}^d$, which is continuous and surjective. It has a continuous section $i_A : \mathbb{R}^d\Lambda \hookrightarrow A^{\mathrm{an}}$. Then we prove the following theorem which is a certain non-archimedean analogue of the classical Calabi-Yau theorem.

Let A and L be as above. For any measure $\mu = f\mathrm{d}\mathbf{x}$ of $\mathbb{R}^d/\Lambda$ with f a positive smooth function and $\int_{\mathbb{R}^d/\Lambda}\mu = \deg_L(A)$, there is a semi-positive metric $\|\ \|$ on L in the sense of Zhang, unique up to a constant multiple, such that $c_1(\overline{L})^d = (i_A)_*\mu$, where $\mathrm{d}\mathbf{x}$ is the Lebesgue measure on R^d/Λ and $\overline{L} = (L, \|\ \|)$. (Received September 08, 2010)

1065-14-195 **Eric Katz*** (eekatz@math.utexas.edu), 1 University Station C1200, Austin, TX 78712-0257. *Lifting Tropical Curves in Space and Linear Systems on Graphs.*

Tropicalization is a procedure for associating a polyhedral complex to a subvariety of an algebraic torus. We give a necessary condition for a graph to arise as the tropicalization of an algebraic curve. We make use of Baker's technique of specializing linear systems from curves to graphs to study the vanishing locus of particular

1-forms on a degenerating family of algebraic curves. Our condition reproduces a generalization of Speyer's well-spacedness condition and also gives new conditions. The method used is closely related to Coleman's method of effective Chabauty in the bad reduction case as studied by Lorenzini-Tucker and McCallum-Poonen. No knowledge of tropical geometry is required. (Received September 13, 2010)

1065-14-201 **Joseph D Rabinoff*** (rabinoff@post.harvard.edu), Department of Mathematics, One Oxford Street, Cambridge, MA 02143. *Metric aspects of the tropicalization of a Berkovich curve.*

Payne has shown that if X is a quasi-projective variety over a non-Archimedean field K, then the Berkovich analytification of X is naturally homeomorphic to the inverse limit of all tropicalizations of X under toric embeddings. In other words, one can naturally view the various tropicalizations of X as finite approximations, or retracts, of X^{berk}. In fact these approximations reflect much more than just the topological structure of X^{berk}. When X is a curve, both X^{berk} and any tropicalization of X have a natural metric graph structure, which are compatible in an interesting (and nontrivial) way. This compatibility allows one to relate the reduction theory of X with its tropicalizations. As an example application, we gain a deeper understanding of and a strengthening of Katz-Markwig-Markwig's theorem relating the tropical j-invariant of a tropical elliptic curve with the valuation of its ordinary j-invariant. (Received September 13, 2010)

1065-14-256 **Fedor A Bogomolov*** (bogomolo@cims.nyu.edu), 251 Mercer Street, New York, NY 10012. *Projective curves over small fields.*

The geometry of projective curves defined over $\bar{Q}$ or $\bar{F}_p$ differs dramatically from the geometry of curves over other fields. It is manifested for example by famous Belyi theorem. In my talk I will discuss several results about unramified coverings of the curves over small fields (i.e $\bar{Q}$ or $\bar{F}_p$) motivated by the following question.

Let C_1, C_2 be two hyperbolic(i.e. genus ≥ 2) projective curves over a small field L. Is it possible to find a projective curve C which is a (geometric) unramified covering of C_1 and has a surjection onto C_2? The answer to this question in full generality is unknown but I will provide many cases when such a "unramified correspondence" exists.

The talk is based on our joint results with Yuri Tschinkel and contains both published and new results on the topic. (Received September 14, 2010)

15 ► Linear and multilinear algebra; matrix theory

1065-15-94 **Luz M. DeAlba*** (luz.dealba@drake.edu), Drake University, 2507 University Avenue, Des Moines, IA 50311. *Minimum skew rank of powers of paths.* Preliminary report.

The minimum skew rank of a simple graph G is the smallest possible rank among all real skew symmetric matrices, whose (i, j)-entry (for $i \neq j$) is nonzero whenever ij is an edge in G and is zero otherwise. The graph G to the power r is the graph G^r, where ij is an edge of G^r if and only if there is a walk in G from vertex i to vertex j of length at most r. The graph G to the strict power r is the graph $G^{(r)}$, where ij is an edge in $G^{(r)}$ if and only if there is a walk in G from vertex i to vertex j of length exactly r. In this talk we solve the problem of minimum skew rank of powers and strict powers of paths. (Received September 04, 2010)

1065-15-104 **Amy Wangsness Wehe*** (awehe@fitchburgstate.edu), Mathematics Department, 160 Pearl St, Fitchburg, MA 01420, and **Luz Maria DeAlba** and **Judith J McDonald**. *When* $\mathrm{mr}^-(G) = \mathrm{MR}^-(G)$ *in Skew Symmetric Matrices.* Preliminary report.

This talk will explore the question of when $\mathrm{mr}^-(G) = \mathrm{MR}^-(G)$ in skew symmetric matrices. In particular, the talk will show some results toward answering this question and will also give insight into the process used in finding these results. (Received September 07, 2010)

1065-15-230 **Shaun M Fallat*** (sfallat@math.uregina.ca), Department of Mathematics and Statistics, Regina, Sask. s4s0a2, Canada. *Zero Forcing Parameters and Minimum Rank of a Graph.* Preliminary report.

For a given graph G, suppose a subset S of the vertices of G are coloured black and remaining are coloured white. By rule, a white vertex may be coloured black if it is the unique white neighbour of a black vertex. We call a set S of the vertices a zero forcing set if whenever the vertices of S are all coloured black, then, by the colour change rule, all of the vertices of G may be changed to the colour black. The zero forcing number of G, denoted by $Z(G)$, is defined as the fewest number of vertices in a zero forcing set for G.

The goal of this lecture is to demonstrate the connection between colouring the vertices of a graph black and white, and the nullity of certain symmetric matrices associated with a graph, and to survey a number of

interesting results involving the parameter $Z(G)$, and it relationship with the maximum nullity and hence the minimum rank of a graph. (Received September 14, 2010)

1065-15-261 **Louis Deaett*** (deaett@math.uvic.ca), Dept of Mathematics and Statistics, University of Victoria, P.O. Box 3060 STN CSC, Victoria, BC V8W 3R4, Canada. *The incidence graph of a Steiner triple system and its minimum semidefinite rank.* Preliminary report.

Given a finite incidence structure, consider the problem of assigning a vector in $\mathbb{C}^k$ to each point and to each block in such a way that a point and a block are incident if and only if their corresponding vectors are *not* orthogonal. For how small a k is this possible? This is equivalent to asking for the minimum semidefinite rank of the incidence graph. In this talk, we consider this question for Steiner triple systems. (Received September 14, 2010)

1065-15-272 **Lon Mitchell*** (lmitchell2@vcu.edu). *Open Problems in Minimum Semidefinite Rank.*

We survey recent results in minimum semidefinite rank and present some open problems for discussion. (Received September 15, 2010)

16 ► Associative rings and algebras

1065-16-58 **Weiqiang Wang***, Department of Mathematics, University of Virginia, Charlottesville, VA 22904. *The center of the symmetric group algebra and three generalizations.*

In a classical work, Farahat and Higman established fundamental properties for the center of the INTEGRAL symmetric group algebra which are closely related to Jucys-Murphy elements. We will explain three generalizations: (1) replace the symmetric group by a wreath product; (2) replace the symmetric group by its spin counterpart; (3) replace the symmetric group algebra by Hecke algebra. (Received August 23, 2010)

1065-16-64 **Evgeny Mukhin*** (mukhin@math.iupui.edu), Department of Mathematics, IUPUI, 402 N.Blackford Street, LD270, Indianapolis, IN 46202. *Representations of the $\mathcal{E}$-algebra.*

We consider the $\mathcal{E}$-algebra which has many names in different publications: the elliptic Hall algebra, the quantum continious $gl(\infty)$, the Ding-Iohara algebra, the quantum toroidal $gl(1)$...

We will discuss a certain class of irreducible highest weight representation of the $\mathcal{E}$-algebra given by appropriate subquotients of the tensor products of the semi-infinite wedge constructions. Those representations come with natural bases labeled by the tuples of partitions with simple conditions. Different limits of these representations produce modules over W_n algebras or $gl(\infty)$. That gives a simple combinatorial description of those modules.

This is a report on the joint project with B. Feigin, E. Feigin, M. Jimbo and T. Miwa. (Received August 26, 2010)

1065-16-233 **Martina Balagovic*** (martinab@math.mit.edu), Massachusetts Institute of Technology, Department of Mathematics, Room 2-588, 77 Massachusetts Avenue, Cambridge, MA 02139. *Chevalley restriction theorem for vector-valued functions on quantum groups.*

For $\mathfrak{g}$ a simple finite dimensional Lie algebra, $\mathfrak{h}$ its Cartan subalgebra, and W the Weyl group associated to it, Chevalley's classical theorem states that the restriction Res : $\mathbb{C}[\mathfrak{g}]^{\mathfrak{g}} \to \mathbb{C}[\mathfrak{h}]^W$ is an isomorphism. The talk will show how to generalize this statement to the case when $\mathfrak{g}$ is replaced by a quantum group and the target space $\mathbb{C}$ of the polynomial maps is replaced by a finite dimensional representation V of this quantum group. The main theorem is injectivity of the restriction map Res : $(O_q(G) \otimes V)^{U_q(\mathfrak{g})} \to O(H) \otimes V$ and the description of its image. (Received September 14, 2010)

1065-16-254 **Robert Lee Wilson*** (rwilson@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, **Vladimir Retakh** (vretakh@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, and **Shirlei Serconek** (serconek@mat.ufg.br), Institute of Mathematics and Statistics, CX-Postal 131, Goiania, Goias 74000, Brazil. *Hilbert series of algebras associated to directed graphs.*

We describe certain graded algebras associated to directed graphs and give a homological interpretation of the coefficients of the Hilbert series for these algebras and their duals. This allows us to obtain necessary conditions for Koszulity of such algebras in terms of homological properties of the graphs. We use our results to construct algebras of given growth such as noncommutative complete intersections and Calabi-Yau algebras. (Received September 14, 2010)

1065-16-258 **Dijana Jakelić*** (jakelicd@uncw.edu), Department of Mathematics and Statistics, University of North Carolina, Wilmington, 601 S. College Rd, Wilmington, NC 28401, and **Adriano Moura**. *Finite-dimensional representations of quantum affine algebras at roots of unity.*

For generic values of the quantization parameter, results of V. Chari and M. Kashiwara provide a way of obtaining indecomposable objects of the category of finite-dimensional representations of quantum affine algebras by giving sufficient conditions for a tensor product of simple objects to be highest-weight. In particular, a tensor product of fundamental representations can always be reordered in such a way that these conditions are satisfied. Furthermore, this property turned out to be one of the essential ingredients used for obtaining the block decomposition of the category.

In this talk, we will focus on a joint work with A. Moura where we consider the root of unity setting. We prove an analogue of Chari's version of the aforementioned result on tensor products of simple modules. However, the result about tensor products of fundamental representations is no longer valid. We will discuss the techniques we used to overcome this issue for describing the blocks in the root of unity setting. Time allowing, we will also mention some results concerning the q-characters of fundamental representations. (Received September 14, 2010)

17 ► Nonassociative rings and algebras

1065-17-55 **Bojko Bakalov** (bojko_bakalov@ncsu.edu) and **Nikolay M Nikolov*** (nikolay.m.nikolov@gmail.com). *Vertex algebras in higher dimensions and their restrictions to dimension one.*

Vertex algebras in higher dimensions correspond to models of quantum field theory with global conformal invariance. The one-dimensional restriction of a vertex algebra in higher dimensions to a time-like line gives a (usual) vertex algebra endowed with an action of the (higher-dimensional) conformal Lie algebra. We announce that from such data one can reconstruct the initial vertex algebra. (Received September 13, 2010)

1065-17-69 **Nicolas Guay*** (nguay@math.ualberta.ca), University of Alberta, Department of Mathematics, CAB 632, Edmonton, AB T6G 2G1, Canada. *Twisted affine quantized enveloping superalgebra of type Q.*

We consider a twisted loop superalgebra built from a Lie superalgebra of type Q. After presenting some of its properties, we will introduce a quantization of a certain bisuperalgebra structure and we will explain how this new quantized enveloping algebra is related to affine Hecke-Clifford algebras. This is a q-version of previous work of M. Nazarov about the Yangian attached to Lie superalgebras of type Q. (Received August 29, 2010)

1065-17-90 **Maarten J Bergvelt*** (bergv@illinois.edu). *T-Generalized Vertex Algebras and Twisted Modules.* Preliminary report.

For every integral lattice Q there is a lattice vertex algebra V_Q. By (more or less) the same construction one can associate a generalized vertex algebra to the dual lattice Q^* (which is usually rational). This generalized vertex algebra contains, remarkably, all modules for V_Q.

In case V_Q has a finite order automorphism T, one can talk about T-twisted modules for V_Q. In this talk I will discuss the notion of a T-generalized vertex algebra, and the construction of a T-generalized vertex algebra associated to V_Q that contains all the T-twisted modules for V_Q.

(Joint work with Iana Anguelova) (Received September 03, 2010)

1065-17-110 **Ben L. Cox*** (coxbl@cofc.edu), 66 George St., Math department, College of Charleston, Charleston, SC 29401, and **Vyatcheslav futorny**, Sao Paulo, Brazil. *DJKM algebras: Their universal central extension.*

This talk will explicitly describe in terms of generators, relations and certain families of polynomials, the universal central extension of the infinite dimensional Lie algebra, $\mathfrak{g} \otimes \mathbb{C}[t, t^{-1}, u | u^2 = (t^2 - b^2)(t^2 - c^2)]$, appearing in the work of Date, Jimbo, Kashiwara and Miwa in their study of integrable systems arising from the Landau-Lifshitz differential equation. (Received September 07, 2010)

1065-17-173 **Samuel Chamberlin*** (samcham@math.ucr.edu), University of California at Riverside, 900 University Ave., Department of Mathematics Surge 202, Riverside, CA 92521. *Integral bases for the universal enveloping algebra of $\mathfrak{g} \otimes A$.*

Given a finite-dimensional, simple Lie algebra $\mathfrak{g}$ over $\mathbb{C}$ and a commutative, associative algebra with unity over $\mathbb{C}$, A, we exhibit a $\mathbb{Z}$-form for the universal enveloping algebra of $\mathfrak{g} \otimes A$ and an explicit $\mathbb{Z}$-basis for this $\mathbb{Z}$-form.

We also produce explicit commutation formulas in the universal enveloping algebra of $\mathfrak{sl}_2 \otimes A$ that allow us to write certain elements in PBW basis order. (Received September 12, 2010)

1065-17-184 **Rebecca L Jayne*** (rljayne@ncsu.edu), North Carolina State University, Department of Mathematics, Box 8205, Raleigh, NC 27695. *On maximal weights of integrable $\widehat{sl}(n, \mathbb{C})$-modules.* Preliminary report.

For $\lambda = k\Lambda_0$, let $V(\lambda)$ be the integrable highest weight $\widehat{sl}(n, \mathbb{C})$-module. A dominant weight μ of $V(\lambda)$ is maximal if $\mu + \delta$ is not a weight. It is known that the set of maximal dominant weights of $V(\lambda)$ is finite. For $k \geq 1$, we give explicit descriptions of these maximal dominant weights and conjecture that their multiplicities are given by certain avoiding permutations. In particular, we show that for $k = 2$, the multiplicities are in one-to-one correspondence with 321-avoiding permutations. (Received September 13, 2010)

1065-17-187 **Alexander Retakh*** (RetakhA@usmma.edu), USMMA, 300 Steamboat Road, Kings Point, NY 11024. *A vertex algebra-like construction of modules for toroidal algebras.* Preliminary report.

It is well-known that some modules of affine Kac-Moody algebras, in particular vacuum modules, carry a vertex algebra structure. I will discuss emulating their construction in order to describe a class of modules of toroidal algebras. (Received September 13, 2010)

1065-17-193 **Bojko Bakalov*** (bojko_bakalov@ncsu.edu) and **Nikolay M Nikolov**. *Local endomorphisms of vertex algebras.*

We introduce the notion of a local endomorphism of a vertex algebra as a linear operator whose commutator with every vertex operator is local with respect to all other vertex operators. Examples of local endomorphisms are provided by the modes of vertex operators as well as by the action of infinitesimal symmetries. We describe how they are related to the pseudo-derivations of Etingof-Kazhdan and to the derivations of the affinization of the vertex algebra. (Received September 13, 2010)

1065-17-197 **D Grantcharov*** (grandim@uta.edu), Department of Mathematics, UT Arlington, Arlington, TX 76019, and **Vera Serganova**. *On the category of bounded weight modules of $\mathfrak{sl}(n)$.* Preliminary report.

We study the category $\mathcal{B}$ of bounded weight $\mathfrak{sl}(n)$-modules, i.e. modules that equal the direct sum of their weight spaces and whose sets of weight multiplicities are uniformly bounded. The simple objects of $\mathcal{B}$ have been classified by O. Mathieu in 2000. The study of the indecomposable objects of the blocks $\mathcal{B}^\chi$ depends on the type of the central character χ. In this talk we focus on the case of a singular central character χ where interesting relations with layered-type graphs are discovered. (Received September 13, 2010)

1065-17-208 **Naihuan Jing*** (jing@math.ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695. *Quantum TKK algebra.*

We introduce a quantum analogue of a Tits–Kantor–Koecher algebra with a Jordan torus as an coordinated algebra by looking at the vertex operator construction over a Fock space. This is joint work with Y. Gao. (Received September 13, 2010)

1065-17-210 **Minxian Zhu*** (minxian@math.rutgers.edu), 110 Frelinghuysen Road, Department of Mathematics, Rutgers University, Piscataway, NJ 08854. *Vertex operator algebras associated to modified regular representations of the Virasoro algebra.*

We give an abstract construction, based on the Belavin-Polyakov-Zamolodchikov equations, of a family of vertex operator algebras of rank 26 associated to the modified regular representations of the Virasoro algebra. The vertex operators are obtained from the products of intertwining operators for a pair of Virasoro algebras. We explicitly determine the structure coefficients that yield the axioms of VOAs. In the process of our construction, we obtain some hypergeometric identities. (Received September 13, 2010)

1065-17-214 **Alex J Feingold*** (alex@math.binghamton.edu), Dept of Math Sci, Binghamton University, Vestal Parkway East, Binghamton, NY 13902-6000, and **Quincy Loney**. *Spinor construction of representations of affine Kac-Moody algebras of types $G_2^{(1)}$ and $D_4^{(3)}$.* Preliminary report.

In Contemp Math, Vol. 121, Feingold, Frenkel and Ries gave a spinor construction of the vertex operator para-algebra $V = V^0 \oplus V^1 \oplus V^2 \oplus V^3$, whose summands are 4 level-1 irreps of the affine Kac-Moody algebra $D_4^{(1)}$. The triality group S_3 acts on V, preserving V^0, permuting V^i, $i = 1, 2, 3$. V is $\frac{1}{2}\mathbb{Z}$-graded and V_n^i denotes the n-graded subspace of V^i. Vertex operators from V_1^0 represent $D_4^{(1)}$ on V. The 8-dim spaces $V_{1/2}^i$, $i = 1, 2, 3$,

are the natural and two spinor modules of D_4, and their direct sum is the 24-dim Chevalley algebra C. The eigenspace decomposition of the order 3 element $\sigma \in S_3$ on D_4 gives the fixed point subalgebra G_2, and two 7-dim irreps. This lifts to V so that the vertex operators from fixed points of V_1^0 represent the affine algebra $G_2^{(1)}$. Including vertex operators from the other eigenspaces of σ in V_1^0, one should obtain the twisted affine algebra $D_4^{(3)}$. This dissertation research of QL studies the decomposition of V with respect to these two affine algebras, thus obtaining spinor constructions of representations of $G_2^{(1)}$ and $D_4^{(3)}$. (Received September 14, 2010)

1065-17-225 **Alex J Feingold** and **Jurisich Elizabeth*** (jurisiche@cofc.edu), Department of Mathematics, College of Charleston, Robert Scott Small Building / Room 339, Charleston, SC 29424. *Decomposition of a rank 2 hyperbolic Kac-Moody Lie algebra with respect to the Nicolai-Olive principal $so(1,2)$ subalgebra.* Preliminary report.

