ABSTRACTS

of Papers Presented to the American Mathematical Society

Volume 31, Number 3, Issue 161 Summer 2010

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AMS

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* Indicates who will present the paper at the meeting.

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Abstracts of Papers Presented to the American Mathematical Society (ISSN 0192-5857) is published four times a year by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294. The subscription price for Volume 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.

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PAPERS PRESENTED AT MEETINGS

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1063	October 9–10, 2010	Los Angeles, CA	August 17	Vol 31, No. 4
1064	November 5–7, 2010	Notre Dame, IN	September 14	Vol 31, No. 4
1065	November 6–7, 2010	Richmond, VA	September 14	Vol 31, No. 4
1066	December 15–18, 2010	Pucon, Chile	N/A	N/A
1067	January 6–9, 2011	New Orleans, LA	September 22	Vol 32, No. 1
1068	March 12–13, 2011	Statesboro, GA	January 20	TBA
1069	March 18–20, 2011	Iowa City, IA	January 25	TBA
1070	April 9–10, 2011	Worcester, MA	TBA	TBA
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1072	September 10–11, 2011	Ithaca, NY	TBA	TBA
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1075	October 22–23, 2011	Salt Lake City, UT	August 30	TBA
1076	November 29–December 3, 2011	Port Elizabeth, South Africa	TBA	TBA

ALBUQUERQUE, NM, April 17–18, 2010

Abstracts of the 1059th Meeting.

00 ► General

1059-00-83 **Tao Jing*** (jing@math.utah.edu), Department of Mathematics, University of Utah, 155 S 1400 E Room 233, Salt Lake City, UT 84112, and **Rafi Kasra**. *Diameter of the thick part of moduli space.*

Let S be a surface of finite type. We study the shape of moduli space of S. In particular, in either the Teichmüller, Lipschitz, or bi-Lipschitz metric, the diameter of the thick part of moduli space grows like the logarithm of the Euler characteristic of S. A similiar result is true for moduli of graphs (the quotient of Outer space by $\mathrm{Out}(\mathrm{F_n})$). (Received February 17, 2010)

05 ► Combinatorics

1059-05-21 **Fu Liu*** (fuliu@math.ucdavis.edu), One Shields Avenue, Department of Mathematics, 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 January 25, 2010)

1059-05-27 **Sarah C Rundell*** (crowns@denison.edu), Dept. of Mathematics and Computer Science, Denison University, Granville, OH 43023, and **Jane H Long**. *The Hodge Structure of the Coloring Complex of a Hypergraph.*

Let G be a simple graph with n vertices. The coloring complex $\Delta(G)$ was defined by Steingrímsson, and the homology of $\Delta(G)$ was shown to be nonzero only in dimension $n-3$ by Jonsson. Hanlon recently showed that the Eulerian idempotents provide a decomposition of the homology group $H_{n-3}(\Delta(G))$ where the dimension of the j^{th} component in the decomposition, $H^{(j)}_{n-3}(\Delta(G))$, equals the absolute value of the coefficient of λ^j in the chromatic polynomial of G, $\chi_G(\lambda)$.

Let H be a hypergraph with n vertices. In this talk, we will define the coloring complex of a hypergraph, $\Delta(H)$, and show that the coefficient of λ^j in $\chi_H(\lambda)$ gives the Euler Characteristic of the j^{th} Hodge subcomplex of the Hodge decomposition of $\Delta(H)$. We also examine conditions on a hypergraph, H, for which its Hodge subcomplexes have the homology of a wedge of spheres, and thus where the absolute value of the coefficient of λ^j in $\chi_H(\lambda)$ equals the dimension of the j^{th} Hodge piece of the Hodge decomposition of $\Delta(H)$. (Received February 03, 2010)

1059-05-29 **Samuel Robert Kolins*** (skolins@math.cornell.edu), Department of Mathematics, 301 Malott Hall, Cornell University, Ithaca, NY 14853-4201. *f-Vectors of Triangulated Balls.*

In this talk we will look at the problem of determining the possible f-vectors of homology balls. This problem has previously been solved for balls of dimension four or less and Billera and Lee conjectured a characterization for higher dimensions. We will present a new method for showing that certain vectors can not be the f-vector of a homology ball. As a consequence of this result, we disprove the conjectured characterization of Billera and Lee. We will also mention a constructive result for balls with certain prescribed f-vectors and use this to discuss new possible characterizations of the f-vectors of five dimensional homology balls. (Received February 01, 2010)

1059-05-65 **Tricia Muldoon Brown***, Armstrong Atlantic State University, Department of Mathematics, 11935 Abercorn St, Savannah, GA 31419. *The Rees product and cubical complexes.* Preliminary report.