Let $H(3)$ be the rank 2 hyperbolic Kac-Moody Lie algebra with Cartan matrix $\begin{bmatrix} 2 & -3 \\ -3 & 2 \end{bmatrix}$. The Nicolai-Olive principal $so(1,2)$ subalgebra S is isomorphic to sl_2. We study the decomposition of $H(3)$ with respect to S, into a direct sum of irreducible S-modules. This decomposition is of the form $S \oplus V(\infty) \oplus \bigoplus_{k=3}^{\infty} m_k(V(k) \oplus V(-k))$ where $V(\infty)$ is infinite-dimensional having one-dimensional weight spaces for each weight $n \in \mathbb{Z}$. The other summands in the decomposition are either highest weight S-modules, $V(-k)$ with highest weight $-k$, or lowest weight S-modules, $V(k)$, with lowest weight k. The multiplicities, m_k, with which these occur, are the dimensions of the spaces of extremal vectors in these modules. We conjecture that the Lie subalgebra of extremal vectors of positive weight is a free subalgebra. (Received September 14, 2010)

1065-17-264 **A Milas*** (antun.milas@gmail.com), 1400 Washington Ave, Albany, NY 12222. *Whittaker vectors and the AGT conjecture.*

We construct a family of nonstandard (Whittaker) representations for certain W-algebras, including the Virasoro algebra. This construction is motivated by a conjecture of Alday, Gaiotto and Tachikawa relating 2d Liouville theory and the Nekrasov partition function. We also explain how to generate Whittaker vectors (or Gaiotto's states) in the completion of the Verma module. (Received September 14, 2010)

1065-17-269 **Erhard Neher**, **Alistair Savage** and **Prasad Senesi*** (senesi@cua.edu), The Catholic University of America, 620 Michigan Ave., N.E., Washington, DC 20064. *equivariant map algebras and their irreducible finite-dimensional representations.*

Let $\mathfrak{g}$ be a finite-dimensional simple Lie algebra and A an affine algebraic variety defined over an algebraically closed field of characteristic 0. Let G be a finite group which acts via automorphisms upon $\mathfrak{g}$ and A. The Lie algebra of regular maps from A to g which are equivariant under the the action of G is called an equivariant map algebra. Examples of such algebras include current algebras, multiloop algebras (in particular, the untwisted loop algebras $\mathfrak{g} \otimes k\left[t^{\pm 1}\right]$ and their twisted subalgebras), and the Onsager algebras. In this talk we will classify the finite-dimensional irreducible representations of an arbitrary equivariant map algebra, and describe some conditions which ensure that all such representations are given by evaluation representations of $\mathfrak{g}$. (Received September 15, 2010)

18 ► Category theory; homological algebra

1065-18-82 **Anton Zeitlin*** (anton.zeitlin@yale.edu), 442 Dunham Lab, 10 Hillhouse Avenue, Department of Mathematics, New Haven, CT 06511. *Homotopy BV algebras, Courant algebroids and String Field Theory.*

We construct the homotopy BV algebra related to vertex algebroid with a Calabi-Yau structure. We show that the corresponding homotopy commutative algebras and homotopy Lie algebras are related to Yang-Mills and Einstein equations and their string theory deformations. We also discuss several open questions, related to interrelations between homotopy algebras and vertex algebras. (Received September 02, 2010)

1065-18-142 **James R. Hughes*** (hughesjr@etown.edu), Mathematical Sciences Department, Elizabethtown College, Elizabethtown, PA 17022. *A Groupoid Model for Voice Leading in Music.* Preliminary report.

Voice leading— the specific means by which sequential sets of musical pitches or pitch classes (chords) are connected through assignment of melodic lines (voices)— is an important consideration in both the composition and the analysis of music. Music theorists have found it helpful to use mathematical tools in the study of

voice leading. In particular, a recent paper of music theorist Dmitri Tymoczko gives mathematically precise definitions of voice leadings between pitch sets and pitch class sets, and uses them to develop analytical tools focusing on the role of efficiency of voice leadings across musical contexts. We offer a recharacterization and extension of Tymoczko's definitions using the categorical, topologically motivated theory of groupoids. The groupoid approach allows for incorporation of a wide variety of voice leading phenomena that occur in music. Its categorical aspect provides a connection with the work of mathematical music theorist Guerino Mazzola and others. Moreover, the utility of groupoids in the study of quotient maps and orbit spaces holds the promise of deeper mathematical application to the idea of generalized voice leading spaces found in recent work of music theorists Callender, Quinn, and Tymoczko. (Received September 11, 2010)

30 ► Functions of a complex variable

1065-30-37 **Tim Ferguson*** (tjferg@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Regularity of Extremal Problems in Bergman Spaces and Extensions of Ryabykh's Theorem.*

We discuss linear extremal problems in the Bergman space A^p of the unit disc for $1 < p < \infty$. Given a functional on the dual space of A^p with representing kernel $k \in A^q$, where $1/p + 1/q = 1$, we discuss how the regularity of k is related to the regularity of the extremal function F. Specifically, we discuss a theorem of Ryabykh and some extensions of this theorem in the case where p is an even integer which relate membership of k in certain Hardy spaces with membership of F in certain Hardy spaces. (Received September 03, 2010)

1065-30-99 **Eric Amar**, Institut de Mathématiques de Bordeaux, Université Bordeaux 1, 351 cours de la Libération, 33405 Talence, France, and **Andreas Hartmann*** (Andreas.Hartmann@math.u-bordeaux1.fr, ahartma2@richmond.edu), Institut de Mathématiques de Bordeaux, Université de Bordeaux, 351 cours de la Libération, 33405 Talence, France. *Interpolation and weak interpolation in backward shift invariant subspaces.*

Given a space of holomorphic functions on a complex domain, a sequence of points in the domain is called interpolating if every sequence of suitable values can be interpolated by a function in the space. This notion of interpolation can be weakened: a sequence is called weak interpolating if we can interpolate sequences which are zero everywhere except at one point under a suitable norm control of the interpolating function.

A prominent example is the Hardy space: For every Blaschke sequence in the disk, the Blaschke product associated with the sequence except one point interpolates zeros everywhere except in that point. Obviously, under what is now known as the Carleson condition the sequence is weak interpolating (the Carleson condition gives automatically the "suitable control of the norm"). One of Carleson's achievements was to prove that such a sequence is already interpolating. It turns out that a similar behaviour holds in many other spaces.

In backward shift invariant subspaces, however, this is not true. Still, in certain situations one can deduce interpolation from weak interpolation by "increasing the size of the space". This will be achieved via Khinchin based methods used previouly by Amar for Hardy spaces of several complex variables. (Received September 05, 2010)

1065-30-100 **Constanze D Liaw*** (conni@math.tamu.edu), Department of Mathematics, Mailstop 3368, College Station, TX 77845. *Deterministic Properties of Anderson-type Hamiltonians.*

An Anderson-type Hamiltonian is a self-adjoint operator on a separable Hilbert space $\mathcal{H}$ which is formally given by $A_\omega = A + V_\omega$ where $V_\omega = \sum_n \omega_n(\,\cdot\,, \varphi_n)\varphi_n$. Here $\{\varphi_n\} \subset \mathcal{H}$ is a sequence and $\omega = (\omega_1, \omega_2, \ldots)$ is a sequence of independent random variables corresponding to a probability measure $\mathbb{P}$ on $\mathbb{R}^\infty$ which is merely assumed to satisfy Kolmogorov's 0-1 law. The main result states that, under mild cyclicity conditions, the essential parts of A_ω and A_η are almost surely (with respect to the product measure $\mathbb{P} \times \mathbb{P}$) unitary equivalent modulo a rank one perturbation. Following ideas developed by A. G. Poltoratski, we will explain how the Krein–Lifshits spectral shift for rank one perturbations represents the central tool of its proof. (Received September 06, 2010)

1065-30-133 **Mishko Mitkovski*** (mishko@math.gatech.edu). *On the basis properties of complex exponentials.*

Questions about various types of expansion properties of the sequence of complex exponentials have a very long history with origins in the works of Paley, Wiener, and Levinson. In this talk we give a characterization of some of these basis properties in terms of the invertibility properties of a certain naturally associated Toeplitz operator. Furthermore, for a given separated frequency sequence $\Lambda = \{\lambda_n\}$ we show that the supremum of all

$c > 0$ for which the corresponding sequence of complex exponentials $\{e^{i\lambda_n t}\}$ is l^2-dependent in $L^2(0, c)$ is equal to the interior Beurling-Malliavin density of Λ. (Received September 10, 2010)

34 ► Ordinary differential equations

1065-34-5 **Ludwig Kohaupt*** (kohaupt@bht-berlin.de), Beuth University of Technology, Department of Mathematics, Luxemburger Str. 10, 13353 Berlin, Germany. *Contributions to optimal bounds on the solution of vibration problems.*

In this talk, we give an overview on the results of the author's recent *Cumulative Habilitation Thesis* and add an outlook on future developments.

In the Habilitation Thesis, we describe the development of a differential calculus for norms of matrix and vector functions, the derivation of new bounds for the initial and terminal domains on the solution of ordinary differential equations representing dynamical systems with vibration behavior and the application of the results to the determination of optimal constants in the bounds. The new results go far beyond what has been known so far. Especially, with respect to two-sided bounds, multi-mass vibration systems can now be handled almost as good as one-mass systems. The new optimal bounds mean a significant theoretical and practical progress in the theory of vibration and cannot be obtained by the methods employed so far. Some of the new results are of general interest. (Received January 08, 2010)

1065-34-53 **Lennard F Bakker*** (bakker@math.byu.edu), 366 TMCB, Department of Mathematics, Brigham Young University, Provo, UT 84602. *Existence and Stability of Symmetric Periodic Simultaneous Binary Collision Orbits in the Pairwise Symmetric Four-Body Problem.*

We prove the analytic existence of a symmetric periodic simultaneous binary collision orbit in a regularized planar pairwise symmetric equal mass four-body problem. We provide some analytic and numerical evidence for this periodic orbit to be linearly stable. We then use a continuation method to numerically find symmetric periodic simultaneous binary collision orbits in a regularized planar pairwise symmetric 1, m, 1, m four-body problem for m between 0 and 1. We numerically investigate the linear stability of these periodic orbits through long-term integration of the regularized equations, showing that linear stability occurs when $0.538 \leq m \leq 1$, and instability occurs when $0 < m \leq 0.537$ with spectral stability for $m \approx 0.537$. (Received August 20, 2010)

1065-34-76 **Martha Alvarez-Ramirez*** (mar@xanum.uam.mx), Departamento de Matematicas UAM-Iztapalapa, San Rafael Atlixco 186 Col. Vicentina, A.P. 55-534, Mexico City, D.F., Mexico, and **Claudio Vidal** (clvidal@ubiobio.cl), Departamento de Matematica, Facultad de Ciencias Universidad del Bio Bio, Avda. Collao No. 1202 Casilla 5-C, 4081112 Concepcion, Chile. *Dynamical aspects of an equilateral restricted four body problem.*

The spatial equilateral restricted four-body problem (ERFBP) is a four body problem where three masses, moving in circular motion such that their configuration is always an equilateral triangle, the fourth mass being small and not influencing the motion of the three primaries. In our model we assume that the two masses of the primaries m_2 and m_3 are equal to μ and the mass m_1 is $1 - 2\mu$. The Hamiltonian function that governs the motion of the fourth mass is derived and it has three degrees of freedom depending periodically on time. Using a synodical system, we fixed the primaries in order to eliminate the time dependence. Similarly to the circular restricted three body problem, we obtain a first integral of motion. With the help of the Hamiltonian structure, we characterize the region of the possible motions and the surface of fixed level in the spatial as well as in the planar case. Among other things we verify that the number of equilibrium solutions depends upon the masses, also we show the existence of periodic solutions by different methods in the planar case. (Received August 30, 2010)

1065-34-79 **Maoan Han*** (mahan@shnu.edu.cn), Department of Mathematics, Shanghai Normal University, Shanghai, 200234, Peoples Rep of China. *Some studies on non-smooth systems.*

We consider a planar non-smooth system of the form

$$\dot{x} = f(x, y),\ \dot{y} = g(x, y), \quad x \neq 0,$$

where

$$(f(x, y), g(x, y)) = \begin{cases} (f^+(x, y), g^+(x, y)), & x > 0, \\ (f^-(x, y), g^-(x, y)), & x < 0, \end{cases}$$

and $f^{\pm}(x, y), g^{\pm}(x, y)$ are supposed to be C^ω functions. Then the two C^ω systems

$$\dot{x} = f^+(x, y), \quad \dot{y} = g^+(x, y), \ \ x > 0,$$

and

$$\dot{x} = f^-(x,y), \quad \dot{y} = g^-(x,y), \ \ x < 0,$$

are called the right and the left subsystem resp.. The flow $\varphi(t,A)$ of the full system can be defined by using the flows $\varphi^{\pm}(t,A)$ of the right subsystem and the left subsystem.

If

$$f(x,y) = H_y, \ g(x,y) = -H_x, \ x \neq 0,$$

where

$$H(x,y) = \begin{cases} H^+(x,y), & x > 0, \\ H^-(x,y), & x < 0, \end{cases}$$

and $H^{\pm}(x,y) \in C^{\omega}$ with $H^{\pm}(0,0) = 0$, then it is called a piecewise Hamiltonian system.

We will introduce some recent studies on the limit cycle bifurcations for planar non-smooth systems, including piecewise Hamiltonian systems and near-Hamiltonian systems. (Received September 01, 2010)

1065-34-138 **Jianjun Paul Tian*** (jtian@wm.edu), 121 Jones Hall, Mathematics Department, College of William and Mary, Williamsburg, VA 23187. *On the global stability of cholera models.* Preliminary report.

We conduct global stability analysis for the endemic equilibria of several deterministic cholera models. These models, incorporating both human population and pathogen concentration, constitute four-dimensional nonlinear autonomous systems where the classical Poincare-Bendixson theory is not applicable. We employ three different techniques, including the monotone dynamical systems, geometric approach, and Lyapunov functions, to investigate the endemic global stability for several biologically important cases. The analysis and results presented in this paper make building blocks towards a comprehensive study of the general mathematical cholera model. This is a joint work with Jin Wang. (Received September 10, 2010)

1065-34-148 **Douglas E Norton*** (douglas.norton@villanova.edu), Department of Mathematical Sciences, Villanova University, 800 Lancaster Avenue, Villanova, PA 19085. *Phase Portraits from Varying Parameters in Families of Systems of Differential Equations.*

The phase plane provides a context in which to represent some qualitative properties of solutions of systems of differential equations in two variables. A phase portrait traditionally provides a visual representation of a particular solution of a particular system or several solutions with different initial conditions. In this report on continuing investigations, we explore some graphical representations of solution curves of systems that are close in parameter space and that share common initial conditions. We present examples in which the patterns and information carried differ from the usual phase diagrams and explore the potential for new and potentially aesthetically pleasing representation of dynamical information about families of systems. (Received September 11, 2010)

1065-34-154 **Andrei V. Olifer*** (aolifer@emory.edu), Emory University, 1510 Clifton Rd. NE, Room 2172, Atlanta, GA 30322, and **Astrid A. Prinz**. *Geometry and Dynamics of Activity-Dependent Homeostatic Regulation in Neurons.*

Activity-dependent homeostatic regulation (ADHR) maintains robust neuronal functioning in the face of intra- and extracellular perturbations and, in particular, constant turnover of the proteins that determine neuronal excitability. Such regulation is critical for normal processing of the nervous system, avoiding pathological states such as seizures, and recovering from injuries, for example caused by stroke. The physiological mechanisms of ADHR are complex. They involve multiple biochemical pathways and act at several spatial and temporal scales. Known mathematical models of ADHR mimic experimental data but limitations and mathematical properties of these models are poorly understood. To understand ADHR better, we set and solve a prototypical homeostatic regulation problem for a classical Morris-Lecar neuronal model. We solve the problem by separating fast neuronal and slow regulatory dynamics of the system. The success or failure of regulation is determined by considering the bifurcation diagram of the averaged fast system and the manifolds of the regulated parameters. The obtained results are discussed from the control theory perspective. Our work clarifies existing models and formulates specific questions for future experimental and theoretical studies of ADHR. (Received September 12, 2010)

1065-34-177 **Jianjun Paul Tian*** (jptian@math.wm.edu), 121 Jones Hall, Mathematics Department, College of William and Mary, Williamsburg, VA 23187. *The Replicability of Oncolytic Virus: Defining Conditions in Tumor Virotherapy.* Preliminary report.

The replicability of an oncolytic virus is measured by its burst size. The burst size is the number of new viruses coming out from a lysis of an infected tumor cell. Some clinical evidences show that the burst size of an oncolytic virus is a defining parameter for the success of virotherapy. This article analyzes a basic mathematical model that

includes burst size for oncolytic virotherapy. The analysis of the model shows that there are two threshold values of the burst size: below the first threshold, the tumor always grows to its maximum (carrying capacity) size; while passing this threshold, there is a locally stable positive equilibrium solution appearing through transcritical bifurcation; while above the second threshold, there exits one or three families of periodic solutions rising from Hopf bifurcations. The study suggests that the tumor load can drop to a undetectable level either during the oscillation or when the burst size is large enough. (Received September 12, 2010)

1065-34-234 **Bourama Toni*** (btoni@vsu.edu), Virginia State University, Department of Mathematics & Computer Science, Petersburg, VA 23806. *Almost and Pseudo-almost Limit Cycles for Differential Systems.*

We introduce the concepts of Almost and Pseudo-almost Limit Cycles, and determine the conditions of their existence, uniqueness, stability and bifurcation, as well as the existence of the related isochrons, for planar differential systems. In application we study a class of almost and pseudo-almost periodically forced Lienard systems (Received September 14, 2010)

1065-34-244 **Renee Fister*** (renee.fister@murraystate), Dept. of Mathematics and Statistics, 6C-5 Faculty Hall, Murray State University, Murray, KY 42071, and **Glenna Buford**, **Bryce Norris**, **Suzanne Lenhart**, **Peng Zhong**, **Elsa Schaefer** and **Holly Gaff**. *Age Structured Investigation of Cholera with Optimal Control.* Preliminary report.

Cholera is a diarrheal disease that has caused significant loss of life and financial devastation. The question arises of how does one control it effectively without creating further harm to the persons infected. Initial work on control dynamics has shown promising scenarios with combination strategies. In this presentation, work on a two compartment cholera age-structured model is investigated with numerical analyses of the force of the infection with interactions of susceptible and infected populations. Calculations of R0, the number of secondary infections caused from a primary infected in a susceptible population, has been determined. Optimal control strategies for reduction of the disease are analyzed. (Received September 14, 2010)

1065-34-275 **Daniel Vasiliu*** (daniel.vasiliu@cnu.edu), 1st University Place, Newport News, VA 23188. *The Dynamics of Recombinant and Burst Size Effects in Tumor Viro-therapy.*

In this work we analyze a mathematical model for cancer viro-therapy with recombinant viruses and with the assumption of logistic growth for the uninfected tumor cell population. In the case of measles viruses such models have been studied mostly from the numerical point of view. On the other hand, for different viro-therapy models that do not quantify the recombinant behavior of the oncolytic viruses it was rigorously shown how the inside-tumor replicability of the virus controls the outcome of the therapy. The inside-tumor replicability of the oncolytic virus is measured by its burst size. We advance the analysis of the therapy with recombinant viruses by studying the connection between the burst size and the stability of the equilibrium states corresponding to therapy failure, partial tumor reduction and tumor eradication (Received September 15, 2010)

35 ► Partial differential equations

1065-35-65 **Jibin Li*** (jibinli@gmail.com), Zhejiang Normal University, 688 Yingbin Avenue, Jinhua, Zhejiang 321004, Peoples Rep of China. *On the Travelling Wave Solutions for Some High-Order Nonlinear Wave Equations:Dynamical System Approach.*

For the Lax KdV5 equation and the KdV-Sawada-Kotera-Ramani equation, etc, their corresponding four-dimensional travelling wave systems are studied by using Congrove's results and dynamical system method. Exact explicit gap soliton, embedded soliton, periodic and quasi-periodic wave solutions are obtained. The existence of homoclinic manifolds to three kinds of equilibria including a hyperbolic equilibrium, a center-saddle and an equilibrium with zero pair of eigenvalues is revealed. The bifurcation conditions for equilibria are given. (Received August 26, 2010)

1065-35-68 **Juergen Batt** (batt@mathematik.uni-muenchen.de), Munich, Germany, and **Yi Li*** (yi-li@uiowa.edu), Iowa City. *Steady-States of the Vlasov-Poisson System.*

We will present our study of the **positive** solutions $\phi = \phi(r)$ of the differential equation

$$\phi'' + \frac{2}{r}\phi' = -\frac{r^{\lambda-2}}{(1+r^2)^{\lambda/2}}\phi^p, \qquad p > 1,\ \lambda > 0.$$

In particular, the structure of singular solutions. For $\lambda = 2$, these solutions are the radial solutions of the semilinear elliptic equation

$$\Delta\phi = -\frac{1}{1+|x|^2}\phi^p,$$

on $\mathbb{R}^3$, which T. Matukuma proposed in 1935 for the description of certain stellar globular clusters in a steady state. They correspond to time-independent solutions of the Vlasov-Poisson system

$$\text{(V)} \qquad \partial_t f + v\partial_x f - \partial_x U(t,x)\,\partial_v f = 0$$

$$\text{(P)} \qquad \Delta U(t,x) = 4\pi\rho(t,x)$$

$$\text{(D)} \qquad \rho(t,x) := \int f(t,x,v)\,dv, \qquad x, v \in \mathbb{R}^3,$$

in the case of spherical symmetry; here $f = f(t,x,v) \geq 0$ is the distribution function of the considered system of gravitating mass in the space-velocity space $\mathbb{R}^3 \times \mathbb{R}^3$, $U =$ the Newtonian potential and ρ the local density. (Received August 28, 2010)

1065-35-70 **Shitao Liu*** (sl3fa@virginia.edu), P.O.Box 400137, Ker chof Hall, Department of Mathematics, University of Virginia, Charlottesville, VA 22904, and **Roberto Triggiani** (rt7u@virginia.edu), P.O.Box 400137, Kerchof Hall, Department of Mathematics, University of Virginia, Charlottesville, VA 22904. *Global uniqueness in determining electric potentials for a system of strongly coupled Schrödinger equations with magnetic potential terms.*

We consider the inverse problem of determining two unknown electric potential coefficients for a system of two general strongly coupled Schrödinger equations, with magnetic potential terms and with Neumann boundary conditions, from Dirichlet measurements on a portion Γ_1 of the boundary. Under suitable geometrical assumptions on the complementary unobserved portion Γ_0 of the boundary, we show that one can uniquely determine the two unknowns from Dirichlet boundary measurements on Γ_1 over an arbitrarily short time interval. The proof is based on a recent developed Carleman estimate for single Schrödinger equations. It also takes advantage of a convenient route "post-Carleman estimates" suggested by V.Isakov. (Received August 29, 2010)

1065-35-84 **Xiaofeng Ren*** (ren@gwu.edu), 2115 G Street, NW, Monroe Hall, Room 240, Washington, DC 20052. *Ansatz solutions to a problem of mean curvature and Newtonian potential.*

Pattern formation problems arise in many physical and biological systems as orderly outcomes of self-organization principles. Examples include animal coats, skin pigmentation, and morphological phases in block copolymers. Recent advances in singular perturbation theory and asymptotic analysis have made it possible to study these problems rigorously. In this talk I will discuss a central theme in the construction of various patterns as solutions to some well known PDE and geometric problems: how a single piece of structure built on the entire space can be used as an ansatz to produce a near periodic pattern on a bounded domain. We start with the simple disc and show how the spot pattern in morphogenesis and the cylindrical phase in diblock copolymers can be mathematically explained. More complex are the ring structure and the oval structure which can also be used to construct solutions on bounded domains. Finally we discuss the newly discovered smoke-ring structure and the toroidal tube structure in space. (Received September 02, 2010)

1065-35-114 **Philip L. Korman*** (kormanp@math.uc.edu), Deparment of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221-0025. *Existence and uniqueness of solutions for a class of p-Laplace equations on a ball.*

For a class of equations generalizing the model case

$$\Delta_p u - a(r)u + b(r)u^q = 0 \text{ in } B,\ u = 0 \text{ on } \partial B,$$

where B is the unit ball in R^n, $n \geq 1$, $r = |x|$, $p, q > 1$, and Δ_p denotes the p-Laplace operator, we give conditions for the existence and uniqueness of positive solution. In case $n = 1$, we give a much more detailed result. (Received September 08, 2010)

1065-35-120 **Irena Lasiecka*** (il2v@virginia.edu), Department of Mathematics, University of Virginia, Charlottesville, VA 22901, and **Barbara Kaltenbacher**. *Well-posedness and exponential decay for the quasilinear Westervelt equation arising in modeling of high intensity ultrasound.*

Global solvability of Westervelt equation, which model arises in the context of high intensity ultrasound HIFU. The PDE equations derived are evolutionary quasilinear, potentially degenerate damped wave equations defined on a bounded domain in $R^n, n = 1, 2, 3$.

We prove local and global well-posedness as well as exponential decay rates for the Westervelt equation with *inhomogeneous Dirichlet boundary conditions* and small Cauchy data. The local existence proofs are based on an application of Banach's fixed point theorem to an appropriate formulation of these PDEs.

Global wellposedness is shown by exploiting functional analytic properties enjoyed by the semigroups generated by strongly damped wave equations. These include analyticity, dissipativity and suitable characterization of fractional powers of the generator -properties that enable the applicability of the "barrier" method .

The obtained result holds for all times, provided that the Cauchy data are taken from a suitably small (independent on time) ball characterized by the parameters of the equation, and the boundary data satisfy some decay condition. (Received September 08, 2010)

1065-35-124 **Xiaojie Hou*** (houx@uncw.edu), Department of Mathematics and Statistics, University of North Carolina Wilmington, Wilmington, NC 28403. *On the Minimal Wave Speed for a Lotka Volterra System.*

Abstract. Under mild conditions we derive the minimal speed for the wave solutions of a Lotka Volterra competition system. Also we investigate the uniqueness, asymptotics of the wave solutions by using the sliding domain method and exponential dichotomy. (Received September 08, 2010)

1065-35-129 **Eunkyoung Lee**, **Sarath Sasi** and **Ratnasingham Shivaji*** (shivaji@ra.msstate.edu), Department of Mathematics/CCS, Mississippi State University, Mississippi State, MS 39762. *S-Shaped Bifurcation Curves in Ecosystems.*

We consider the existence of multiple positive solutions to the steady state reaction diffusion equation with Dirichlet boundary conditions of the form:

$$\begin{cases} -\Delta u = \lambda[u - \dfrac{u^2}{K} - c\dfrac{u^2}{1+u^2}], & x \in \Omega \\ u = 0, & x \in \partial\Omega. \end{cases}$$

Here $\Delta u = div(\nabla u)$ is the Laplacian of u, $\frac{1}{\lambda}$ is the diffusion coefficient, K and c are positive constants and $\Omega \subset \mathbb{R}^N$ is a smooth bounded region with $\partial\Omega$ in C^2. This model describes the steady states of a logistic growth model with grazing in a spatially homogeneous ecosystem. It also describes the dynamics of the fish population with natural predation. In this paper we discuss the existence of multiple positive solutions leading to the occurrence of an S-shaped bifurcation curve. We prove our results by the method of sub-super solutions. *Joint work with Eunkyoung Lee and Sarath Sasi (Received September 09, 2010)

1065-35-203 **Seth F Oppenheimer*** (seth@math.msstate.edu), P.O. Drawer MA, Department of Mathematics and Statistics, Mississippi State, MS 39762, **Janice Chambers**, PO Box 6100, CVM Basic Science Department, Mississippi State, MS 39762, and **Shane Burgess**, PO Box 6100, CVM Basic Science Department, Mississippi State, MS 39762. *A model for parathion desulfuration in a liver sinusoid revisited.* Preliminary report.

Organophosphorus insecticides (OP) are one of the most widely used and important insecticide classes. After entering the mammalian blood stream, the OP will pass into the liver and from the portal vein to the central vein via sinusoids. While passing though the sinusoids some amount of the OP will enter the cell lining of the sinusoid and undergo desulfueration. It is this passage and the attendant desulfuration process that we intend to model. We have previously discussed this model we developed some years ago, a set of nonlinear partial and ordinary differential equations. While we had pleasing numerical results, some mathematical questions were left unresolved. It is our hope that we will have them resolved before the slides for this talk are typed. This work has been supported NIH grant DHHS/NIH 5 P20 RR17661-02 (Received September 13, 2010)

1065-35-226 **Roberto Triggiani*** (rt7u@virginia.edu), Mathematics Department, University of Virginia, Charlottesville, VA 22904. *Global uniqueness and stability in an inverse problem for a second order hyperbolic equation with non-homogeneous Neumann boundary term.*

We provide a global uniqueness and stability result in determining the damping coefficient of an inverse hyperbolic problem with non-homogeneous Neumann term, through the measurement of an additional Dirichlet boundary trace over an explicit portion of the boundary and over a close to optimal time. Key ingredients of the proof from past joint work of the author include: (i) sharp and very general Carleman estimates for second order hyperbolic equations; (iii) a correspondingly implied Continuos Observability Inequality; (ii) Sharp/optimal interior and boundary regularity theory of second order hyperbolic equations with Neumann boundary datum. This is joint work with Shitao Liu, Uva. (Received September 14, 2010)

1065-35-250 **Judith C Hill*** (hilljc@ornl.gov), PO Box 2008 MS 6367, Oak Ridge National Laboratory, Oak Ridge, TN 37831, and **Katherine Evans**, **George Fann** and **Jun Jia**. *High-order deferred correction time integration methods for climate models.*

Modern atmospheric climate models that are part of the Community Earth System Model include coupled nonlinear physical and chemical processes that span multiple scales. Spatially, resolution of the smaller scales is achieved by finer grid resolution or higher-order spatial approximations. Because of the scalability and throughput requirements of production simulations, many of the climate models employ first-order accurate fully explicit temporal discretizations. However, because of the finer spatial resolutions now required, the restriction on the time step size for the stability of these schemes is severe.

In this talk, we will discuss the spectral and Krylov deferred correction methods that provide a spectral discretization in time and yield high-order accuracy that is dependent on the discretization order. We will demonstrate that these techniques, implemented in a production atmospheric model, allow time steps on the order of one day (compared to minutes for a first-order method) to be taken without loss of accuracy. We will also compare the algorithmic cost of these methods to the existing leapfrog scheme and show that, despite a higher per time step cost, the increase in time step size yields a net gain in efficiency. (Received September 14, 2010)

1065-35-251 **Shanshan Chen*** (chenshanshan221@gmail.com), Harbin Institute of Technology, Harbin, 150001, Peoples Rep of China, **Junping Shi**, College of William and Mary, Williamsburg, VA 23187, and **Junjie Wei**, Harbin Institute of Technology, Harbin, 150001, Peoples Rep of China. *Hopf bifurcation of a delayed diffusive predator-prey system with Holling type-II predator functional response.*

A delayed diffusive predator-prey system with Holling type-II predator functional response subject to Neumann boundary conditions is considered here. The stability/instability of coexistence equilibrium and associated Hopf bifurcation are investigated by analyzing the characteristic equations. By the theory of normal form and center manifold, an explicit formula for determining the stability and direction of periodic solution bifurcating from Hopf bifurcation is derived. (Received September 14, 2010)

1065-35-278 **Haitao Fan*** (fanh@georgetown.edu), Dept. of Math., Georgetown Univ., Washington, DC 20057. *Reactive flows of monostable type and its applications in phase transitions.*

In this talk, we shall discuss a model governing fluid flows involving liquid/vapor phase transitions, in particular that for fluids with high molar heat capacities such as gasoline and diesel. The system is a combination of conservation laws and a reaction-diffusion equation. The conditions existence and nonexistence of traveling waves are obtained. Riemann solvers are constructed and their behavior is compared with the actual experiments to show that the model can capture almost all one-dimensional wave patterns observed in experiments. The symmetry breaking and ring formation phenomenon is explained. The study of the stability of its traveling waves provides a way to look at the Wilson Lines of metastable fluids and the onset of rapid phase changes in such fluids. Results on the spherical symmetric flows will be presented. (Received September 15, 2010)

37 ► Dynamical systems and ergodic theory

1065-37-2 **Michael Field*** (mikefield@gmail.com), Department of Mathematics, University of Houston, Houston, TX 77204-3008. *Symmetry, structure, and stochastic fluctuations associated to some models of neural dynamics.*

In this talk we describe a simple, yet dynamically rich, discrete model motivated by neural dynamics. This model incorporates both random and deterministic components. On the mathematical side, there are a number of interesting questions about the statistical (ergodic) behavior of this system. From the point of view of numerics and modeling, a feature of the system is its capability of simulating very large numbers of interacting "neurons" with relatively few dynamically interacting nodes. We show some striking visualizations and representations of the complex dynamics that may occur with this model. These images have a number of interpretations which we explore. In particular, they suggest the utility of thinking of observable (neural) outputs as statistical averages; just as we regard physical and chemical laws as statistical averages. (Received September 11, 2010)

1065-37-8 **Ghasemi Gader** (sahadpour@yahoo.com), Department of Physics, University of Mohagheg, 1343137831 Ardabil, Ardabil, Iran, and **Sodeif Ahadpour*** (sahadpour@yahoo.com), Department of Physics, University of Mohagheg, 1378134378 Ardabil, Ardabil, Iran. *Calculation invariant measure using stieltjes transform approach.*

we study the spectral properties of the Perron–Frobenius operator of the one-dimensional maps Based on the moment method. In this note we make an investigation into the properties of self-similar measures related to the theory of orthogonal polynomials. Numerical investigation of a particular family of maps shows that the spectrum generates the invariant measure. Analytical considerations generalize the results to a broader class of the maps. Some examples of this method are presented through out the paper. (Received April 29, 2010)

1065-37-25 **J. Ding*** (jiudin@gmail.com), Department of Mathematics, 118 College Dr., Box 5045, Hattiesburg, MS 39406. *Birkhoff's Individual Ergodic Theorem and Piecewise Constant Maximum Entropy Method.*

Let (X, Σ, σ) be a σ-finite measure space and $S : X \to X$ be a nonsingular transformation such that the corresponding Frobenius-Perron operator $P_S : L^1(X) \to L^1(X)$ has a stationary density f^*. We show that a piecewise constant maximum entropy method for the computational recovery of f^* can be interpreted as a numerical realization of the classic Birkhoff's individual ergodic theorem. (Received July 26, 2010)

1065-37-86 **Aaron W Brown*** (aaron.brown@tufts.edu), Department of Mathematics, Tufts University, 503 Boston Ave, Medford, MA 02155. *Rigid properties of some measures on the torus.*

We present examples of singular measures on the 2-torus such that each measure imposes rigid constraints on the group of measure preserving diffeomorphisms. All our measures are constructed as invariant measures for an auxiliary non-linear Anosov diffeomorphism $f\colon \mathbb{T}^2 \to \mathbb{T}^2$. In the first example, we construct equilibrium states for f such that the group of measure preserving diffeomorphisms is virtually infinite cyclic. In the second example, we show that, for a larger class of measures, the set of entropies for all measure preserving diffeomorphisms has a semi-group structure isomorphic to $\mathbb{N}$. (Received September 02, 2010)

1065-37-101 **A C Freitas**, **J M Freitas** and **Mike Todd*** (mtodd@math.bu.edu), Dept of Math and Stats, 111 Cummington St, Boston, MA 02215. *Extremal index in dynamical systems.*

The notion of extremal index in Extreme Value Theory is a parameter $\theta \in [0, 1]$ determining the degree of clustering of extremes of some time series data. If the data is independently identically distributed then there is no clustering and the extremal index is 1. In the context of dynamical systems, Extreme Value Theory can be understood in terms of recurrence, where, fixing a point z in phase space and then taking some typical point x, an extreme event corresponds to an iterate of x landing very close to z. We show that for general systems, having an extremal index $\theta \in (0, 1)$ means that z is a repelling periodic point. Motivated by this problem in the dynamical systems context, we have developed easily checkable conditions which are applicable in both this and in the classical Extreme Value Theory context. Moreover, we show that clustering is generally produced by periodic behavior. (Received September 06, 2010)

1065-37-103 **Renato Feres*** (feres@math.wustl.edu), Department of Mathematics, Washington University, Campus Box 1146, St. Louis, MO 63130, and **Hong-Kun Zhang**. *Billiards, Markov chains, and classical scattering.*

We consider Markov chains with continuous state space derived from billiard dynamical systems. The transition probabilities operator for these chains represents a classical scattering operator associated to a surface with "billiard microstructure." The main results concern the connection between the spectrum of the scattering operator and the shape of the microstructure, as well as a central limit theorem. These results are interpreted in terms of random flights of billiard particles in channels and their diffusion limit. (Received September 07, 2010)

1065-37-108 **Anthony Michael Bloch*** (abloch@umich.edu), Department of Mathematics, University of Michigan, 530 Church Street, Ann Arbor, MI 48109, and **Fred C Adams**. *Products of random matrices and the randomly forced Hill's equation.*

In this talk we derive expressions for the growth rates for the random 2 by 2 matrices that result from solutions to the random Hill's equation. The parameters that appear in Hill's equation include the forcing strength and oscillation frequency . The development of the solutions to this periodic differential equation can be described by a discrete map, where the matrix elements are given by the principal solutions for each cycle. Variations in the parameters lead to matrix elements that vary from cycle to cycle. We present an analysis of the growth rates including cases where all of the cycles are highly unstable, where some cycles are near the stability border, and

where the map would be stable in the absence of fluctuations. For all of these regimes, we provide expressions for the growth rates of the matrices that describe the solutions. Applications to the dynamics arising from particle motion in a dark matter halos are discussed. (Received September 07, 2010)

1065-37-115 **Vaughn Climenhaga***, Department of Mathematics, University of Maryland, College Park, MD 20742, and **Yakov Pesin** and **Dmitry Dolgopyat**. *SRB measures for non-uniformly hyperbolic systems.*

We describe a general procedure for constructing SRB measures, which is well-suited to the case of non-uniform hyperbolicity. This procedure can be carried out for maps with measurable cone families satisfying a certain asymptotic condition, without assuming the existence of a dominated splitting or other uniform geometric structure. We give examples where such uniform structures are not present but where our methods yield the existence of an SRB measure. (Received September 08, 2010)

1065-37-121 **Daniel J Thompson*** (thompson@math.psu.edu), Mathematics Department, Penn State University, State College, PA 16802, and **Vaughn Climenhaga**, Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742. *Subshift factors of the β-shift are intrinsically ergodic.*

We show that every subshift factor of a β-shift has a unique measure of maximal entropy. This provides an affirmative answer to Problem 28.2 of Mike Boyle's article 'Open problems in symbolic dynamics'. We will explain the problem and it's relation to existing results, and give some idea of how our approach works. We will also discuss some other examples of symbolic spaces where our technique can be applied. (Received September 09, 2010)

1065-37-158 **Ian Melbourne**, **Viorel Niţică** and **Andrew Török*** (torok@math.uh.edu), University of Houston, Dept. of Mathematics, 651 PGH, Houston, TX 77204-3008. *Transitivity of non-compact extensions of hyperbolic systems.*

Consider a hyperbolic basic set of a smooth diffeomorphism. We are interested in the transitivity of Hölder skew-extensions with fiber a non-compact connected Lie group. In the case of compact fibers, the transitive extensions contain an open and dense set. For the non-compact case, we conjectured that this is still true within the set of extensions that avoid the obvious obstructions to transitivity. Within this class of cocycles, we prove generic transitivity for extensions with fiber the special Euclidean group $SE(n)$, n odd (the case n even was known earlier), more general Euclidean-type groups $G \ltimes \mathbb{R}^n$ with G compact connected, and some nilpotent groups. (Received September 12, 2010)

1065-37-159 **Manfred Denker** and **Matthew Nicol*** (nicol@math.uh.edu), 4800 Calhoun Road, Houston, TX 77204. *Erdös-Rényi laws for hyperbolic dynamical systems.*

We establish Erdös-Rényi limit laws for Lipschitz observations on a class of non-uniformly expanding dynamical systems, including logistic-like maps. These limit laws give the maximal average of a time series over a time window of logarithmic length. We also give results on the rate of convergence in the limit law. (Received September 12, 2010)

1065-37-161 **Robert M Spann*** (bobspann@gmail.com), 3001 Veazey Terrace, NW, Apt. 802, Washington, DC 20008. *Newton Maps for Complex Polynomials with Complex Exponents.*

Newton's method is one of the most widely used methods for finding roots of non linear equations. Numerous authors have also applied the Newton iteration function, or Newton Map, to functions of a complex variable to obtain images. This paper extends that body of work to polynomials with complex exponents. I obtain images by iterating the Newton Map of complex polynomials such as $Z^\lambda - \rho = 0$ where Z is a complex variable, ρ a complex number, $\lambda = n + mi$, n,m are integers. Complex integer exponents, instead of real integer exponents, changes the Newton Map and hence the images that are obtained. Complex polynomials of the form $Z^{mi} - \rho = 0$ will have either a (countably) infinite number of roots or no roots in the complex plane. It is well known that infinity is a repelling fixed point for Newton Maps of complex polynomials with real exponents. There are infinitely many attracting fixed points in any neighborhood of infinity for Newton Maps of complex polynomials of the form $Z^{mi} - \rho = 0$. These differences, as well as other differences between Newton Maps of complex polynomials with complex, as opposed to real, exponents and the impacts on the images obtained are discussed. (Received September 12, 2010)

1065-37-170 **Chinmaya Gupta*** (chinmaya.gupta@usc.edu), 3620 South Vermont Ave., KAP 108, Los Angeles, CA 90089, and **Matthew Nicol** and **William Ott**. *Dynamical Borel-Centelli lemmas for some nonuniformly hyperbolic dynamical systems.*

In classical probability theory, the Borel-Cantelli lemmas state that if $A_n \in \mathcal{B}$ is a sequence of independent subsets of a set X, and $(X, \mathcal{B}, \mu)$ is a probability space, then $\sum_{n=0}^{\infty} \mu(A_n) = \infty$ implies that $\mu\left\{ x \in X : x \in A_n \text{ infinitely often} \right\} = 1$. In the context of dynamical systems, if $T : X \to X$ is a map preserving the measure μ, we may ask under what conditions $\mu\{x \in X : T^n(x) \in A_n \text{ infinitely often}\} = 1$ when $\sum_{n=0}^{\infty} \mu(A_n) = \infty$.