In this preliminary report, we discuss the action of the Rees product with a chain on the face lattice of the cubical complex consisting of two d–dimensional cubes joined at a $(d-k)$–dimensional face. The resulting complex is a wedge of m spheres of dimension d where m is given by a sum of the Möbius functions of the Rees products of the d and $(d-k)$–dimensional cubical lattices with the chain. These results can be generalized to certain complexes which are homotopic to a wedge of k-spheres and further to the Rees product of the face lattices of these complexes with a t-ary tree. (Received February 15, 2010)

1059-05-76 **Anna Gundert** and **Edward D Kim*** (ekim@math.ucdavis.edu), Department of Mathematics, One Shields Avenue, Davis, CA 95616, and **Daria Schymura**. *Lattice paths and Lagrangian matroids.* Preliminary report.

Lagrangian matroids are a class of Coxeter matroids, an extension of ordinary matroids. Many subclasses of Coxeter matroids, including Lagrangian matroids, can be defined directly in terms of ordinary matroids or exchange axioms. We investigate lattice path Lagrangian matroids, a family of Lagrangian matroids introduced by Joe Bonin and Anna de Mier, following a suggestion of Vic Reiner that there could be a Lagrangian counterpart to the Catalan matroid. One definition for Lagrangian matroids involves a construction of ordinary matroids. We prove that, for lattice path Lagrangian matroids, the matroids arising from this construction are indeed lattice path matroids. (Received February 16, 2010)

1059-05-86 **Mathias Drton**, **Caroline Klivans** and **Ed Swartz*** (ebs22@cornell.edu), Malott Hall, Cornell University, Ithaca, NY 14850. *Projections volumes of real hyperplane arrangements.*

We consider projections of points in R^n onto chambers of real linear hyperplane arrangements. We show that the coefficients of the characteristic polynomial are proportional to the average spherical volumes of the sets of points that are projected onto faces of a given dimension. As a corollary we obtain that for real finite reflection arrangements the coefficients of the characteristic polynomial precisely give the spherical volumes of points projected onto faces of a fixed dimension of the fundamental chamber. An intermediate result computes the angle sums of zonotopes.

This talk reflects joint work with Mathias Drton and Caroline Klivans. (Received February 17, 2010)

1059-05-102 **Matthew D. Zeckner*** (mzeckner@ms.uky.edu), 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **Benjamin J. Braun** (benjamin.braun@uky.edu), 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506. *Deformation Retracts of Neighborhood Complexes of Stable Kneser Graphs.* Preliminary report.

Anders Björner and Mark de Longueville proved in 2001 that the neighborhood complex of any stable Kneser graph is homotopy equivalent to a sphere. They further conjectured that every such neighborhood complex contains a polytopal sphere as a deformation retract and proved this in special cases. We prove their conjecture for other special cases. (Received February 19, 2010)

1059-05-103 **Benjamin J. Braun*** (benjamin.braun@uky.edu), 715 Patterson Office Tower, University of Kentucky, Lexington, KY 40506, and **Matthias Beck** (beck@math.sfsu.edu). *Nowhere-harmonic colorings of graphs.* Preliminary report.

Proper vertex colorings of a graph are related to its boundary map, also called its signed vertex-edge incidence matrix. The vertex Laplacian of a graph, a natural extension of the boundary map, leads us to introduce nowhere-harmonic colorings and analogues of the chromatic polynomial and Stanley's theorem relating negative evaluations of the chromatic polynomial to acyclic orientations. Further, we discuss some examples demonstrating that nowhere-harmonic colorings are more complicated from an enumerative perspective than proper colorings. This is joint work with Matthias Beck. (Received February 19, 2010)

1059-05-126 **Eran Nevo*** (en87@cornell.edu), **Kyle Petersen** and **Bridget Tenner**. *On γ-vectors.* Preliminary report.