In this talk, we will establish various versions of the Borel-Cantelli property for appropriate sequences of sets A_n for nonuniformly hyperbolic dynamical systems $(X, \mathcal{B}, \mu, T)$. (Received September 12, 2010)

1065-37-179 **Nicolai T Haydn*** (nhaydn@usc.edu), Department of Mathematics, University of Southern California, Los Angeles, CA 90089. *Return times statistics for Markov towers.*

We show that for Lai-Sang Young's Markov towers the return times are in the limit Poisson distributed for return sets that are allowed to be countably infinite unions of cylinders. We use the decay of correlations for Hölder continuous functions paired up with L^∞ functions and the Chen-Stein method to obtain the approximate Poisson distribution for the return times distribution. We also obtain error estimates assuming the return set satisfies a 'non-periodicity' condition to avoid very short periodic like returns. (Received September 13, 2010)

1065-37-198 **M. Drew LaMar*** (mdlama@wm.edu), Department of Applied Science, The College of William and Mary, 311 McGlothlin-Street Hall, Williamsburg, VA 23187, and **Sarah Day** (sday@math.wm.edu). *Global dynamics of pulse-coupled oscillators.*

Networks of coupled oscillators have been used as models in many biological systems, from neural networks to populations of fireflies. Central questions in this area include under what conditions the oscillators will synchronize as well as what type of asynchronous behavior can be observed. In this talk we explore these questions by considering the global dynamics of three pulse-coupled oscillators over various network topologies. Due to the discontinuous nature of the system, we restrict ourselves to appropriate Poincare maps on restricted domains and then use algebraic topological tools to uncover dynamical structures on these regions. (Received September 13, 2010)

1065-37-215 **Christian Wolf*** (cwolf2@ccny.cuny.edu), City College of New York, Department of Mathematics, New York, NY 10031. *Boundary regularity of rotation sets.*

Let $T : X \to X$ be a continuous transformation on a compact metric space, and let $\phi_1, \cdots, \phi_n$ be continuous observables. The rotation set $R_T(\phi_1, \cdots, \phi_n)$ is the set of all μ-integral vectors where μ runs over all invariant probability measures. It is easy to see that the rotation set is a compact, convex subset of R^n. In particular, it has a Lipschitz boundary. In this talk we discuss the opposite question, namely is every set with these properties attained as a rotation set of a particular set of potentials within a particular class of dynamical systems. We give a positive answer in the case of shift maps and also provide criteria implying that the boundary of the rotation set is piecewise smooth. (Received September 14, 2010)

1065-37-227 **Michael Field*** (mikefield@gmail.com), Dept Mathematics, University of Houston, Houston, TX 77204-3008. *Statistical properties of dynamical systems of mixed type and skew extensions.*

We describe some recent work on statistical properties of some classes of dynamical systems which contain both random and deterministic components. We also address the problem of obtaining a qualitative description of the dynamics using skew extensions. (Received September 14, 2010)

1065-37-231 **Keith Burns*** (burns@math.northwestern.edu), Department of Mathematics, Northwestern University, Evanston, IL 60208, **Howard Masur** (masur@math.uchicago.edu), Department of Mathematics, University of Chicago, Chicago, IL 60607, and **Amie Wilkinson** (wilkinso@math.northwestern.edu), Department of Mathematics, Northwestern University, Evanston, IL. *Ergodicity of the Weil-Petersson geodesic flow.*

The Weil-Petersson metric is an incomplete Riemannian metric on Teichmueller space with negative sectional curvatures. It is invariant under the action of the mapping class group and projects to a metric with finite volume on moduli space. Recently the techniques of Pesin theory, in particular the work of Katok-Strelcyn, have been applied to show that this geodesic flow is ergodic. (Received September 14, 2010)

1065-37-248 **De-Jun Feng**, Department of Mathematics, The Chinese University of Hong Kong, Shatin, Hong Kong, and **Huyi Hu*** (hu@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Local dimensions for iterated function systems.*

We study iterated function systems $\{S : X \to X : i = 1, \dots \ell\}$ on a closed subset $X \subset \mathbb{R}^n$. A probability measure μ is said to be *exact dimensional* if there is a constant C such that the *local dimension* $d(\mu, x) = \lim_{r\to 0} \frac{\log \mu(B(x,r))}{\log r}$ exists and equals C for μ-a.e. $x \in \mathbb{R}^d$, where $B(x, r)$ denotes the closed ball of radius r centered at x. It is well known that if a system is conformal and satisfies some separation condition, then any invariant measure is exact dimensional. We show that the results also hold for conformal systems with overlaps, and for affine systems of the form $S_i = A_i x + a_i$ with $A_i A_j = A_j A_i$. (Received September 14, 2010)

1065-37-266 **Cecilia Gonzalez-Tokman** and **Brian R Hunt*** (bhunt@umd.edu). *Ensemble Methods and Data Assimilation.*

I will speak about ensemble methods that approximate and/or characterize a trajectory (or pseudotrajectory) of a chaotic dynamical system without linearizing the system, including a particular method ("Local Ensemble Transform Kalman Filter") developed at the University of Maryland for data assimilation in spatially extended systems. By "ensemble method" I mean an iterative procedure that alternately: (1) makes a short-term forecast from an ensemble of initial conditions; and then (2) adjusts the ensemble by some prescribed algorithm to determine initial conditions for the next forecast. The methods I consider seek to maintain an ensemble whose spread is reasonably small and that approximately spans the most unstable directions in its vicinity. In data assimilation, the method inputs a time series of (noisy) observations of an otherwise unknown trajectory, and seeks to keep the ensemble close to that trajectory. I will discuss theoretical results for hyperbolic systems, joint with Cecilia Gonzalez-Tokman, and practical results for data assimilation in spatially extended systems, including weather forecast models. (Received September 14, 2010)

1065-37-270 **William Raymond Ott*** (ott@math.uh.edu), 651 Philip G Hoffman Hall, Department of Mathematics, University of Houston, Houston, TX 77382, and **Mikko Stenlund**. *From limit cycles to strange attractors.*

We define a quantitative notion of shear for limit cycles of flows on finite-dimensional spaces. We prove that strange attractors and SRB measures emerge when systems exhibiting limit cycles with sufficient shear are subjected to periodic pulsatile drives. The strange attractors possess a number of precisely defined mathematical properties that collectively imply chaos that is both sustained in time and physically observable. (Received September 15, 2010)

42 ► Fourier analysis

1065-42-9 **Ravshan Ashurov*** (ashurovr@yahoo.com), Institute of Advanced Technology (ITMA), Univarsity Putra Malaysia, 43400 Serdang, Malaysia, and **Almaz Butaev**. *On the Pinsky phenomenon and the Kahane theorem.*

Let C be a smooth bounded, strongly convex symmetric set in R^n and f be a piecewise smooth function with the surface of discontinuity Γ. We consider non-spherical partial sums of n-fold Fourier integrals associated with C, i.e.

$$S_{\lambda C} f(x) = \int\limits_{\lambda^{-1}\xi \in C} \hat{f}(\xi) e^{ix\xi} d\xi,$$

where $\hat{f}$ is the Fourier transform of a piecewise smooth function f. It is well known, that if $n = 2$, then the partial sums $S_{\lambda C} f(x)$ of a piecewise smooth function f converge uniformly on any compact $K \subset R^n \setminus \Gamma$, no matter how the set C and the set of discontinuity Γ of f are related. But when $n \geq 3$, however, this relation is a key factor. If C is a ball, then we have the spherical partial sums, and the relation between convergence properties of spherical partial sums and geometry of discontinuities Γ was investigated by many outstanding mathematicians: Taylor, Pinsky, Kahane, Alimov and many others. The most remarkable results here are: the Pinsky (known as the Pinsky phenomena) and Kahane theorems. In this paper we prove these theorems for general non-spherical partial sums $S_{\lambda C} f(x)$ with an arbitrary C.

(Received May 30, 2010)

46 ► Functional analysis

1065-46-32 **Narcisse Randrianantoanina*** (randrin@muohio.edu), Department of Mathematics, Miami University, Oxford, OH 45056. *Fixed point properties of semigroups of nonexpansive mappings.*

A topological semigroup S is said to be left-reversible if for any $a, b \in S$, $\overline{aS} \cap \overline{bS} \neq \emptyset$. We will discuss (common) fixed point properties of left-reversible semigroups of nonexansive mappings acting on bounded subsets of Banach spaces. We will focus mostly on spaces such as von Neumann Schatten classes, Hardy spaces, and Fourier-Stieltjes algebras of locally compact groups. (Received August 06, 2010)

1065-46-47 **Alexander A. Katz** (katza@stjohns.edu), St. John's University, Department of Mathematics & Computer Science, 300 Howard Ave., DaSilva Academic Center 314, Staten Island, NY 10301, and **Roman Kushnir*** (kushnir_roman@yahoo.com), University of South Africa, Department of Mathematical Sciences, P.O. Box 392, Pretoria, 0003, South Africa. *On measurable bundles of JB-algebras.*

We introduce and study JB-algebras over $L_0(\Omega)$ (Jordan Banach-Kantorovich algebras over the ring on all measurable functions whose norm satisfies conditions similar to those of JB-algebras). It is shown that each such algebra admits a unique up to Jordan isometry representation by means of a measurable bundle of JB-algebras with vector-valued lifting. (Received August 17, 2010)

1065-46-62 **Alexander A. Katz*** (katza@stjohns.edu), St. John's University, Department of Mathematics & Computer Science, 300 Howard Ave., DaSilva Academic Center 314, Staten Island, NY 10301. *On Maharam traces on JBW-algebras.*

We consider traces on JBW-algebras (without type I_2-summands) with values in real complete vector lattices. A full description of these traces is obtaned in the case of Maharam traces. A Radon-Nikodym type theorem for Maharam traces is established. (Received August 26, 2010)

1065-46-106 **Jean Bourgain** and **Stephen J Dilworth*** (dilworth@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208, and **Kevin Ford**, **Sergei Konyagin** and **Denka Kutzarova**. *Explicit Constructions of RIP Matrices and Related Problems.*

We give a new explicit construction of $n \times N$ matrices satisfying the Restricted Isometry Property (RIP). Namely, for some $\varepsilon > 0$, large N and any n satisfying $N^{1-\varepsilon} \leq n \leq N$, we construct RIP matrices of order $k^{1/2+\varepsilon}$ and constant $\delta^{-\varepsilon}$. This overcomes the natural barrier $k = O(n^{1/2})$ for proofs based on small coherence, which are used in all previous explicit constructions of RIP matrices. Key ingredients in our proof are new estimates for sumsets in product sets and for exponential sums with the products of sets possessing special additive structure. We also give a construction of sets of n complex numbers whose k-th moments are uniformly small for $1 \leq k \leq N$ (Turán's power sum problem), which improves upon known explicit constructions when $(\log N)^{1+o(1)} \leq n \leq (\log N)^{4+o(1)}$. This latter construction produces elementary explicit examples of $n \times N$ matrices that satisfy RIP and whose columns constitute a new spherical code; for those problems the parameters closely match those of existing constructions in the range $(\log N)^{1+o(1)} \leq n \leq (\log N)^{5/2+o(1)}$. (Received September 07, 2010)

1065-46-112 **A. T. Szankowski***, Institute of Mathematics, Hebrew University, Jerusalem, Israel. *Hereditary Approximation Property.*

We say that a Banach space has the hereditary approximation property (or is a HAPpy space) if all of its subspaces have the approximation property. In 1976 Johnson constructed the first examples of HAPpy spaces not isomorphic to a Hilbert space. Later Pisier developed the theory of weak Hilbert spaces and proved that they all have the HAP. The spaces constructed by Johnson as well as all weak Hilbert spaces are asymptotically Hilbertian. An asymptotically Hilbertian space cannot have a symmetric (or even subsymmetric) basis unless it is isomorphic to ℓ_2. This immediately prompts the following problem: "Is there a HAPpy space which has a symmetric basis but is not isomorphic to ℓ_2?". We give an affirmative answer to this question. The crucial quantity is $d_n(X) = \sup\{d(E, \ell_2^n) : E \subset X, \dim E = n\}$. Our main result is that if $d_n(X)$ goes sufficiently slowly to ∞, then X is HAPpy. The proof is rather tricky. Then it remains, given any sequence α_n which goes to ∞ , to construct a space X with symmetric basis such that $d_n(X) \leq \alpha_n$ but $d_n(X)$ goes to ∞. We construct a corresponding Tsirelson/Schlumprecht type space and an Orlicz space.

This is joint work with Bill Johnson. (Received September 08, 2010)

1065-46-117 **Niels Jacob Laustsen**, **Edward Odell** and **Thomas Schlumprecht*** (schlump@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843, and **Andras Zsak**. *On the closed ideals of operators on* $(\oplus_{n=1}^{\infty}\ell_1^n)_{c_o}$.

We discuss the closed operator ideals on the space $\left(\oplus_{n=1}^{\infty}\ell_1^n\right)_{c_o}$ and othe rspaces (Received September 08, 2010)

1065-46-119 **Dale Alspach***, Department of Mathematics, Oklahoma State University, 401 Mathematical Sciences, Stillwater, OK 74078, and **Eloi M. Galego**. *Geometry of the Banach spaces* $C(\beta\mathbb{N}\times K, l_p)$ *for compact metric spaces* K.

We provide the complete isomorphic classification of the spaces $C(\beta\mathbb{N}\times K, l_p)$ of all continuous l_p-valued functions, $1 \leq p < \infty$, defined on the topological product of the Stone-Cech compactification of the natural numbers $\mathbb{N}$ and an arbitrary infinite compact metric space K. The results can be reformulated as classifying spaces of compact operators since these spaces are isomorphic to spaces of compact operators from l_1 into $C(K, l_p)$. (Received September 08, 2010)

1065-46-125 **Patrick Dowling*** (dowlinpn@muohio.edu), Department of Mathematics, Miami University, Oxford, OH 45056, **Christopher Lennard** (lennard@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260, **Beata Randrianantoanina** (randib@muohio.edu), Department of Mathematics, Miami University, Oxford, OH 45056, and **Barry Turett** (turett@oakland.edu), Department of Mathematics and Statistics, Oakland University, Rochester, MI 48309. *Weak Grothendieck compactness principles.* Preliminary report.

Grothendieck proved that a closed subset of a Banach space is norm compact if and only if it is contained in the closed convex hull of a norm-null sequence. We consider the question of which Banach spaces have the property that each of it's weakly compact subsets is contained in the closed convex hull of a weakly-null sequence. (Received September 09, 2010)

1065-46-128 **E. Odell*** (odell@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712. *Renormings and Symmetry Properties of One-Greedy Bases.*

We report on a recent joint paper with S.J.Dilworth, Th. Schlumprecht and A. Zsák. We give examples of 1-greedy bases that are not symmetric and consider certain renorming questions. (Received September 09, 2010)

1065-46-160 **Daniel Freeman*** (freeman@math.utexas.edu), **Ryan Hotovy**, **Eileen Martin**, **Daniel Poore**, **A. Rebecca Wei** and **Madeline Wyse**. *Redundant frames for vector bundles.* Preliminary report.

Frames can be thought of as redundant or linearly dependent bases for Hilbert spaces, and have important applications in such areas as signal processing, data compression, and sampling theory. Apart from applications, substantial research has been devoted to understanding the theory and geometry of frames as well. We will discuss both some theorems and obstacles related to extending the theory of frames for Hilbert spaces to the continuous setting of vector bundles. (Received September 12, 2010)

1065-46-171 **Anna Kamińska*** (kaminska@memphis.edu), The University of Memphis, Department of Math Sciences, Memphis, TN 38152. *The Daugavet property and weak neighborhoods in Banach lattices.*

The Daugavet property and the diameters of relatively weakly open subsets of unit balls in Banach lattices X on measure spaces are studied. It is shown that under mild assumptions the subspace X_a of order continuous elements inherits the Daugavet property from X. This is applied to prove that if X has the Daugavet property and the Köthe dual X' is strictly monotone (resp. order continuous) then X' contains a lattice isometric (resp. isomorphic) copy of $L_1(0,1)$. These results yield that a large class of r.i. spaces including several interpolation sums fail the Daugavet property and also that any r.i. space over a finite atomless measure space with the Daugavet property coincide to either L_1 or L_∞. Applications are shown for Orlicz, Lorentz, Marcinkiewicz spaces as well for Nakano spaces. It is established that in most cases these spaces do not enjoy the Daugavet property. However, it is proved that in a large class of Orlicz or Nakano spaces, all relatively weakly open subsets of their unit balls have diameter two. These are joint results with M. D. Acosta and M. Mastyło (Received September 12, 2010)

1065-46-207 **S. J. Dilworth** and **Denka Kutzarova*** (denka@math.uiuc.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana, IL 61801, and **Thomas Schlumprecht** and **P. Wojtaszczyk**. *Branch greedy algorithms.*

We consider several different types of branch greedy systems and study their connections and properties. This talk is related to one of the numerous areas of the work of Nigel Kalton and we dedicate it to his memory. (Received September 13, 2010)

1065-46-216 **Chris J Lennard** and **Veysel Nezir*** (ven1@pitt.edu), 1939 Seaton st., Pittsburgh, PA 15226. .

In 2004 Dowling, Lennard and Turett showed that every non-weakly compact, closed, bounded, convex (c.b.c.) subset K of $(c_0, \|\cdot\|_\infty)$ is such that there exists a $\|\cdot\|_\infty$-nonexpansive mapping T on K that is fixed point free. This mapping T is generally not affine. We prove that if a Banach space contains an asymptotically isometric (ai) c_0-summing basic sequence $(x_n)_{n\in\mathbb{N}}$, then the closed convex hull of $(x_n)_{n\in\mathbb{N}}$, $E := \overline{\text{co}}(\{x_n : n \in \mathbb{N}\})$, fails the fixed point property for affine nonexpansive mappings. Also, there exists an *affine contractive* mapping $U : E \longrightarrow E$ that is fixed point free. We conclude

$$for\ \overrightarrow{b} = (b_n)_{n\in\mathbb{N}}\ in\ \mathbb{R}\ s.t.$$

$$0 < m := \inf_{n\in\mathbb{N}} b_n\ and\ M := \sup_{n\in\mathbb{N}} b_n\ < \infty$$

The c.b.c. subset E,

$$E := \left\{ \sum_{n=1}^{\infty} t_n\, f_n : 1 = t_1 \geq t_2 \geq \cdots \geq t_n \downarrow_n 0 \right\}\ .$$

where $f_n := b_n\, e_n$, for all $n \in \mathbb{N}$, fails the fpp (affine, n.e.).

Note that this applies to $b_n = r_n$, where $(r_n)_{n\in\mathbb{N}}$ is an enumeration of $[m, M)$, $\forall\, 0 < m < M < \infty$. (Received September 14, 2010)

1065-46-218 **Thomas M Everest** (tme3@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260, **Chris Lennard*** (lennard@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260, and **Veysel Nezir** (ven1@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *Recent results in metric fixed point theory for affine maps.*

We will discuss recent results obtained in joint work with Mr. Thomas M. Everest and Mr. Veysel Nezir.

In work with Tom, we explore conditions under which asymptotically nonexpansive, affine maps have or fail to have fixed points on a large class of non-weak* compact, closed, bounded, convex subsets of ℓ^1.

In work with Veysel, we consider a large class of non-weakly compact, closed, bounded, convex subsets of c_0, and show that they all fail to have the fixed point property for nonexpansive, affine maps. (Received September 14, 2010)

1065-46-229 **Mikhail Popov*** (popovm@muohio.edu), Miami University, Department of Mathematics, Oxford, OH 45056. *Some open problems on narrow operators.*

The most classes of operators which are not isomorphic embeddings, more or less are characterized by some "smallness" condition. Narrow operators are those operators defined on function spaces which are "small" at signs, i.e. at $\{-1, 0, 1\}$-valued functions. The idea to consider such operators has led to interesting problems which can be applied to Geometric Functional Analysis. To some extand, narrow operators generalize the notion of compact operators. Nevertheless, there are "very" non-compact narrow operators. One of the most interesting things is that if an r.i. function space E on $[0, 1]$ has an unconditional basis then every (continuous linear) operator on E is a sum of two narrow operators, since the sum of two narrow operators on L_1 is narrow. To explane this phenomena, the notion of narrow operators was recently extended to vector lattices. One deep result asserts that, under some natural assumptions on Banach lattices E, F, the set of all narrow regular operators from E to F is a band in the lattice of all regular operators from E to F. Since on L_1 all operators are regular, this clarifies the phenomena. The talk is planned to be devoted to the most interesting problems concerning narrow operators related to the Geometry of Banach Spaces. (Received September 14, 2010)

1065-46-232 **Alfred M Dahma*** (alfy@iup.edu), 114 Sandra Drive, Delmont, PA 15626. *Generalized Roundness Of The Schatten Class.*

Generalized roundness is a geometric concept developed in the late 1960s by Per Enflo to study the uniform structure of metric spaces. In their paper *Generalized Roundness and Negative Type*, Lennard, Tonge, and Weston show that generalized roundness in a metric space is equivalent to that of negative type, and prove that for $p > 2$, L_p fails to have generalized roundness q for any $q > 0$. As a consequence, the Schatten class $\mathcal{C}_p$, for

$p > 2$, has maximal generalized roundness 0. In this talk I will briefly discuss some of these results, and how they can be extended to include values of $p < 2$. (Received September 14, 2010)

1065-46-236 **Per Enflo*** (enflo@math.kent.edu). *Groups modeled on Banach Spaces.*
In 1900 Hilbert asked - his fifth problem - in particular, if a locally Euclidean group must be a Lie group. The affirmative answer to this was given fifty years later, through the joint efforts of several researchers. One can ask similar questions on groups modeled on Banach Spaces - whether a certain regularity of the group operations will make the group an infinite-dimensional Lie group. Not surprisingly, the geometry of the Banach Space will be important for the answer. There are many positive results and many counterexamples for this type of questions.I will give a survey on what is known and on open problems in this area. (Received September 14, 2010)

1065-46-239 **Bunyamin Sari*** (bunyamin@unt.edu), University of North Texas, Department of Mathematics 1155 Union Circle #, Denton, TX 76203-5017. *Kalton's last (?) theorem on uniform homeomorphisms.* Preliminary report.
We will speak on a remarkable theorem of Nigel Kalton (perhaps his last result on the subject) on the invariance of asymptotic uniform convexity under uniform homeomorphisms. (Received September 14, 2010)

1065-46-241 **Chris Lennard** and **Dan Radelet*** (dradelet@iup.edu), Mathematics Department, Indiana University of PA, Indiana, PA 15705. *Frames and n-Cesáro bases in Hilbert space.*
Let $(H, < \cdot, \cdot >)$ be a Hilbert space over $\mathbb{C}$ with orthonormal basis $(e_k)_{k\in\mathbb{N}}$; the reconstructive properties of the basis for elements of H are well known. Frames can be thought of as overcomplete bases with added flexibility, making frames desirable for certain applications such as signal processing. We examine classes of vector sequences that are Banach frames (but not Hilbert frames) for H of the form

$$(g_j)_{j\in\mathbb{N}} := \left(\sum_{k\in\mathbb{N}} a_k e_{j+k}\right)_{j\in\mathbb{N}}$$

with $(a_k) \in c_{00}$, which, when paired with a unique biorthogonal sequence in H, are Markuschevich bases for the Hilbert space. Although reconstruction of arbitrary $f \in H$ using only $(g_j)_{j\in\mathbb{N}}$ fails, an appropriate use of the Cesáro averaging operator will allow a frame type reconstruction of arbitrary vectors in H via the M-basis pair mentioned above. (Received September 14, 2010)

1065-46-242 **J. Alejandro Chavez Dominguez***, Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Duality for Lipschitz p-summing operators.*
Building upon the ideas of R. Arens and J. Eells we introduce the concept of spaces of Banach-space-valued molecules, whose duals can be naturally identified with spaces of operators between a metric space and a Banach space. On these spaces we define analogues of the tensor norms of S. Chevet and P. Saphar, whose duals are spaces of Lipschitz p-summing operators. In particular, we identify the dual of the space of Lipschitz p-summing operators from a finite metric space to a Banach space — answering a question of J. Farmer and W. B. Johnson — and use it to give a new characterization of the non-linear concept of Lipschitz p-summing operator between metric spaces in terms of linear operators between certain Banach spaces. (Received September 14, 2010)

1065-46-249 **Thomas Michael Everest*** (tme3@pitt.edu), Department of Mathematics, University of Pittsburgh, 301 Thackeray Hall, Pittsburgh, PA 15260, and **Chris Lennard**. *Fixed points of asymptotically non-expansive maps and uniformly Lipschitzian maps on certain closed, bounded, convex subsets of ℓ^1.*
In this talk, I will give an overview of the following joint work with Chris Lennard.

In 1979 Goebel and Kuczumow introduced a certain closed, bounded, convex, non-weak*-compact subset K of ℓ^1 (with its usual norm), and showed that K has the fixed point property for nonexpansive mappings.

We show that K also has the fixed point property for asymptotically nonexpansive mappings with approximate fixed point sequences. This class of mappings includes those that are asymptotically nonexpansive and affine.

We further calculate the best uniform-Lipschitz constant of the right shift R on K.

We also consider another closed, bounded, convex, non-weak*-compact subset H of the positive face of the usual unit sphere, S, in ℓ^1. Dowling, Lennard and Turett recently showed that H has the fixed point property for nonexpansive mappings. In this paper we show that, in contrast to the set K above, H fails to have the fixed point property for asymptotically nonexpansive mappings with approximate fixed point sequences.

The above results can be generalized to a large class of non-weak* compact, closed, bounded, convex subsets of ℓ^1. (Received September 14, 2010)

47 ► Operator theory

1065-47-4 **Stefan Richter*** (Richter@math.utk.edu), The University of Tennessee, Department of Mathematics, Knoxville, TN 37996-0614. *Boundary behavior and invariant subspaces in spaces of analytic functions.*

Let H^2 denote the Hardy space of the unit disc. The classical theorem of Beurling relates the function theory of the functions in H^2 to the operator theory of the unilateral shift. Much of the success of the H^2 theory is due to the fact that functions in the Hardy space have boundary values on the unit circle. For spaces that are larger than H^2 such as the Bergman space it turns out that the existence of functions without nontangential limits has direct consequences for the operator theory of the corresponding shift operators.

In this talk I will make the statements of the above paragraph precise and I will also have a look at the corresponding situation for the unit ball or polydisc in $\mathbb{C}^n$. (Received September 13, 2010)

1065-47-16 **Carl C. Cowen*** (ccowen@iupui.edu), IUPUI Dept of Math Sciences, 402 N Blackford St, Indianapolis, IN 46202, and **Eva A. Gallardo-Gutiérrez** (eva@unizar.es), Departmento de Matemáticas, Plaza San Francisco s/n, 50009 Zaragoza, Spain. *Unitary Equivalence of One-parameter Groups of Toeplitz and Composition Operators.*

On the Hardy space H^2 of the unit disk, an analytic Toeplitz operator is multiplication by a bounded analytic function and a composition operator is composition with an analytic function that maps the disk into itself. The composition operators on H^2 whose symbols are automorphisms of the disk fixing ± 1 form a one-parameter group of bounded operators and the analytic Toeplitz operators coming from covering maps of annuli centered at the origin whose radii are reciprocals also form a one-parameter group. The point spectra of the composition operators and of the adjoints of the Toeplitz operators are each this family of open annuli. There is not a unitary operator on H^2 that takes the group of composition operators to the group of adjoints of analytic Toeplitz operators. However, the subspace zH^2 forms an invariant subspace for each operator in the group of analytic Toeplitz operators and in the group of adjoints of the composition operators. From the corresponding eigenvectors associated with the point spectra noted above, a direct unitary equivalence *is* found between the group of restrictions of the analytic Toeplitz operators and the group of restrictions of the adjoints of the composition operators. (Received July 08, 2010)

1065-47-23 **Philip Chodrow**, **Cole Franks** and **Brian Lins*** (blins@hsc.edu), Box 131, Hampden-Sydney College, Hampden-Sydney, VA 23112. *Iterates of Order-Preserving Homogeneous Maps and the Perron-Frobenius Theorem.* Preliminary report.

Let C be a closed cone in R^n, and suppose that $T : C \to C$ is homogeneous of degree one and order-preserving with respect to the partial ordering induced by C. If C is the positive orthant in R^n, we prove bounds on the iterates of T that restrict the location of accumulation points of the discrete dynamical system $x^{k+1} = T(x^k)/||T(x^k)||$. For other closed cones C, we establish similar bounds when T is linear. Certain other special bounds are also established for general T. Applications of these results to linear and nonlinear maps are discussed. (Received July 26, 2010)

1065-47-60 **John E. McCarthy*** (mccarthy@math.wustl.edu), Dept. of Math, Washington University, 1 Brookings Drive, St. Louis, MO 63105, and **Richard M Timoney**. *Non-commutative Andô inequalities.*

Let p be a polynomial in d variables. Let T be a d-tuple of operators which need not commute. Define $p(T)$ in a symmetric way, by averaging over all possible products. Can one prove non-trivial inequalities on $\|p(T)\|$ subject to norm constraints on T?

This is joint work with Richard Timoney. (Received August 24, 2010)

1065-47-74 **Mrinal Raghupathi*** (mrinal.raghupathi@vanderbilt.edu), 1326 Stevenson Center, Department of Mathematics, Nashville, TN 37240. *Interpolation theorems for multiparameter dirichlet space and subalgebras of H^∞.* Preliminary report.

In this talk I will describe some initial results that have been obtained with Brett Wick on interpolating sequence for products of complete pick kernels and for subalgebras of H^∞.

If A is a function algebra on X, then a sequence $(x_n) \subseteq X$ is called interpolating if the map $f \mapsto (f(x_n))$ is surjective. We present results that characterize the interpolating sequence for the maximal tensor product of multiplier algebras of reproducing kernel Hilbert spaces. We also present some results for subalgebras of H^∞ and Riemann surfaces. (Received August 30, 2010)

1065-47-75 **Alberto A. Condori*** (acondori@fgcu.edu), Department of Chemistry and Mathematics, 10501 FGCU Blvd. S., Fort Myers, FL 33965-656. *An index formula in connection with meromorphic approximation.* Preliminary report.

We show that for the class of bounded $n \times n$ *admissible* matrix-valued functions Φ (e.g. any continuous matrix-valued function) on the unit circle with superoptimal meromorphic approximant Q having at most k poles in $\mathbb{D}$ (i.e. the McMillan degree of Q in $\mathbb{D}$ is at most k) the Toeplitz operator $T_{\Phi-Q}$ is Fredholm and has index

$$\mathtt{ind}\left(T_{\Phi-Q}\right) = \dim\ker T_{\Phi-Q} = 2k + \dim\mathcal{E},$$

where $\mathcal{E} = \{\xi \in \ker H_Q : \|H_\Phi\xi\|_2 = \|(\Phi - Q)\xi\|_2\}$ and $H_{\Phi-Q}$ denotes the Hankel operator on the Hardy space $H^2(\mathbb{C}^n)$ with symbol $\Phi - Q$. (Received August 30, 2010)

1065-47-81 **Warren Wogen*** (wrw@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Spatial Isomorphisms of Truncated Toeplitz Operators.*

Each inner function I determines an invariant subspace, called a model space, for the backward shift. Compressing the space of Toeplitz operators to this model space yields an operator space of truncated Toeplitz operators, or TTOs. We investigate how the structure of these spaces of TTOs depends on I. In particular, for which inner functions are the corresponding TTO spaces spatially isomorphic? We also consider when certain natural algebras of TTOs are spatially isomorphic. This is joint work with J. Cima, S. Garcia, and W. Ross. (Received September 01, 2010)

1065-47-88 **Michael Jury** and **Scott McCullough*** (sam@ufl.edu). *An Abel-Jacobi map for hypo-Dirichlet algebras.*

A candidate for the Abel-Jacobi map associated to a uniform algebra A satisfying axioms a bit weaker than hypo-dirichlet and its connection to Pick interpolation will be considered. In the case that A is the uniform algebra of functions continuous on the closure and analytic in the interior of a nice multiply connected domain R in the complex plane the construction yields the usual Abel-Jacobi map for the Schottky double of R (restricted to R). Further examples, including the case that A is the sub-algebra of the disc algebra of functions whose derivative at zero is zero, will be discussed. This work is joint with Michael Jury and will complement his talk at this meeting. (Received September 03, 2010)

1065-47-89 **Katie Spurrier Quertermous*** (querteks@jmu.edu), Department of Mathematics & Statistics, MSC 1911, James Madison University, Harrisonburg, VA 22807. *C*-algebras Generated by Linear-fractionally-induced Composition Operators.*

Let φ be an analytic self-map of the unit disk $\mathbb{D}$, and let $H^2(\mathbb{D})$ denote the Hardy space of the disk. We define the composition operator C_φ by $C_\varphi f = f \circ \varphi$ for all $f \in H^2(\mathbb{D})$. We are particularly interested in composition operators induced by linear-fractional, non-automorphism self-maps of $\mathbb{D}$ that fix a given point ζ on the unit circle and satisfy $\varphi'(\zeta) \neq 1$.

In this talk, we consider two types of C*-algebras: $C^*(C_\varphi, \mathcal{K})$, the unital C*-algebra generated by the ideal of compact operators and a single linear-fractionally-induced composition operator of the form described above, and $C^*(\mathcal{F}_\zeta)$, the unital C*-algebra generated by the collection of all composition operators induced by linear-fractional non-automorphisms that fix a given point ζ on the unit circle. We show that each of these C*-algebras is isomorphic, modulo the ideal of compact operators, to the unitization of an appropriate crossed product C*-algebra. We then apply known results for crossed products by the integers to determine the K-theory of $C^*(C_\varphi, \mathcal{K})$ and calculate the essential spectra of a class of operators in this C*-algebra. (Received September 03, 2010)

1065-47-105 **Greg Knese*** (geknese@bama.ua.edu), University of Alabama, Department of Mathematics, Box 870350, Tuscaloosa, AL 35487-0350. *Rational inner functions in the Schur-Agler class.*

The Schur-Agler class is a subclass of the bounded analytic functions on the polydisk with close ties to operator theory. We shall describe our recent investigations into the properties of rational inner functions in this class. Non-minimality of transfer function realization, necessary and sufficient conditions for membership (in special cases), and low degree examples are among the topics we will discuss. (Received September 07, 2010)

1065-47-145 **Robert F Allen** and **Flavia Colonna*** (fcolonna@gmu.edu), 4400 University Drive, Fairfax, VA 22030, and **Glenn R Easley**. *Multiplication operators on Lipschitz-type spaces over a tree.*

In recent years, the operator theory of many functional Banach spaces that arise in complex function theory has been studied extensively. However, very little has been done in a discrete setting. An important class of

operators to be discussed in this talk is the *multiplication operators*

$$M_\psi(f) = \psi f,$$

where ψ is a function defined on an infinite tree T and f belongs to a functional Banach space with domain T. An environment for this study is a space $\mathcal{L}$ of Lipschitz functions on T, that is, the functions f satisfying

$$|f(v) - f(w)| \leq C\, d(v, w), \quad v, w \in T,$$

for some $C > 0$, where $d(v, w)$ is the number of edges in the unique geodesic path from v to w. The space $\mathcal{L}$ may be considered as a discretization of the familiar Bloch space. Characterizations on the boundedness and compactness of the operator M_ψ as well as operator norm and essential norm estimates and a description of the spectrum will be given. The multiplication operators on a class of weighted Lipschitz spaces over a tree will be also considered. (Received September 11, 2010)

1065-47-149 **Thomas L. Kriete*** (tlk8q@virginia.edu), Department of Mathematics, Kerchof Hall, P. O. Box 400137, Charlottesville, VA 22904-4137, and **Barbara D. MacCluer**. *Distance in the Calkin algebra between composition operators.* Preliminary report.

For a pair of sufficiently nice analytic self-maps φ and ψ of the unit disk (e.g. analytic across the entire unit circle but not finite Blaschke products) having the same angular derivative points on the unit circle, the pseudohyperbolic distance $\rho(e^{i\theta})$ between $\varphi(e^{i\theta})$ and $\psi(e^{i\theta})$ extends continuously to the set F of common angular derivative points. In this situation it is known that the difference of the associated composition operators C_φ and C_ψ is compact on H^2 if and only if the extended ρ vanishes identically on F. This talk will discuss estimates involving ρ for the essential norm of $C_\varphi - C_\psi$ when the difference is not compact. (Received September 13, 2010)

1065-47-162 **Ilya M Spitkovsky***, College of William and Mary, Department of Mathematics, P.O.Box 8793, Williamsburg, VA 23187. *Toeplitz operators with matrix almost periodic symbols: the state of affairs.*

There is a drastic change in the behavior of Toeplitz operators with matrix (as opposed to scalar) almost periodic symbols: a phenomenon not previously observed for symbols with better smoothness properties. In particular, a verifiable criterion for the invertibility of such operators is currently not known. We will discuss recent progress in two directions: (i) various sufficient invertibility results, that is (in alternative but equivalent language) description of new subsets of APF — the set of all factorable almost periodic matrix functions, and (ii) quantitative results on the topological structure of APF.

The talk is based on joint work with A. Brudnyi, C. Camara, Yu. Karlovich, and L. Rodman. (Received September 12, 2010)

1065-47-182 **Nathan S Feldman*** (feldmanN@wlu.edu), Mathematics Department, Washington & Lee University, Lexington, VA 24450. *n-Weakly Hypercyclic Operators.*

An operator T on a separable Hilbert space H is said to be hypercyclic if there is a vector x in H whose orbit, $\{T^n x : n \geq 0\}$, is dense in H. Similarly, an operator T is called supercyclic if there is a vector x whose scaled orbit under T, $\{cT^n x : n \geq 0, c \in \mathbb{C}\}$, is dense in H. If an operator T has a vector whose orbit is weakly dense in H (or a scaled orbit that is weakly dense in H), then we say that the operator is weakly hypercyclic (or weakly supercyclic).

In this talk we will introduce weaker forms of weak hypercyclicity and weak supercyclicity. For an integer $n \geq 1$ and a set $E \subseteq H$, we define E to be n-weakly dense in H if E has a dense orthogonal projection onto every n-dimensional subspace of H. One can easily check that a set E in H is weakly dense in H if and only if E is n-weakly dense in H for every $n \geq 1$. We then define an operator T to be n-weakly hypercyclic (resp. n-weakly supercylcic) if there is a vector x in H whose orbit (resp. scaled orbit) is n-weakly dense in H.

We will discuss some examples of such operators and surprisingly there are matrices with some of these properties. (Received September 13, 2010)

1065-47-191 **Michael Jury*** (mjury@ufl.edu), Department of Mathematics, University of Florida, PO Box 118105, Gainesville, FL 32611-8105, and **Scott McCullough** (sam@ufl.edu), Department of Mathematics, University of Florida, PO Box 118105, Gainesville, FL 32611-8105. *Nevanlinna-Pick interpolation in hypo-Dirichlet and related algebras.* Preliminary report.

We consider the Nevanlinna-Pick interpolation problem in H^∞ spaces associated to uniform algebras A, satisfying axioms slightly weaker than hypo-Dirichlet. A necessary and sufficient condition for interpolation is obtained in terms of the positivity of a family of Pick matrices. In the key motivating examples, we recover in a unified way the results of Abrahamse (for finitely connected planar domains) and Davidson, Paulsen, Raghupathi and Singh

(for constrained interpolation in the disk). By comparing the representations of H^∞ associated to the different kernels in the family, we obtain an abstract Abel-Jacobi map on the maximal ideal space of A. This is joint work with Scott McCullough and will complement his talk at the meeting. (Received September 13, 2010)

1065-47-206 **Malgorzata Marta Czerwinska*** (mmczrwns@memphis.edu). *Complex uniform rotundity in symmetric spaces of measurable operators.*

We say that a Banach space $(X, \|\cdot\|)$ is *complex uniformly rotund* if for any $\epsilon > 0$ there exists $\delta(\epsilon) \in (0,1)$ such that

$$\sup_{|\lambda|\leqslant 1} \|x + \lambda y\| \geqslant 1 + \delta(\epsilon) \text{ whenever } \|y\| \geqslant \epsilon \text{ and } \|x\| = 1.$$

Let $\mathcal{M}$ be a semifinite von Neumann algebra with a faithful, normal, semifinite trace τ, and E be a symmetric Banach function space on $[0, \tau(\mathbf{1}))$. The symmetric spaces $E(\mathcal{M}, \tau)$ consists of all τ-measurable operators x for which the singular value function $\mu(x)$ belongs to E and is equipped with the norm $\|x\|_{E(\mathcal{M},\tau)} = \|\mu(x)\|_E$.

We show that the symmetric space $E(\mathcal{M}, \tau)$ is complex uniformly rotund if and only if E is complex uniformly rotund. (Received September 13, 2010)

49 ► Calculus of variations and optimal control; optimization

1065-49-189 **David George Caraballo*** (dgc3@georgetown.edu), Department of Mathematics and Statistics, 3rd floor, St. Mary's Hall, Georgetown University, Washington, DC 20057-1233. *On surface energy minimizing partitions of R^n into regions having specified volumes.*

I will present my proof of the existence of surface energy minimizing partitions of Euclidean space R^n (for n = 2,3,...), satisfying volume constraints, and with independent smooth surface energy densities satisfying BV-ellipticity. This work extends well-known results by Fred Almgren, who, in 1976, gave the first existence and regularity results for minimal partitions with volume constraints, using surface energy density functions which are all scalar multiples of a fixed smooth norm.

For many years, problems involving partitions of R^n have been of interest in mathematics, materials science, biology, image processing, and many other fields. It is natural to consider partitions of space into regions having specified volumes, as with materials of fixed volumes attempting to find a least-energy configuration (e.g., soap bubble clusters, immiscible fluids, polycrystals). Understanding, for instance, the possible singularities in energy minimizers would improve our insight into and ability to predict properties of polycrystalline materials, in which surface energy density functions are typically not scalar multiples of one another.

In this talk, I will focus on the existence proof but will also comment briefly on regularity of the minimizers. (Received September 13, 2010)

51 ► Geometry

1065-51-34 **Reza Sarhangi*** (rsarhangi@towson.edu), Reza Sarhangi, PhD, Department of Mathematics, Towson University, 8000 York Road, Towson, MD 21252. *Compass and Straightedge Constructions and Modularity.*

The first part of this presentation is about geometric constructions using different types of compasses. The paper addresses the mathematics and history behind the three artwork plates, which will be shown during this talk.

After introducing the Collapsing Compass, the construction of the regular pentagon using a Rusty Compass will be presented along with artwork inspired by this construction. The next is the regular 17-gon construction. The historical significance of this construction, which led Johann Carl Friedrich Gauss (1777-1855)to prove the impossibility of 7-gon construction, will be discussed. The last section of the first part is about introducing an approximation of the regular heptagon based on a construction presented by Abûl-Wefâ Buzjani (940-998).

The second part of the talk is based on a different approach than using a compass in making designs. The creation of geometric mosaic designs has long relied on compass-straightedge constructions. Nevertheless, artisans have used other methods, such as modules formed from "cutting and pasting" of single-color tiles. During this talk it will be demonstrated how modules created from simple tiles may be used as a medium for designing more complex mosaic patterns. (Received September 09, 2010)

1065-51-35 **Godfried T. Toussaint*** (godfried@cs.mcgill.ca), Department of Music, Music Building, North Yard, Harvard University, Cambridge, MA 02138. *Mathematical Property-Preserving Shellings of Musical Rhythms.* Preliminary report.

In its simplest form, a musical rhythm may be represented as a binary sequence of unit time pulses, in which one symbol represents a sounded pulse, and the other a silent pulse. For example, the world-renown 16-pulse "clave son" rhythm would thus be notated by the sequence [x . . x . . x . . . x . x . . .], where x denotes the sounded pulse. The mathematical operation of shelling a rhythm consists of replacing a pulse of one kind with a pulse of the other kind. The minimalist composer Steve Reich, who made use of rhythmic shelling in some of his compositions, called these operations, construction and reduction, respectively. For example, the "shave and a haircut, two bits" rhythm [x . x x x . x . . . x . x . . .] is a 2-step construction of the clave son, whereas the rhythm [x . . x . . x . . . x . . . . .] is a 1-step reduction of the clave son. It is well known that "good" rhythms sometimes possess certain mathematical properties such as maximal evenness, deepness, flatness, full-interval-content, and symmetry. This paper analyzes some families of rhythms that exhibit such property-preserving shellings. For instance, it is shown that the beginning and ending portions of Steve Reich's piece "Drumming" are characterized by symmetry-preserving shellings. (Received August 08, 2010)

1065-51-102 **Egon Schulte*** (schulte@neu.edu), Northeastern University, Department of Mathematics, Boston, MA 02115. *Regular Polyhedra of Index Two in Space.*

A polyhedron in Euclidean 3-space is said to be a regular polyhedron of index 2 if it is combinatorially regular but "fails geometric regularity by a factor of 2"; that is, its combinatorial automorphism group is flag-transitive but its geometric symmetry group has two flag orbits. We report on the complete classification of the regular polyhedra of index 2. This is joint work with Anthony Cutler and is described in his 2009 PhD thesis at Northeastern University. (Received September 06, 2010)

1065-51-176 **Douglas Dunham*** (ddunham@d.umn.edu), Department of Computer Science 320 HH, 1114 Kirby Drive, Duluth, MN 55812-3036. *Hyperbolic Truchet Tilings: First Steps.* Preliminary report.