I'll describe recent developments concerning the γ-vectors of flag simplicial spheres. Some of the results are joint work with Kyle Petersen and Bridget Tenner. (Received February 21, 2010)

1059-05-179 **Hasan Coskun*** (hasan_coskun@tamu-commerce.edu), 2600 S Neal St, Department of Mathematics, Commerce, TX 75429. *Multilateral basic hypergeometric summation identities and hyperoctahedral group symmetries.*

We give new proofs for certain bilateral basic hypergeometric summation formulas using the symmetries of the corresponding series. In particular, we present proofs for Ramanujan's ${}_1\psi_1$ sum and Bailey's ${}_3\psi_3$ summation formula as applications. We also construct multiple series analogues of these identities considering hyperoctahedral symmetries of higher ranks. (Received February 22, 2010)

1059-05-207 **John Shareshian*** (shareshi@math.wustl.edu) and **Michelle Wachs** (wachs@math.miami.edu). *Chromatic quasisymmetric functions.*

Given a graph G, we study a quasisymmetric function F_G with coefficients in the ring of polynomials in one variable t. Upon substituting 1 for t, F_G becomes Stanley's chromatic symmetric function. I will discuss various results about the functions F_G. (Received February 23, 2010)

1059-05-212 **I. V. Hicks** and **S. Margulies***, 6100 Main St. MS 134, Houston, TX 77098. *Vizing's Conjecture and Techniques from Computer Algebra.*

Given a graph G, a dominating set is a subset of vertices such that every vertex in the graph is in, or adjacent to a vertex, in the dominating set. The size of a minimum cardinality dominating set is denoted by $\gamma(G)$. Given two graphs, G and H, and the cartesian product graph $G\Box H$, V. Vizing conjectured in 1968 that $\gamma(G)\gamma(H) \leq \gamma(G\Box H)$. We represent the problem of finding a dominating set of size k in an arbitrary graph G as a system of polynomial equations, and show that Vizing's conjecture is equivalent to a conjecture about the equality of two particular ideals. We discuss techniques from computer algebra that can aid in the proof of Vizing's conjecture, or in the search for a counter-example. Additionally, we conjecture a very specific graph-theoretic interpretation of the unique, reduced Gröbner basis of these ideals. (Received February 23, 2010)

1059-05-233 **Andrew Berget*** (berget@math.ucdavis.edu), Mathematical Sciences Building, One Shields Avenue, University of California, Davis, CA 95616. *The rank partition of a matroid.*

The rank partition of a matroid M is a subtle isomorphism invariant that measures how close M is to being a union of bases. It was used by Dias da Silva to characterize the vanishing of symmetrized tensors and irreducible character immanants. In this talk, I will explain how it relates to matroid base polytope decompositions using representation theory. No familiarity with matroids will be assumed. (Received February 23, 2010)

1059-05-249 **Michelle L Wachs*** (wachs@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33124, and **John Shareshian**. *Topology of Rees products of posets and multiset derangements.* Preliminary report.

The notion of Rees products of posets was introduced by Björner and Welker in their study of connections between poset topology and commutative algebra. They conjectured and Jonsson proved that the Rees product of a truncated Boolean algebra and a chain has the homotopy type of a wedge of d_n spheres of dimension $n-1$, where d_n is the nth derangement number. In a previous paper we obtained a q-analog and type B analog of this result. In this paper we extend the result in yet another direction by replacing the Boolean algebra by any product of chains and the derangement numbers by mutliset derangement numbers. We also obtain various analogs of the chain product result. (Received February 24, 2010)

13 ► Commutative rings and algebras

1059-13-43 **D. Katz*** (dlk@math.ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045, and **J. Validashti**, Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Multiplicities and Rees valuations.*

Let $(R, \mathfrak{m})$ be a local ring and $I \subseteq R$ be an ideal with maximal analytic spread. We show that the j-multiplicity of I is determined by the Rees valuations of I that are $\mathfrak{m}$-valuations. We also discuss a multiplicity that is the limsup of a sequence of lengths that grow at an $O(n^d)$ rate. (Received February 09, 2010)

1059-13-69 **Yu Xie*** (yxie@nd.edu), South Bend, IN 46637. *Formulas for the multiplicity of graded algebras.*