Truchet tilings have been studied for over 300 years, beginning with Sebastien Truchet himself. The original tile was a square divided into a black and white triangles by a diagonal, which thus has four orientations depending on which corner is completely black in an upright square. Copies of this tile are arranged on a square grid, in a pattern or with random orientations. One modification of the Truchet tile is a square decorated with two quarter arcs of circles that connect midpoints of adjacent sides, one arc on each side of a diagonal. Such a tile has two orientations in an upright square. The modification can also be applied to a regular hexagon tile, giving patterns based on the regular hexagon tessellation. Both the original Truchet tile and the modified versions can be generalized to regular p-sided polygons in the hyperbolic plane, and thus be used to create Truchet-like patterns based on the regular tessellations {p,q} of p-sided polygons meeting q at each vertex ((p-2)(q-2) must be greater than 4 for the tessellation to be hyperbolic). We will show such patterns and indicate mathematical challenges that arise from them. (Received September 12, 2010)

52 ► Convex and discrete geometry

1065-52-6 **Valeriu Soltan*** (vsoltan@gmu.edu), George Mason University, 4400 University Drive, Fairfax, VA 22030. *Convex surfaces with planar quadric sections.* Preliminary report.

We define a convex quadric surface in $\mathbb{R}^n$ as the boundary of a convex component of $\mathbb{R}^n \setminus Q$, if any, where Q is a real quadric surface. We review existing results and open problems related to characterizations of convex quadric surfaces in terms of their planar sections. (Received April 17, 2010)

1065-52-7 **Márton Naszódi*** (nmarci@math.elte.hu), Dept. of Geometry, Eötvös University, Pázmány Péter sétány 1/c, Budapest, 1117, Hungary. *On the maximal distance between convex bodies in $\mathbb{R}^n$.*

We consider the following version of the Banach–Mazur distance of (non-symmetric) convex bodies in $\mathbb{R}^n$ which was introduced by Grünbaum:

$$d(K, L) = \inf\{|\lambda| : \lambda \in \mathbb{R}, \tilde{K} \subseteq \tilde{L} \subseteq \lambda\tilde{K}\},$$

where the infimum is taken over all non-degenerate affine images $\tilde{K}$ and $\tilde{L}$ of K and L. Gordon, Litvak, Meyer and Pajor showed that for any two convex bodies $d(K, L) \leq n$, moreover, if K is a simplex and $L = -L$ then $d(K, L) = n$. The following question arises naturally: Is equality only attained when one of the sets is a simplex? Leichtweiss, and later Palmon proved that if $d(K, B_2^n) = n$, where B_2^n is the Euclidean ball, then K is the

simplex. We proved the affirmative answer to the question in the case when one of the bodies is strictly convex or smooth, thus obtaining a generalization of the result of Leichtweiss and Palmon. Joint work with Carlos Hugo Jiménez, Universidad de Sevilla, Spain. (Received April 27, 2010)

1065-52-11 **Michael J. Mossinghoff*** (mimossinghoff@davidson.edu), Department of Mathematics, Davidson College, Davidson, NC 28035-6996. *Enumerating isodiametric and isoperimetric polygons.*

For a positive integer n that is not a power of 2, precisely the same family of convex polygons with n sides is optimal in three different geometric problems. These polygons have maximal perimeter relative to their diameter, maximal width relative to their diameter, and maximal width relative to their perimeter. We study the number of different convex n-gons $E(n)$ which are extremal in these three isodiametric and isoperimetric problems. We show that $E(n) > \frac{p}{4n} \cdot 2^{n/p}$ if p is the smallest odd prime divisor of n, prove that $E(n) = 1$ if and only if $n = p$ or $n = 2p$ for some odd prime p, and compute the exact value of $E(n)$ in several cases. (Received June 11, 2010)

1065-52-12 **Zokhrab Mustafaev*** (mustafaev@uhcl.edu), 2700 Bay Area Blvd, Houston, TX 77058, and **Horst Martini** (horst.martini@mathematik.tu-chemnitz.de), 09107 Chemnitz, Germany. *Cross-section measures and their applications in Minkowski spaces.* Preliminary report.

We continue to investigate extremal values of inner and outer radii of the unit ball in Minkowski spaces (i.e., finite dimensional real Banach spaces) for the Holmes-Thompson and Busemann measures. Furthermore, we give a related new characterization of ellipsoids in $\mathbf{R}^d$ via codimensional cross-section measures. (Received June 12, 2010)

1065-52-13 **Marilyn Breen*** (mbreen@ou.edu), Department of Mathematics, 601 Elm Avenue, University of Oklahoma, Norman, OK 73019. *Some combinatorial results for staircase visibility.*

Many results in convexity that involve the usual notion of visibility via straight line segments have interesting analogues that employ the idea of visibility via staircase paths. Here we present several examples of these analogues, including the following: In the plane, let C be an orthogonal polygon bounded by a simple closed curve, and assume that C is starshaped via staircase paths. Let P be a set in the complement of the interior of C, int C. If every 4 points of P see a boundary point of C via staircase paths in the complement of int C, then there is a boundary point b of C such that every point of P sees b (via staircase paths in the complement of int C). The number 4 is best possible, even if C is convex via staircase paths. (Received June 16, 2010)

1065-52-14 **Deborah Oliveros*** (dolivero@matem.unam.mx), Instituto de Matematicas, C.U, Area de la Investigacion cientifica, Coyoacan, 04510 Mexico City, D.F., Mexico. *Helly Type theorems and intersection graphs, one nice relation.* Preliminary report.

Given a family of convex sets in the n-dimensional euclidean space, it is natural to define a graph called the intersection graph, were its vertices are the elements of the family and two vertices will have an edge in common if they have a point in common, a similar definition can be done to define uniform intersection λ-hyerpgraphs, were λ vertices become a hyperedge if the corresponding λ convex sets intersect. It turns out, that there are several Helly type theorems that can be investigated by using chromatic number and extremal theory such as covering or transversal numbers for intersection graphs and hypergraphs. In this talk, we will discuss some of these applications. (Received June 30, 2010)

1065-52-31 **Horst Martini*** (martini@mathematik.tu-chemnitz.de), Faculty of Mathematics, University of Technology, Chemnitz, 09106 Chemnitz, Saxony, Germany. *Some topics and notions from convexity extended to normed linear spaces.*

In this talk we will discuss some basic topics and notions from classical convexity, e.g. cross-section measures and special classes of convex bodies (like ellipsoids, centrally symmetric bodies or reduced bodies). We will present their role in the geometry of finite dimensional Banach spaces, also called Minkowski geometry, by giving examples how these topics and notions from convexity theory yield new results in Minkowski geometry, as tools and also as studied objects. (Received August 04, 2010)

1065-52-40 **Gabor A Toth*** (gtoth@camden.rutgers.edu), 411 North 5th Street, Camden, NJ 08102. *A measure of symmetry for convex sets and its application to moduli for minimal immersions of spheres.* Preliminary report.

Asymmetry of a compact convex body $\mathcal{L} \subset \mathbf{R}^n$ viewed from an interior point $\mathcal{O}$ can be measured by considering how far $\mathcal{L}$ is from its inscribed simplices that contain $\mathcal{O}$. This leads to a sequence of measures of symmetry $\{\sigma_k(\mathcal{L}, \mathcal{O})\}_{k\geq 1}$ in the sense of Grünbaum. This sequence of measures has interesting arithmetic properties. The interior of $\mathcal{L}$ naturally splits into regular and singular sets, where the singular set consist of points with largest possible $\sigma_n(\mathcal{L}, \mathcal{O})$. In general, to calculate the regular and singular sets is difficult. In this talk we give a variety of methods that facilitate this calculation. The methods are illustrated by several examples. The original motivation for introducing these measures is to describe the geometry of the DoCarmo-Wallach moduli spaces of minimal immersions of spheres. We use the DeTurck-Ziller minimal orbit method for $SU(2)$ to calculate these measures on the $SU(2)$-equivariant moduli of S^3 into spheres. (Received August 11, 2010)

1065-52-83 **T. Bisztriczky*** (tbisztri@math.ucalgary.ca), 2500 University Drive NW, Calgary, Alberta , Canada, **K. Boroczky**, Budapest, Hungary, and **A. Heppes**, Budapest, Hungary. *The T(5) Property of Families of Overlapping Unit Disks.*

We consider a finite family F of unit disks in the plane with the properties: T(k): Any k-element subfamily of F has a (line) transversal, and O(d): The distance between the centres of any two elements of F is greater than d. It is well known that F has a transversal in each of the following cases: k=3 and d=2sqrt(2)(sharp), k=4 and d=4/sqrt(3)(sharp) and k=5 and d=2.

In this preliminary report, we present arguments that F has a transversal in the case that k=5 and d=sqrt(3). (Received September 02, 2010)

1065-52-93 **Efren Morales*** (efren@mathacapulco.mx), Carlos E. Adame No. 54, Col. Garita, 39650 Acapulco, Mexico, **Jesus Jeronimo** (jeronimo@mathacapulco.mx), Carlos E. Adame No. 54, Col. Garita, Acapulco, Mexico, and **Luis Montejano** (luis@matem.unam.mx), Mexico, Mexico. *Only Solid Spheres Admit a False Axis of Revolution.*

Let $K \subset \mathbb{R}^3$ be a convex body. A point p_0 is a point of revolution for K if every section of K through p_0 has an axis of symmetry that passes through p_0. In particular, every point that lies in an axis of revolution is a point of revolution. A line $L \subset R^3$ is a *false axis of revolution*, if every point of L is a point of revolution for K but L is not an axis of revolution. The purpose of this paper is to prove that only solid spheres admit a false axis of revolution. (Received September 03, 2010)

1065-52-118 **Andras Bezdek*** (bezdean@auburn.edu), Department of Mathematics and Statistics, Auburn University, Parker Hall 221, Auburn, AL 36849. *Thin covering of the sphere with various convex spherical sets.* Preliminary report.

One of the basic problems in discrete geometry is to determine the most efficient packing or covering of a given convex set in the plane, in the space or on the sphere. This talk will concentrate on coverings of the surface of the unit sphere S^2 (in three dimensional space). In case of a given convex spherical set, one wants to find the smallest number of congruent copies needed to cover S^2. This talk will describe a new family of convex spherical sets, which do not tile S^2, yet for which the optimal coverings can be determined. These convex sets also have an unexpected covering property: no rearrangement of the sets taking part of the covering can produce a crossing free covering (we say that two spherical discs cross each other if the removal of their intersection causes each disk to fall into disjoint components). These results were motivated by the construction and the proof technique used in a recent joint paper with W. Kuperberg: Unavoidable crossings in the thinnest plane covering with congruent convex discs (Discrete Comput. Geom. (2010) 43: 187-208). (Received September 08, 2010)

1065-52-123 **Wlodzimierz Kuperberg*** (kuperwl@auburn.edu). *The set of packing and covering densities of convex disks.*

For each convex disk K (a convex compact subset of the plane, with a non-void interior), its packing density $\delta(K)$ and covering density $\vartheta(K)$ form an ordered pair of real numbers, i.e., a point on the coordinate plane. The set Ω, consisting of points assigned this way to all convex disks, is the subject of this talk. A few known inequalities on $\delta(K)$ and $\vartheta(K)$ jointly outline a relatively small convex polygon that contains Ω, but the exact shape of Ω remains a mystery. We present this polygonal region, and then we explicitly exhibit a certain convex region contained in Ω and occupying a good portion of it. (Received September 08, 2010)

1065-52-188 **David George Caraballo*** (dgc3@georgetown.edu), Department of Mathematics and Statistics, 3rd floor, St. Mary's Hall, Georgetown University, Washington, DC 20057-1233. *Convexity and geometric measure theory.*

In this talk, I will present my recent work establishing strong, new connections between geometric measure theory and results concerning convexity theory which have found wide application in fields such as functional analysis, economics, optimization, and control theory.

One of the most important and well-known properties of convex sets is the fact that a closed subset K of R^n with non-empty interior is convex if and only if it has a supporting hyperplane through each point of its topological boundary.

I have refined this result, showing that such a set K is convex if and only if it has a supporting hyperplane through each point of its reduced boundary, which may be much smaller than the topological boundary. This is surprising as it is not at all clear why the reduced boundary from geometric measure theory should contain all the convexity information about a closed subset of R^n with non-empty interior.

I similarly refined a standard separation theorem, as well as a representation theorem for convex sets, and extended each result to other notions of boundary from the literature, deducing the corresponding classical results from convex analysis as special cases. (Received September 13, 2010)

1065-52-192 **Jim Lawrence*** (lawrence@gmu.edu), Department of Mathematical Sciences, George Mason University, 4400 University Drive, Fairfax, VA 22030-4444. *Intersections of Descending Sequences of Affinely Equivalent Polytopes.*

In 1952 Borovikov published a proof of the conjecture of Kolmogorov that the intersection of a descending sequence of simplexes in Euclidean space must be a simplex. We consider the following question, analogous to Kolmogorov's: What are the possibilities for the intersection of a descending sequence of compact convex sets, each of which is affinely equivalent to a given compact convex set? The answer to this question involves the notion of an "affine retract" and yields a generalization of the result of Borovikov. (Received September 13, 2010)

1065-52-194 **Rick Vitale*** (r.vitale@uconn.edu), PO Box 805, Wallingford, CT 06492. *Intrinsic volumes.* Preliminary report.

Intrinsic volumes are key functionals defined on convex bodies and figure in a number of different questions. Here we discuss in particular their connections with Gaussian processes, with the Wills functional, and with some open problems, as time permits. (Received September 13, 2010)

1065-52-222 **James E. Mihalisin*** (mihalisi@meredith.edu), Meredith College, SMB, 3800 Hillsborough St., Raleigh, NC 27607. *Near Cubes: A relatively simple family of simple relatives of the cube.* Preliminary report.

The family of "near cubes" will be defined. Simply put – near cubes are the convex polytopes and non-convex polytopal complexes that are obtainable by performing a sequence of "clique swaps" on the d-cube. A "clique-swap" is just the dual version of a bi-stellar flip.

The combinatorial symmetries of the near cubes will be determined and the non-convexity of some of them will be discussed.

As time permits and audience interest allows, the connection between clique swaps and the Gale transform will be discussed and the general utility of clique swaps will be debated. (Received September 14, 2010)

1065-52-245 **Jesus De Loera** (deloera@math.ucdavis.edu), One Shields Avenue, Davis, CA 95616, **Katherine Jones** (kljones@math.ucdavis.edu), One Shields Avenue, Davis, CA 95616, and **Mohamed Omar*** (momar@ucdavis.edu), One Shields Avenue, Davis, CA 95616. *Permutation Polytopes and Ehrhart Polynomials.*

Permutation polytopes are convex hulls of real representations of finite groups. The Birkhoff polytope is a classical example, and it is well known that this polytope is the convex hull of doubly stochastic matrices. Of particular interest has been the study of volumes of the Birkhoff polytope and its faces. We study this in a more general context by studying Ehrhart polynomials of general permutation polytopes, providing an intimate interplay between convex geometry, group theory, and optimization. (Received September 14, 2010)

1065-52-262 **Carlos M. Nicolas*** (cmnicola@uncg.edu), Mathematics and Statistics Department, University of North Carolina at Greensboro, NC 27402. *Interval decompositions of k-edges and applications.*

Given a set S of points in the plane, a *k-edge interval* is the set of k-edges of S whose normal vectors belong to a given interval of the unit circle. These intervals are complete in the following sense: any k-edge interval is equal

to an i-edge interval for the set of vertices incident to its edges, for some $i \leq k$. This provides a recursive approach to the study of k-edges because k-edge intervals decompose into simpler edge-disjoint sub-intervals. Using this approach we obtain alternative proofs, sometimes simpler, for several properties of the set of k-edges such as the k-edge crossing identity and the current lower bound on the number of k-edges. (Received September 14, 2010)

60 ► Probability theory and stochastic processes

1065-60-10 **Manfred Denker*** (denker@math.psu.edu), Mathematics Department, Penn State Un iversity, State College, PA 16802. *Some new results on martingale approximation for stationary processes.* Preliminary report.

We use Gordin's martingale approximation to obtain new central limit theorems for the stationary solution of random affine transformations and for partial sums of higher dimensional kernels (von Mises statistics) when the sampling is stationary. The work is jointly with Dehling, Gordin and Iwata. (Received June 02, 2010)

62 ► Statistics

1065-62-152 **Thomas Schwarz*** (ts_schwarz@web.de), Biesenbrower Straße 120, 13057 Berlin, Germany. *Soccer World Cup 2010 - Did the man in the street benefit?*

The Soccer World Cup (WC) 2010 hosted by South Africa proved to be a great marketing success for South Africa. But did the economy, did the businesses and ultimately "the man in the street" benefit? The current analysis investigates the impact of the WC on the South African economy. Resulting from previous analyses of mega sports events, e.g. the WC in France 1998 and Germany 2006, no significant effect was proven. We have developed new procedures for analysing the impact. The conducted study is based on an online survey amongst the members of Southern African - German Chamber of Commerce and Industry. We have determined and, thus, explored indicators, which show potential changes in Gross Domestic Product. For the first time we use tools of applied and descriptive statistics and the exploratory data analysis, which shed light on the economical impact of a WC. (Received September 12, 2010)

65 ► Numerical analysis

1065-65-24 **Jiu Ding*** (jiudin@gmail.com), Department of Mathematics, 118 College Dr., Box 5045, Hattiesburg, MS 39406, and **Noah Rhee**, Department of Mathematics and Statistics, Kansas City, MO 64110. *A Maximum Entropy Method Based on Orthogonal Polynomials for Frobenius-Perron Operators.*

Let $S : [0, 1] \to [0, 1]$ be a chaotic map and let f^* be a stationary density of the Frobenius-Perron operator $P_S : L^1 \to L^1$ associated with S. We develop a numerical algorithm for approximating f^*, using the maximum entropy approach to an under-determined moment problem and the Chebyshev polynomials for the stability consideration. Numerical experiments show considerable improvements to both the original maximum entropy method and the discrete maximum entropy method. (Received July 26, 2010)

1065-65-27 **Xiaoping A Shen*** (shen@math.ohiou.edu), Athens, OH, **Katheryn A Farris**, Wright-Patterson Air Force Base, Dayton, OH, **David J Rieksts**, Athens, OH , and **Paul R Havig**, Wright-Patterson Air Force Base, Dayton, OH. *Entropy revisited: A brief review and new developments.* Preliminary report.

Shannon entropy as a measure of uncertainty has found many applications in engineering and other areas. This article provides a brief review of the concepts, algorithms, and most recent applications. Numerical experiments related to the simulation of complex systems are used to illustrate the applications. New results reveal the relation between the Hurst parameter and entropy of certain time series of long range memory are reported. (Received July 27, 2010)

1065-65-29 **S S Gregory Cochran*** (gcochra1@gmu.edu), 4400 University Dr., MS 3F2, fairfax, VA 22030, and **Thomas Wanner**. *A Modified Algorithm for Verification of Homology Computations of Nodal Domains.*

Homology provides a useful tool in studying the patterns resulting from modeling. If the patterns result from the nodal domains of real-valued functions, a natural question to ask if the homology computed is the actual homology. We will present a modified algorithm that correctly computes the homology of 1 and 2 dimensional

nodal domains. Using this algorithm, we will present the results from simulations to get averaged homology computations of random functions. We will also use this algorithm to compute the homology of time-dependent solutions of the Cahn-Hilliard equation. (Received July 28, 2010)

1065-65-116 **Sarah Day*** (sday@math.wm.edu), The College of William and Mary, Department of Mathematics, P.O. Box 8795, Williamsburg, VA 23187-8795, and **Jean-Philippe Lessard** and **Konstantin Mischaikow**. *Validated Continuation: a study of the Swift-Hohenberg Equation.*

Traditionally, stationary solutions of PDEs have been studied numerically via Galerkin projections and continuation algorithms. Many arguments may be made as to why this approach is expected to yield useful results under certain conditions. However, the traditional approach does not include verifying that the required conditions are met and may lead to misleading results. In this talk, we present a rigorous numerical method called "validated continuation" which combines topological tools with continuation algorithms to obtain proofs about the structure of the set of stationary solutions. The computational cost of validated continuation is arguably less than the cost of the traditional continuation approach. For illustration, these techniques are demonstrated in a study of the Swift-Hohenberg equation modeling pattern formation and thermal convection. If time permits, we will discuss how these and similar computations can be used to construct a model of the global attractor for the system. (Received September 08, 2010)

1065-65-126 **Andrei Draganescu*** (draga@umbc.edu), UMBC, Department of Mathematics and Statistics, 1000 Hilltop Circle, Baltimore, MD 21250, and **Cosmin Petra**. *Multigrid preconditioning of linear systems for interior point methods applied to a class of box-constrained optimal control problems.*

In this work we construct and analyze multigrid preconditioners for a class of operators arising in the solution process of distributed optimal control problems with box constraints on the controls. The presented preconditioning technique is related to the one developed by Draganescu and Dupont for the associated unconstrained problem, and is intended for large-scale, high-resolution problems. As in the unconstrained case, the quality of the resulting preconditioners is shown to increase with mesh-size $h \to 0$ at a rate that is optimal with respect to h. We test this algorithm first on a Tikhnov-regularized backward parabolic equation with box constraints and on an elliptic-constrained optimization problem. In both cases it is shown that the number of linear iterations per optimization step, as well as the total number of fine-scale matrix-vector multiplications is decreasing with increasing resolution, thus showing the method to be potentially very efficient for truly large-scale problems. (Received September 09, 2010)

1065-65-135 **Murli M Gupta*** (mmg@gwu.edu), Department of Mathematics, The George Washington University, 2115 G Street (Monroe 221), Washington, DC 20052. *High accuracy solution of partial differential equations of fluid mechanics.*

We have recently proposed high accuracy compact finite difference schemes for a variety of differential equations, including the convection- diffusion equation. This work has been extended to the steady-state two-dimensional Navier- Stokes equations for which we have proposed a compact streamfunction- velocity (ψ-v) formulation. This formulation has been shown to avoid the difficulties associated with the traditional formulations (primitive variables, and streamfunction- vorticity formulations). In this presentation, we describe the ideas behind the development of compact formulations and present results for a variety of fluid flow problems. (Received September 10, 2010)

1065-65-166 **J. A. De la Cruz** (jdelacruz@mail.barry.edu), Department of Mathematics & Computer Science, Barry University, 11300 NE 2nd Ave., Miami Shores, FL 33179, and **Jai N. Singh*** (jsingh@mail.barry.edu), Department of Mathematics & Computer Science, Barry University, 11300 NE 2nd Ave., Miami Shores, FL 33161. *Explicit Solutions for Transcendental Equations: A Technical Note.*

A method based on Cauchy's integral theorem to formulate the roots of analytic transcendental functions, is applied to the solution of some transcendental equations: exp (-b z) = z, exp (5-z) +.01 z -.55 =0 and tan z = h z. It represents a simple and fast way to solve analytical transcendental equations. (Received September 12, 2010)

1065-65-190 **Katharine F Gurski*** (kgurski@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *An Explicit Super-Time-Stepping Scheme for Non-Symmetric Parabolic Problems.*

Explicit numerical methods for the solution of a system of differential equations may suffer from a time step size that approaches zero in order to satisfy stability conditions. When the differential equations are dominated by a skew-symmetric component, the problem is that the real eigenvalues are dominated by imaginary eigenvalues. We compare results for stable time step limits for the super-time-stepping method of Alexiades, Amiez, and Gremaud (super-time-stepping methods belong to the Runge-Kutta-Chebyshev class) and a new method modeled on a predictor-corrector scheme with multiplicative operator splitting. This new explicit method increases stability of the original super-time-stepping whenever the skew-symmetric term is nonzero, which occurs in particular convection-diffusion problems and more generally when the iteration matrix represents a nonlinear operator. The new method is stable for skew symmetric dominated systems where the regular super-time-stepping scheme fails. We present a comparison between the two super-time-stepping methods to show the speed up available for any non-symmetric system using the nearly symmetric Black-Scholes equation as an example. (Received September 13, 2010)

1065-65-211 **Padmanabhan Seshaiyer*** (pseshaiy@gmu.edu), 4400 University Drive, MS: 3F2, Mathematical Sciences, Science and Tech I, George Mason University, Fairfax, VA 22030. *Numerical Methods for Multi-physics Applications with Fluid-structure Interaction.* Preliminary report.

In this talk, numerical methods for efficient computation of the nonlinear interaction of fluid with a solid will be presented. Theoretical and numerical results for some coupled fluid-structure interaction problems that arise from biological and bio-inspired applications will be presented that validate the reliability and robustness of the proposed computational methodology. (Received September 13, 2010)

1065-65-219 **Robert E White*** (white@math.ncsu.edu), SAS 3140, Department of Mathematics, North Carolina State University, Raleigh, NC 27695-8205. *Hazard Identification: Sensitivity and Optimal Location of Sensors.* Preliminary report.

Consider a hazard whose concentration is governed by a partial differential equation and a finite number of "point" sources. The discrete model is considered with more sensors than sources. The objective is to locate and determine the intensities of the sources from data collected at the sensors. This leads to a nonnegative nonlinear least squares problem, which may be ill-conditioned. The location of the sensors and the physical data such as velocity and mass diffusion give perturbations of the matrix and vector in the right side. These perturbations can give rise to ill-conditioned problems; that is, variations in the sensor locations and physical data may induce significant errors in the solution of the nonnegative nonlinear least squares problem. Numerical studies and a variation of condition number of the matrix will be presented. (Received September 14, 2010)

68 ► Computer science

1065-68-38 **Amir Finkelstein*** (amir.f22@gmail.com), Haifa, Israel. *Introduction to semi-discrete calculus.* Preliminary report.

Ever since the early 1980's, computer scientists have been using an algorithm named "Summed Area Tables", also known as "Integral Image". This algorithm was shown to provide a tremendous computational gain, since it fits precisely to the needs of discrete geometry researchers, due to its discrete nature. In 2007, Wang and his colleagues suggested a rigorous formulation of an extension to this algorithm (discrete Green's theorem), and in this book it is suggested, among others, that a decisive parameter at this theorem can be naturally defined via a simpler pointwise operator than the derivative. The main operator of this theory is defined by a mixture of the discrete and continuous, to form a semi discrete and more efficient operator than the derivative, given that one aims at classification of monotony. This approach to analyze functions is hence more suitable for computers (in order to save computation time), and the simplicity of the definition allows further research in other areas of classical analysis. (Received August 11, 2010)

70 ► Mechanics of particles and systems

1065-70-33 **Tiancheng Ouyang** and **Zhifu Xie*** (zxie@vsu.edu), Department of Math. & Computer Science, P.O.Box 9068, Virginia State University, Petersburg, VA 23806. *Number of Central Configurations in the Collinear Four-body Problem.*

For a given $m = (m_1, m_2, \cdots, m_n) \in (\mathbf{R}^+)^n$, let p and $q \in (\mathbf{R}^d)^n$ be two central configurations for m. Then we call p and q *geometrically equivalent* and write $p \sim q$ if they differ by a rotation followed by a scalar multiplication as well as by a permutation of bodies. Denote by $L(n, m)$ the set of geometric equivalence classes of n-body collinear central configurations for any given mass vector m. There are other different understandings of equivalence of central configurations in collinear n-body problem. Under the usual definition of equivalence of central configurations in history, permutations of the bodies are not allowed and we call them *permutation equivalence*. In this case Euler found three collinear central configurations and Moulton generalized to $n!/2$ central configurations for any given mass m in the collinear n-body problem under permutation equivalence. The main result in this paper is the discovery of the explicit parametric expressions of the union H_4 of the singular surfaces in the mass space $m \in (\mathbf{R}^+)^4$. We prove that the number of central configurations $^{\#}L(4, m) = 4!/2 - 1 = 11$ if m_1, m_2, m_3 and m_4 are mutually distinct and $m \in H_4$. (Received August 06, 2010)

1065-70-78 **Dmitry V Zenkov*** (dvzenkov@ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695-8205, and **Cameron Lynch**. *Structurally Stable Nonholonomic Integrators.*

When simulating mechanical systems numerically, it may be desirable to preserve some of the system's intrinsic structures. For instance, in the absence of velocity constraints, it is desirable to preserve a symplectic form. Integrators that preserve suitable quantities in the presence of velocity constraints will be introduced. (Received August 31, 2010)

1065-70-253 **Magdalena M Musielak***, Department of Mathematics, The George Washington University, 2115 G St. NW, Room 240, Washington, DC 20052. *Point-IBCell model for growth of multicellular tissues.* Preliminary report.

We present a biomechanical model of growth of multicellular tissues, based on an immersed boundary method that couples mechanics of elastic cells with the dynamics of the viscous incompressible fluid, motion of which is governed by the Navier-Stokes equations. Individual cells are represented here as single points connected by springs to neighboring cells. Voronoi Tessellation technique is used to reproduce the individual cell membranes, which allows for a realistic representation of the whole tissue composed of individual cells inhomogeneous in their shape and behavior, but acting together as one complex tissue. Our approach, dictated by the trade-off between computational cost and biological realism, allows us to handle large number of cells with simplified cell geometry, that interact with their immediate neighbors, but still treat them as individual entities that act independently of others, e.g. have individual cell cycle. (Received September 14, 2010)

81 ► Quantum theory

1065-81-18 **Siavash H. Sohrab*** (s-sohrab@northwestern.edu), Northwestern Uinversity, Dept. Mech. Engin., 2145 Sheridan Road, Evanston, IL 60208. *Scale Invariant Statistical Theory of Turbulence and Hydrodynamic Foundations of Schrödinger and Dirac Wave Equations.*

A scale invariant model of statistical mechanics from cosmic to Planck scale is presented with particles that at thermodynamic equilibrium will have Gaussian velocity distributions, Planck energy distribution, and Maxwell-Boltzmann speed distribution. Physical space is identified as a tachyonic fluid that is stochastic ether of Dirac or "hidden thermostat" of de Broglie. Invariant Schrödinger equation and Dirac relativistic wave equation are derived. Compressibility of physical space is shown to result in Lorentz-FitzGerald contraction thus accounting for null result of Michelson-Morley experiment. The physical foundation of special theory of relativity is examined leading to two paradigms: (A) Poincaré-Lorentz dynamic theory of relativity with space and time (x, t) altered due to causal effects of motion on the ether (B) Einstein kinematic theory of relativity with Space and time (x, t) are altered due to the two postulates of relativity (1) The laws of physics do not change form for all inertial frames of reference (2) Velocity of light is a universal constant independent of the motion of its source. A scale-invariant definition of time is presented and it is shown that parallel to lengths time durations contract such that the speed of light remains invariant. (Received July 13, 2010)

1065-81-97 **Iana I Anguelova*** (anguelovai@cofc.edu), College of Charleston, Math Department, 66 George Street, Charleston, SC 29424. *Bicharacter construction for the boson-fermion correspondence of type B.* Preliminary report.

The charged free boson-fermion correspondence plays an important role in the representation theory of the a_∞ algebra, as well as for the KP hierarchy. It is an isomorphism between two super vertex algebras (and so with singularities in the OPEs only of the type $z = w$). The boson-fermion correspondence of type B plays a similar role in the representation theory of the b_∞ algebra and for the BKP hierarchy. The vertex operators describing it have singularities in the OPEs at both $z = w$ and $z = -w$, and thus need a more general notion than a super-vertex algebra. This is the simplest, and important, example of what we call a "T-generalized vertex algebra". In this talk we present a bicharacter construction for this collection of vertex operators, which will then be used for studying the properties of the corresponding T-generalized vertex algebra. This talk will serve as a motivation for the definition of a T-generalized vertex algebra, and for the talk by Maarten Bergvelt T-Generalized Vertex Algebras and Twisted Modules". (Received September 05, 2010)

1065-81-186 **George Androulakis*** (giorgis@math.sc.edu), Columbia, SC 29208, and **Jean Bellissard** and **Christian Sadel**. *A model for Mott hopping conductivity.* Preliminary report.

We introduce a dissipative quantum model describing Mott's hopping conductivity in highly dopped semiconductors. This is a joint work with Christian Sadel and Jean Bellissard. (Received September 13, 2010)

90 ► Operations research, mathematical programming

1065-90-57 **Jai N. Singh*** (jsingh@mail.barry.edu), Department of Mathematics & Computer Science, Barry University, 11300 NE 2nd Ave., Miami Shores, FL 33161, and **Prabhat Kumar**. *Karmarkar's Algorithm in Linear Programming and its Consequences in Computational Mathematics.*

In this talk we present various results related to the convergence of iterates, termination of the algorithm and the choice of the step-length of Karmarkar's polynomial-time algorithm in linear programming and indicate some of its recent consequences in computational mathematics. (Received August 23, 2010)

1065-90-172 **Robert Bosch*** (rbosch@oberlin.edu), Department of Mathematics, Oberlin College, Oberlin, OH 44074. *Constrained Mosaicking: Less Can Be More.* Preliminary report.

We consider two types of constrained mosaics - edge-matched mosaics and map-colored mosaics - and argue that in each case, less can be more. That is, contrary to what one might expect, one can often produce much more attractive mosaics with a smaller set of tesserae (in the case of edge-matched mosaics) or a smaller number of shades of gray (in the case of map-colored mosaics) than with a larger set of tesserae or a larger number of shades of gray. (Received September 12, 2010)

92 ► Biology and other natural sciences

1065-92-19 **Jonas Denissen*** (jonas.denissen@gmail.com), Ansbacher Str. 21, 10787 Berlin, Germany. *Modeling of gene regulatory networks.*

Gene regulatory networks (GRNs) represent the functional interactions between macromolecular compounds, such as DNA and proteins in a cell. Classically, various approaches are concerned with GRN modeling. In this presentation we will focus on an asynchronous multi-valued logical approach where genes have discrete expression levels depending on the state of the system. The qualitative analysis introduced by Thomas allows us to understand GRN dynamics via the logic parameters and to reason about the model. Biological properties, such as homeostasis, cyclic attractors and reachability can be expressed in temporal logic. We will show how model checking can be used to determine feasible models w.r.t. a temporal formula. Unfortunately, GRN modeling is limited by an incomplete knowledge about the system. Therefore, we will introduce a reverse-engineering method: constraints on logic parameters are deduced from a temporal formula and checked for satisfiability. (Received July 16, 2010)

1065-92-21 **Andrew N Samuelson*** (asamuels@gmu.edu), 8711 Chippendale Court, Annandale, VA 22003, and **Padmanabhan Seshaiyer**. *Analytical and Computational Methods for Fluid-Structure Interaction Applications to Aneurysms.* Preliminary report.

Despite major advances in this area, there is still a need for more sophisticated models which provide better insight into understanding the biomechanics of aneurysms. In this talk, we present the development of analytical and computational models for understanding the soft tissue mechanics, fluid dynamics, and their interaction. In particular, we will present the development of a hyperelastic membrane model which incorporates fluid-structure interaction for a cylindrical geometry undergoing radial inflation. The proposed models that will be presented in this work will be studied for a variety of biomechanical factors including viscoelasticity, anisotropy, and growth and remodeling. A stability analysis and numerical results for benchmark problems will be presented. (Received July 23, 2010)

1065-92-36 **John A Adam***, Department of Mathematics & Statistics, Old Dominion University, Norfolk, VA 23529. *"Waves" of healing, the critical size defect and keloid scars: some speculation.*

Two related models are presented for wound healing on a spherical surface. By interpreting the healing process as a "pseudowave" propagating across the spherical surface a heuristic account of the "speed" of healing is possible, and a corresponding upper bound on the healing time is characterized. Of particular importance in relation to animal models is the existence (or not) of a critical size defect (a CSD, defined below); this is discussed as a consequence of the stability of the steady states of the system to non-uniform spatial (or angular) perturbations. Explicit criteria are derived under which a CSD exists (within the model) in terms of the skull radius and wound radius. The second model invokes a weighted spatial average cell density which permits the presence of both a short-range activation term (as in the first model) and a long-range inhibition term. Under these circumstances, within a suitable parameter range, the phenomenon of aggregation may occur in addition to the behavior predicted by the first model. It is speculated that such aggregation is manifested in the case of keloid scarring, which can occur as a result of wound healing in tissue. (Received August 10, 2010)

1065-92-41 **Yan Hao*** (yxhaox@wm.edu), The College of William and Mary, Applied Science Dept., Williamsburg, VA 23187, and **Gregory D Smith** (greg@wm.edu), POBox 8795, Applied Science Dept., Williamsburg, VA 23187. *A Langevin description of the stochastic dynamics of calcium release sites composed of multiple intracellular channels.* Preliminary report.

Compositionally defined Markov chain models have been used to study the relationship between single channel gating of intracellular calcium (Ca2+) channels and the stochastic dynamics of Ca2+ "puffs" and "sparks," intracellular Ca2+ release events that arise from the cooperative activity of clusters of Ca2+ channels. In such models, the transition probabilities of individual channels depend on the local Ca2+ concentration and thus the state of the other channels. Consequently, Markov chain models of Ca2+ release sites often possess intractably large state spaces that impede computational analysis. To overcome this difficulty, we derived a general Langevin formulation for the stochastic dynamics of Ca2+ release sites complosed of a large number of intracellular Ca2+ channels. We validate this Langevin formulation by comparison to Markov chain simulations and perform benchmark simulations that demonstrate its computational efficiency for single channel models with 2 or more states and release sites composed of 20 to 80 channels. This project is joint work with Gregory D. Smith. (Received August 11, 2010)

1065-92-48 **Holly D Gaff*** (hgaff@odu.edu), Dept of Biological Sciences, 110 MGB, Old Dominion University, Norfolk, VA 23529. *Estimating tick-borne disease risk with an agent-based model.*

Ticks have a unique life history including a distinct set of life stages and a single bloodmeal per life stage. While some tick species have a single preferred host for each life stage, other tick species will feed on a variety of hosts. All of this makes tick-host interactions more complex from a mathematical perspective. In addition, any model of these interactions must involve a significant degree of stochasticity on the individual tick level. In an attempt to quantify these relationships, we have developed an individual-based model of the interactions between ticks and their hosts as well as the transmission of tick-borne disease between the two populations. Preliminary analysis of disease prevalence as a function of host diversity is presented. (Received August 18, 2010)

1065-92-49 **Jemal S Mohammed-Awel*** (jmohammedawel@valdosta.edu), P.O.Box 5743, Valdosta, GA 31603, and **John Bantle**, **Aaron Festinger**, **Ryan Klafehn**, **Hee-Joon Jo** and **John Ringland**. *Boundaries of Sustainability in Simple and Elaborate Models of Agricultural Pest Control with a Pesticide and a Nontoxic Refuge.*

In two models of pest control using a pesticidal crop along with a non-pesticidal refuge to prevent the development of resistance, we numerically compute the bifurcations that bound the region in parameter-space where control is sustainable indefinitely. An exact formula for one of the bifurcation surfaces in one of the models is also found. One model is conceptual and as simple as possible. The other is realistic and very detailed. Despite the great differences in the models, we find the same distinctive bifurcation structure. We focus on the parameters that determine: (i) the restriction of pest exchange between the crop and the refuge, which we call screening the refuge, and (ii) the recessiveness of the resistance trait. The screened refuge technique is seen to work in the models up to quite high values of the fitness of resistant heterozygotes, i.e., even when resistance is not strongly recessive. (Received August 19, 2010)

1065-92-66 **Jinfeng Wang** (jfwangmath@gmail.com), Harbin Institute of Technology, Harbin, 150001, Peoples Rep of China, **Junping Shi*** (jxshix@wm.edu), College of William and Mary, Williamsburg, VA 23187, and **Junjie Wei** (weijj@hit.edu.cn), Harbin Institute of Technology, Harbin, 150001, Peoples Rep of China. *Predator-prey model with strong Allee effect on prey population.*

Classical Rosenzweig-MacArthur predator-prey model assumes a logistic growth for the prey population. A strong Allee effect on the prey population introduces a population threshold. The dynamics of ODE model is completely classified, with phenomena of Hopf bifurcation, unique limit cycle, and heteroclinic loop. The dynamics, bifurcations, and a priori estimates for the PDE model will also be discussed. (Received August 26, 2010)

1065-92-67 **Gary R. Greenfield*** (ggreenfi@richmond.edu), Mathematics and Computer Science, University of Richmond, Richmond, VA 23173. *Reaction-diffusion in pattern formation and the fine arts.* Preliminary report.