We generalize a formula by Simis, Ulrich and Vasconcelos about homogeneous inclusions of standard graded Noetherian algebras over an Artinian local ring. The main application of this formula is to compute the multiplicity for special fiber rings of homogeneous ideals. In algebraic geometry, the special fiber ring of a homogenous ideal describes the homogeneous coordinate ring of the image of the rational map induced by this ideal. As a special case this construction yields homogeneous coordinate rings of Gauss images and of secant varieties. It is important to compute the multiplicity of the special fiber ring. Our formula can be used to find the multiplicity for any such special fiber rings. In particular, it gives the degree of dual varieties of any hypersurfaces and a generalization of Teissier's Plücker formula to hypersurfaces with non-isolated singularities. The first formula relating the degree of the dual variety to the degree of the variety itself was given by Plücker in 1834 for complex plane curves. Many generalizations for this formula were made after that. All the existing results require the variety has non-deficient dual (i.e., the dual variety is a hypersurface). In our formula, we do not need to assume the dual variety is a hypersurface. (Received February 15, 2010)

1059-13-74 **Laura R Lynch*** (s-llynch1@math.unl.edu) and **Tom Marley**. *Annihilators of Local Cohomology.* Preliminary report.

In many important theorems in the homological theory of commutative local rings, an essential ingredient in the proof is to consider the annihilators of local cohomology modules of the ring with respect to an ideal (not necessarily the maximal ideal). One interesting result, proved by Hochster and Lyubeznik in independent cases, says that in the case of a regular local ring containing a field, a local cohomology module (of the ring) is nonzero if and only its annihilator is zero. We will examine the annihilators of local cohomology modules in other situations and, in particular, that of the top local cohomology module of an arbitrary local ring with support in a given ideal. (Received February 16, 2010)

1059-13-97 **Angela L Kohlhaas*** (akohlhaa@nd.edu), 1176 Center Pl, Dubuque, IA 52001. *The core versus the adjoint of a monomial ideal.* Preliminary report.

Given an ideal I in a Noetherian ring R, the core of I is the intersection of all ideals contained in I with the same integral closure as I. The core naturally arises in the context of the Briançon-Skoda theorem as an ideal which contains the adjoint of a certain power of I. As the arbitrary-characteristic analog of the multiplier ideal, the adjoint is an important tool in the study of resolutions of singularities, and the question of when the core and the adjoint of a power of I are equal has been tied to a celebrated conjecture of Kawamata about the non-vanishing of sections of line bundles. By illustrating symmetry properties of the core of a monomial ideal in a polynomial ring, I will show that for certain classes of monomial ideals, this equality holds if and only if the core is integrally closed. (Received February 18, 2010)

1059-13-108 **Giulio Caviglia**, 150 N University St, West Lafayette, IN 47907-2067, and **Manoj Kummini***, 150 N University St, West Lafayette, IN 47907-2067. *Poset Embeddings of Hilbert Functions.* Preliminary report.

Let R be a standard graded algebra over a field. We look at embeddings of the poset of Hilbert functions of ideals of R into the poset of ideals of R, as a way of classifying the possible Hilbert functions for ideals of R. (Received February 19, 2010)

1059-13-113 **Florian Enescu*** (fenescu@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, and **Yongwei Yao** (yyao@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *The lower semicontinuity of the Frobenius splitting numbers.*

We show that, under mild conditions, the normalized Frobenius splitting numbers of a ring of positive characteristic are lower semicontinuous. (Received February 20, 2010)

1059-13-117 **Ananthnarayan Hariharan*** (ahariharan2@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, and **Craig Huneke** (huneke@math.ku.edu), Department of Mathematics, University of Kansas. *Three-standardness of the maximal ideal.*

We first define and study some consequences of the notion of n-standardness of a filtration associated to an ideal primary to the maximal ideal in a Cohen-Macaulay local ring. Using techniques borrowed from the world of prime characteristic, we then give some conditions under which the maximal ideal is three-standard. (Received February 22, 2010)

1059-13-127 **Bruce Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, Las Cruces, NM 88003-8001. *Embedding dimension, multiplicity and Cohen-Macaulayness of subintegral extensions of local Noetherian domains.* Preliminary report.