Turing (1952), Meinhardt (1972), Young (1986), Witkin and Kass (1991), and Fleisher (1995) have all famously considered mathematical models based on reaction and diffusion - which exhibit increasing degrees of complexity and sophistication - in order to simulate biological pattern formation. We investigate a reaction-diffusion model after Eggenberger (1994) that is more faithful to the notion of cellular processes and more amenable to applications in the fine arts, and we discuss the convergence of reaction-diffusion generative art methods with swarm, autonomous agent, and collective robotic techniques. (Received August 28, 2010)

1065-92-72 **Ka Ying Lam*** (lam.ying@kaust.edu.sa), Mail Box 1662, 4700 King Abdullah University, of Science and Technology, Thuwal, 23955-6900, Saudi Arabia, and **May Boggess** (mboggess@math.tamu.edu), Texas A & M University, College Station, TX 77840. *Epidemic Models for H1N1 Influenza in Hong Kong.*

Human Swine Influenza is caused by the novel Influenza A(H1N1) virus. Since its discovery in North America in April 2009, the disease has led to epidemics in many parts of the world. A traveler who arrived Hong Kong by air on May 1 2009 from Mexico was diagnosed with the disease and was Asia's first confirmed case of the new flu. In this paper,we apply various deterministic models to the H1N1 epidemic of 2009 in Hong Kong. We then consider a modified logistic curve and a Double Epidemic Susceptible-Exposed-Infected-Removed-Protect model. (Received August 30, 2010)

1065-92-77 **Doron Levy*** (dlevy@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *On the Dynamics of Cancer Stem Cells and Drug Resistance.*

Often, resistance to drugs is an obstacle to a successful treatment of cancer. In spite of the importance of the problem, the actual mechanisms that control the evolution of drug resistance are not fully understood. In this talk we present our recent results on mathematical models for studying cancer stem cells and their role in developing drug resistance. We derive a new estimate of the probability of developing drug resistance by the time a tumor is detected. We then combine our mathematical results together with clinical and experimental data on chronic myelogenous leukemia to propose answers to open problems regarding the dynamics of hematopoietic cancer stem cells. This is a joint work with Cristian Tomasetti. (Received August 31, 2010)

1065-92-92 **Mette S Olufsen*** (msolufse@ncsu.edu), Campus Box 8205, Raleigh, NC 27695, and **Brooke N Steele**, **Daniela Valdez-Jasso** and **Mansoor A Haider**. *Predicting arterial flow and pressure dynamics using a 1D fluid dynamics model coupled with a generalized viscoelastic wall model.*

It has long been know that the systemic arteries are viscoelastic, yet few fluid dynamics models account for this phenomenon. In this study, we discuss how to couple a viscoelastic wall model with a 1D fluid dynamics model allowing accurate prediction of arterial blood flow, pressure, and vessel area. The fluid dynamics model is derived from the 1D Navier Stokes equations for an incompressible non-Newtonian flow through a cylindrical tube. This model is combined with a viscoelastic constitutive equation derived using the QLV theory to relate pressure and vessel area. The viscoelastic model is derived in general incorporating both a linear (yielding a Kelvin model) and a nonlinear sigmoidal elastic response. For the fluid domain the model assumes that a given flow is applied at the inlet, across vessel junctions the model assumes that flow is conserved and pressure is continuous, and at the vessel outlet we apply a three-element Windkessel boundary condition. This boundary condition allows us to account for the overall behavior of the remainder of the system. The coupled fluid structure interaction model is solved using a finite element method, adapted to account for time-history of the viscoelastic model. (Received September 03, 2010)

1065-92-96 **David Chan*** (dmchan@vcu.edu), Dept. of Mathematics and Applied Mathematics, PO Box 842014, Richmond, VA 23284, and **Jean M Tchuenche**, **Christinah Chiyaka**, **Ghislaine Mayer** and **Amanda Matthews**. *A Mathematical Model for Antimalarial Drug Resistance.*

We formulate and analyze a mathematical model for malaria with treatment and three levels of resistance in humans. The model incorporates both sensitive and resistant strains of the parasites. Analytical results reveal that the model exhibits the phenomenon of backward bifurcation (co-existence of a stable disease-free equilibrium with a stable endemic equilibrium), an epidemiological situation where although necessary, having the basic reproduction number less that unity, it is not sufficient for disease elimination. Through quantitative analysis, we show the effects of varying treatment levels in a high transmission area with different levels of resistance. Increasing treatment has limited benefits in a population with resistant strains, especially in high transmission settings. Thus, in a cost-benefit analysis, the rate of treatment and percentage to be treated become difficult questions to address. (Received September 05, 2010)

1065-92-107 **Rebecca Segal*** (rasegal@vcu.edu), Department of Mathematics, Virgina Commonwealth University, PO Box 842014, Richmond, VA 23221-2041, and **Angela Reynolds**. *A Model of Wound Healing via Collagen Accumulation.*

Wound healing is achieved through the production of collagen by fibroblast cells. In this differential equation model we investigate the competing actions of fibroblast cells and inflammatory cells on collagen accumulation. The healing time course and collagen accumulation rates are confirmed with experimental data. The model can replicate non healing wounds as well and will be used to investigate the impact of circulating systemic hormones on wound and patient outcomes. (Received September 07, 2010)

1065-92-109 **Sun Ruoyan*** (rsun@email.wm.edu), Department of Mathematics, College of William and Mary, Williamsburg, VA 23187. *Global stability of the endemic equilibrium of multigroup SIR model with nonlinear incidence.*

We introduce a basic reproduction number for a multigroup epidemic model with nonlinear incidence. Then, we establish that global dynamics are completely determined by the basic reproduction number R_0. It shows that, the basic reproduction number R_0 is a global threshold parameter in the sense that if it is less than or equal to one, the disease free equilibrium is globally stable and the disease dies out; whereas if it is larger than one, there is a unique endemic equilibrium which is globally stable and thus the disease persists in the population. (Received September 07, 2010)

1065-92-113 **Georgia Pfeiffer*** (gwpfeiffer@email.wm.edu), CSU 2912, PO Box 8793, Williamsburg, VA 23187, and **Masami Fujiwara** and **Jay Walton**. *Extinction Equilibria of Stage Structured Populations.*

Invasive species have disrupted ecosystems worldwide threatening native populations that are often ill equipped to out compete them. The interaction between invasive and native populations can be complicated by varying intensities of competition at different life stages. In this study, we analyzed competition of two stage-structured populations. The model takes the form of two Lefkovitch matrix models interacting through density dependent terms. The stability of equilibrium densities was investigated under varying competition strength and intrinsic growth rates of the two populations. We show that it is possible for both partial extinction equilibria (persistence

of only one population) and the total extinction equilibrium (extinction of both populations) to be simultaneously stable under some parameters. (Received September 08, 2010)

1065-92-130 **Laura A Miller*** (lam9@email.unc.edu), Department of Mathematics, CB 3250 Phillips Hall, Chapel Hill, NC 27599, and **Christina Hamlet** (chamlet@email.unc.edu) and **Arvind Santhanakrishnan**. *Viscous flow through arrays of cylinders with applications to biological protective layers and filtering.*

Arrays of extracellular proteins and cellular protrusions can act as both vasculoprotective layers and mechanosensors. For example, blood flow profiles through the endothelial surface layer determine the amount of shear stress felt by the endothelial cells and may alter the rates at which molecules enter and exit the cells. Characterizing the flow profiles through such layers is therefore critical towards understanding the function of such arrays in cell signaling and molecular filtering. Since in vivo and in vitro measurements of flow near and within these layers are difficult to obtain, previous work has focused on mathematical models that treat the layers as homogeneous porous layers. The limitations of such models for irregular regions of the layers as well as for particle transport are not clear. In this presentation, dynamically scaled physical models were used to study the flow profiles through arrays of cylinders. The results were then compared to numerical simulations using the Method of Regularized Stokeslets. The volume fraction, height, and length of the physical and mathematical models were varied. The results were then used to understand how variations in density and height of such structures alter shear stresses and bulk flows. (Received September 09, 2010)

1065-92-139 **James F Selgrade*** (selgrade@math.ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695-8205, and **Alison Margolskee**, Department of Mathematics, North Carolina State University, Raleigh, NC 27695. *Comparing the Effects of Delay and No Delay in a Model for Hormonal Regulation of the Menstrual Cycle.* Preliminary report.

A model is presented for hormonal control of the menstrual cycle, which has 41 parameters and one discrete time delay for the effect of inhibin on the synthesis of follicle stimulating hormone. Although the model with no delay gives an adequate fit to data in the literature, a delay of 1.5 days improves the fit to data and improves model behavior with respect to variations in sensitive parameters. One of the most sensitive parameters represents the level of estradiol sufficient for significant synthesis of luteinizing hormone, which causes ovulation. Bifurcation diagrams with respect to this parameter reveal an interval of parameter values for which a unique stable periodic solution exists and it represent an ovulatory cycle. This interval is referred to as the cycle uniqueness interval and is determined by two saddle-node bifurcations of periodic solutions. As the inhibin delay is increased from zero, degenerate Hopf bifurcations and transcritical bifurcations cause the cycle uniqueness interval to enlarge. These dynamics are illustrated and biological implications are discussed. (Received September 10, 2010)

1065-92-143 **Frederic Mazenc**, Projet INRIA DISCO, CNRS-Supelec, 3 rue Joliot Curie, 91192 Gif-sur-Yvette, France, **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-4918, and **Marcio de Queiroz**, Department of Mechanical Engineering, Louisiana State University, Baton Rouge, LA 70803-6413. *Tracking Control and Robustness Analysis for a Nonlinear Model of Human Heart Rate During Exercise.*

The control of human heart rate during exercise is an important problem that has implications for the development of protocols for athletics, assessing physical fitness, weight management, and preventing heart failure. We provide a new stabilization technique for a recently-proposed nonlinear model for human heart rate response that describes the central and peripheral local responses during and after treadmill exercise. The control input is the treadmill speed, and the objective is to make the heart rate and peripheral responses track a prescribed reference trajectory. We use a strict Lyapunov function analysis to design new state and output feedback tracking controllers that globally exponentially stabilize the tracking dynamics to zero and ensure input-to-state stable performance with respect to actuator errors. (Received September 14, 2010)

1065-92-144 **Frederic Mazenc**, Projet INRIA DISCO, CNRS-Supelec, 3 rue Joliot Curie, 91192 Gif-sur-Yvette, France, and **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, Louisiana State University, 303 Lockett Hall, Baton Rouge, LA 70803-4918. *Stabilization of a Chemostat Model with Haldane Growth Functions and a Delay in the Measurements.*

The stabilization of equilibria in chemostats with measurement delays is a complex and challenging problem, and is of significant ongoing interest in bioengineering and population dynamics. In this paper, we solve an output feedback stabilization problem for chemostat models having two species, one limiting substrate, and either

Haldane or Monod growth functions. Our stabilizing feedbacks depend only on (1) a given linear combination of the species concentrations, which are measured with an unknown time delay and (2) a known upper bound for the delay. Our feedbacks ensure persistence of both species. Our work is based on a Lyapunov-Krasovskii argument. (Received September 11, 2010)

1065-92-155 **Raina Robeva*** (robeva@sbc.edu), Department of Mathematical Sciences, Sweet Briar College, VA , and **Jennifer Kim Penberthy**. *A Computational Method for Psycho-Physiological Assessment of Attention Deficit/Hyperactivity Disorder (ADHD).*

Attention Deficit/Hyperactivity Disorder (ADHD) is the most common developmental disorder of childhood and often continues into adulthood. The US Centers for Disease Control and Prevention estimate that approximately 4.6 million (8.4%) American children aged 6-17 years have at some point in their lives received a diagnosis of ADHD. However, unlike a neurological condition such as stroke, in which examination and neuroimaging provide clear, objective criteria in diagnosis, ADHD lacks the "hard evidence" that aids in evaluation and treatment. Even though ADHD is a physiologically based disorder with a multifactorial etiology, the diagnosis has been traditionally based on a subjective history of symptoms. Currently there is no objective criteria for diagnosis and no objective way to determine what medication and doses are optimally effective or if the condition is changing with maturation.

We present a combined psycho-physiological computational procedure that has been shown to improve the assessment of ADHD. We use this method to combine data from five studies that examine the diagnostic abilities of different behavioral rating scales and EEG assessments of ADHD, enrolling a total of 56 ADHD and 55 control subjects of different age groups and gender. (Received September 12, 2010)

1065-92-165 **Sivan Leviyang*** (sr286@georgetown.edu), Georgetown University, Dept. Mathematics, Washington, DC 20057. *The Effect of Immune System Attack on Intrahost HIV Genealogies.*

In order to analyze a collection of intrahost, HIV genetic samples, one must construct a genealogy that reflects the ancestral relationships of the genetic samples. The genealogy or set of genealogies constructed reflect modeling assumptions one makes on the forces shaping the evolution of HIV. Most tools currently used to construct such genealogies in the context of HIV use generic models that do not include the selective force produced by immune system attack. We will describe a model that includes the effects of immune system attack on HIV. We then use this model to analyze HIV genetic diversity during an infection. Mathematically, this work draws on ideas from coalescent theory and, more generally, stochastic processes. (Received September 12, 2010)

1065-92-180 **Luis F. Gordillo*** (luis.f.gordillo@gmail.com), PO Box 7342, Mayagüez, PR 00681, and **Yongkuk Kim**. *Spread of pine wilt disease subject to early eradication of infected trees.* Preliminary report.

Pine wilt disease is currently among the most devastating pine trees plagues on earth. It is caused by the pinewood nematode *Bursaphelenchus xylophilus* in a perfect, and beautifully synchronized, mutualistic relationship with beetles of the genus *Monochamus*. The disease has a fast and efficient spread, which turns most of the efforts to control it practically insufficient. We investigate how early eradication of infected pine trees, i.e. eradication of trees which just ceased oleoresin exudation, may affect the disease spread. In contrast to the sole eradication of killed trees, our results show that under an appropriate combination of eradication strategies: (1) There is a significant increase in the minimum pine density below which the disease fails to invade, (2) The region where reproductive Allee effects may take place are significatively enlarged, (3) It is possible to design optimal policies for eradication through stochastic search optimization techniques, for instance. We conclude that disease extinction can be reached faster with appropriate combinations of eradication policies, which minimize the damage on healthy pine trees and operational costs. (Received September 13, 2010)

1065-92-209 **Maeve Lewis McCarthy*** (maeve.mccarthy@murraystate.edu), Mathematics & Statistics, Murray State University, 6C Faculty Hall, Murray, KY 42071. *Intermorph cannibalism amongst Arizona Tiger Salamanders.*

The Arizona Tiger Salamanders at the Mexican Cut Nature Preserve in Colorado form a closed population due to the elevation of their habitat. They exhibit facultative paedomorphosis in which salamander larvae either metamorphose into terrestrial adults or become sexually mature while still in their larval form. Although many salamanders exhibit cannibalism of larvae, the Arizona Tiger Salamander also exhibits cannibalism of one adult morph by the other. We formulate an ODE model of this system, treating one adult form as a predator, the other as a prey, and the larvae as juveniles whose stage duration is short in comparison to adult life expectancy.

We incorporate Allee effects by modeling the predator as a generalist predator that is either hungry or satiated. We discuss the analysis and interpretation of the model. (Received September 13, 2010)

1065-92-240 **John E. Franke*** (franke@math.ncsu.edu), Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695-8205, and **Abdul-Aziz Yakubu** (ayakubu@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *Periodically Forced Discrete-Time SIS Epidemic Model With Disease Induced Mortality.*

We use a periodically forced SIS epidemic model with disease induced mortality to study the combined effects of seasonal trends and death on the extinction and persistence of discretely reproducing populations. We introduce the epidemic threshold parameter, R0, for predicting disease dynamics in periodic environments. Typically, R0 < 1 implies disease extinction. However, in the presence of disease induced mortality, we extend the results of Franke and Yakubu to periodic environments and show that a small number of infectives can drive an otherwise persistence population with R0 > 1 to extinction. Furthermore, we obtain conditions for the persistence of the total population. In addition, we use the Beverton-Holt recruitment function to show that the infective population exhibits period-doubling bifurcations route to chaos where the disease-free susceptible population lives on a 2-cycle (non-chaotic) attractor. (Received September 14, 2010)

1065-92-252 **Tarynn Madysyn Witten*** (tmwitten@vcu.edu), Center for the Study of Biological Complexity, Suite 111, PO Box 842030, 1000 West Cary Street, Richmond, VA 23284-2030. *Flight of the Relativistic Bumble Bee: Developing a System to Fly the Bee at Light Speeds.* Preliminary report.

In this talk we present the ongoing developments of a project to allow a user to interactively fly a bumble bee at a fixed velocity $v < c$ while the bee is playing "Flight of the Bumble Bee." This project is an outgrowth of work originally started while the presenter was a student at the University of Texas at Austin Electronic Music Program. Future goals will be discussed and impediments to the actual completion of the project will be presented. (Received September 14, 2010)

1065-92-263 **Mary Ann Horn*** (mhorn@nsf.gov), 4201 Wilson Blvd, Suite 1025, Arlington, VA 22230. *Modeling the Impact of Antibiotic Resistance in Gram-Negative Bacteria.* Preliminary report.

Drug resistance has been an emerging problem since the discovery of penicillin. Resistance is now seen not only in clinical settings, but also increasingly in the community. Bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA) impacts healthy adults as well as patients in settings such as hospitals and nursing homes. MRSA is an example of a Gram-positive bacteria. More recently, antibiotic resistance in Gram-negative bacteria such as *Escherichia coli* and *Salmonella aureus* is an increasing problem. A primary difference between Gram-positive and Gram-negative bacteria is the composition of the cell walls. Gram-negative bacteria can become resistant to antibiotics through a genetic mechanism, granting them immunity to a wide range of treatments.

This talk will give an overview of some of our recent work on modeling of the development and spread of antibiotic resistance. Mathematical modeling and simulation are used to gain insight into the numerous issues that arise, both in terms of the development of resistance and the spread of the bacteria.

(Joint work with Erika D'Agata, Joanna Pressley, Shigui Ruan, and Glenn Webb.) (Received September 14, 2010)

93 ► *Systems theory; control*

1065-93-46 **Yan Wu*** (yan@georgiasouthern.edu), Department of Mathematical Sciences, P.O. Box 8093, Statesboro, GA 30460. *Stability Analysis of Wavelet-Controlled Dynamical Systems.*

Compactly supported wavelets have certain properties that are useful for controller design. We explore the mechanism of a wavelet controller by integrating the wavelet controller with linear time-invariant systems (LTI). A necessary condition for an effective wavelet-based control is that the footprints of the wavelet network cover the state space where the state trajectories stay. Closed-form bounds on the design parameters of a wavelet controller are derived, which guarantee local asymptotic stability of wavelet-controlled LTI systems. Wavelet network is also effective in adaptive control of chaotic systems when there are uncertainties with the system. In this case, global stability of wavelet-control Lorenz system along with classical state feedback control is investigated. (Received August 17, 2010)

1065-93-228 **Elsa Schaefer*** (elsa.schaefer@marymount.edu), 2807 North Glebe Road, Arlington, VA 22207. *Model assumptions and corresponding implications for control of a cholera outbreak.*

In some ways, we have understood how cholera is spread for more than 150 years when John Snow's investigations of cholera outbreaks in London identified the contamination of the Broad Street water pump. However, according to a March 2010 position paper on cholera vaccines by the World Health Organization, there are likely 3 - 5 million annual cases of cholera worldwide that in turn lead to more than 100,000 annual deaths. It is known that cholera is endemic to our environment, leading to disease in humans in populations with poor sanitation Additionally, endemic and epidemic cholera outbreaks have differing dynamics, as do outbreaks caused by differing strains of bacteria. The WHO underscores the need for finding cost-effective combinations of known treatments (especially vaccination and public health measures) for cholera outbreaks in different settings. Using optimal control theory, I consider several choices of model assumptions for a cholera outbreak, and discuss the differing biological assumptions of those models and, in turn, the impact of model choice on public health policy recommendations. (Received September 14, 2010)

94 ► Information and communication, circuits

1065-94-20 **Keith E Mellinger*** (kmelling@umw.edu), 1301 College Avenue, Trinkle Hall, Fredericksburg, VA 22401, and **Tim L Alderson**. *Families of optimal OOCs with $\lambda = 2$.*

We provide a new construction yielding one new and one known infinite family of optimal $(n, w, 2)$-optical orthogonal codes, $w \in \{4, 6\}$. Our construction relies on various techniques in finite projective spaces involving hyperovals in projective planes and Singer groups. (Received July 21, 2010)

1065-94-98 **Vladimir D Tonchev*** (tonchev@mtu.edu), 1400 Townsend Drive, Houghton, MI 49931. *Quantum Codes from Combinatorial Designs and Finite Geometry.*

Constructions of quantum codes based on combinatorial structures such as generalized balanced weighing matrices, generalized Hadamard matrices, and caps in a finite projective geometry are discussed. (Received September 05, 2010)

97 ► Mathematics education

1065-97-22 **Andrew Bennett**, **Rachel Manspeaker**, **Peter Nguyen** and **Xuan Hien Nguyen*** (xhnguyen@math.ksu.edu), Department of Mathematics, Kansas State University, Manhattan, KS 66506. *Geometry beyond the Euclidean plane for teachers.*

We present three lessons to introduce middle school and high school teachers to concepts in geometry beyond the usual Euclidean plane setting. The lessons were part of a two-week summer program on Geometry and Art for in-service teachers. In the workshop, we focused on finding subjects that can stimulate teachers and students to find mathematics in everyday objects and art, while emphasizing differentiated instruction. (Received July 26, 2010)

1065-97-91 **Sarah Glaz*** (Sarah.Glaz@uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269. *Poetry in the mathematics classroom.*

This talk will discuss the uses of mathematical poetry in college mathematics classes.Its main focus will be the speaker's own experience in courses she taught or developed at the University of Connecticut. This includes a number of poetry projects in a College Algebra course, which were used to ease the transition between word-problems representing natural phenomena and the corresponding mathematical equations. It also includes several historical mathematical poems, authored by the speaker and others, that can be used in higher level mathematics courses to enhance learning, retention, and integration of material. It concludes with an overview of the efforts made by other educators in this direction. (Received September 03, 2010)

1065-97-257 **Jason Parsley***, Department of Mathematics, Winston-Salem, NC , and **Christina Tsoules Soriano**. *Understanding geometry in the dance studio.*

We, a dance professor and a math professor, brought together each of our introductory classes to study geometric objects (Platonic solids and ellipses) through human forms. Come see how they realized a dual octahedron lying inside a cube. We investigate how this physical learning environment molded our students' spatial reasoning and analyze the effects of this cross-disciplinary pedagogical exercise. (Received September 14, 2010)

2010 MATHEMATICS SUBJECT CLASSIFICATION

Compiled in the Editorial Offices of MATHEMATICAL REVIEWS and ZENTRALBLATT MATH

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra; matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory; homological algebra
19 *K*-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control; optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory; control
94 Information and communication, circuits
97 Mathematics education

0192-5857(2010)31:4;1-7

Periodicals postage paid at Providence, RI and additional mailing offices

Abstracts of Papers Presented to the AMS
ISSN 0192-5857
American Mathematical Society
201 Charles Street, Providence, RI 02904-2294 USA
GST No. R121892046