We discuss a class of local Noetherian domains S which admit subintegral extensions that although in one sense very remote from S (they are analytically ramified), have a number of features, such as multiplicity and embedding dimension, that can be determined in a tractable way from S. Whether the subintegral extensions are Cohen-Macaulay or Gorenstein can also be determined, as can ideal-specific properties involving Hilbert functions, reduction number and analytic spread. (Received February 21, 2010)

1059-13-136 **Christopher A Francisco** and **Jeff Mermin*** (mermin@math.okstate.edu), Oklahoma State University, Department of Mathematics, Stillwater, OK 74078, and **Jay Schweig**. *Algorithms for Borel ideals.*

We present algorithms for computing some invariants of a Borel ideal using only a list of its Borel generators. (Received February 22, 2010)

1059-13-148 **L. Ghezzi**, **S. Goto** and **J. Hong*** (hongj2@southernct.edu), Department of Mathematics, Southern Connecticut State University, 501 Crescent Street, New Haven, CT 06515, and **K. Ozeki**, **T. Phuong** and **W. Vasconcelos**. *The signature of the Chern coefficients of local rings.*

The Hilbert coefficients carry a great deal of information about the ideal. In particular, for parameter ideals Q the first Hilbert coefficient $e_1(Q)$ codes structural information about the ring R itself. Noteworthy properties of R associated to values of $e_1(Q)$ are the Cohen–Macaulay, the generalized Cohen–Macaulay and the Buchsbaum conditions. More recently, similar questions have been examined in general Noetherian local rings. In the joint works with Ghezzi, Goto, Ozeki, Phuong, and Vasconcelos, we extend several of the results on the meaning of the sign of $e_1(I)$. Our main results are centered around the following conjecture given by Vasconcelos at the conference in Yokohama in March 2008:

Conjecture (Vasconcelos) Assume that R is unmixed. Then R is a Cohen–Macaulay local ring if and only if $e_1(Q) = 0$ for some parameter ideal Q of R.

We settle this Conjecture affirmatively. Also we study the problem of when $e_1(Q)$ is independent of the choice of the parameter ideal Q in R. Another important issue is that of the variability of $e_1(Q)$, sometimes for Q in a same integral closure class, and its role in the structure of the ring. (Received February 22, 2010)

1059-13-151 **Louiza Fouli** and **Susan E. Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, 601 University Dr., San Marcos, TX 78666. *Depths and Reductions of Edge Ideals of Graphs.* Preliminary report.

There is a natural one-to-one correspondence between square-free monomial ideals generated in degree two and graphs. In this talk, properties of a graph will be used to give algebraic information about the corresponding

edge ideal. Of particular interest will be the depths and reductions of the edge ideals. It will be shown that the depths of low powers of the edge ideal are bounded below by a function of the diameter of the graph, generalizing a previous result for edge ideals of trees. For graphs with at most one cycle, minimal reductions of the edge ideal will be examined. Using the ideal of equations of the fiber cone, it will be shown that the generating sets of minimal reductions of these ideals have a particularly nice form, and this form will be used to shed light on the core of the ideal. (Received February 22, 2010)

1059-13-155 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu), Department of Mathematics and Statistics, Broadway and Boston, M.S. 1042, Lubbock, TX 79409, and **Henrik Holm**. *Vanishing of cohomology over Cohen–Macaulay algebras.* Preliminary report.

Late in his career, Auslander conjectured that every finitely generated module M over a reasonable algebra—such as a commutative artinian local one—would have a latent projective dimension. That is, a number $a(M)$ such that if the cohomology of M with coefficients in a finitely generated module N—i.e. $\operatorname{Ext}^*(M,N)$—vanishes in high degrees, then it vanishes from degree $a(M)$.

The conjecture was disproved seven years ago. It is, however, known that modules over "many" rings do have such a latent projective dimension, but one does not yet understand how this property of a ring relates to classically studied ones. Towards this end, we study the behavior of the property under standard constructions with ring, and in the talk I will discuss recent results about transfer of the property along homomorphisms of local rings. (Received February 22, 2010)

1059-13-156 **Adela Vraciu*** (vraciu@math.sc.edu). *Joint Hilbert-Kunz multiplicities.*

We define joint Hilbert-Kunz multiplicities for pairs of m-primary ideals in a local Noetherian ring of positive characteristic, and we study some of their properties. (Received February 22, 2010)

1059-13-176 **Lori A McDonnell*** (s-lmcdonn1@math.unl.edu). *Remarks on a Conjecture of Watanabe and Yoshida.*

We consider a conjecture of Watanabe and Yoshida concerning the Hilbert - Kunz multiplicity of an ideal in a Cohen-Macaulay ring and discuss a proof of the conjecture in the case the ring is graded. (Received February 23, 2010)

1059-13-185 **T. Clark** and **A. Tchernev*** (tchernev@math.albany.edu). *CW-posets and resolutions of monomial ideals.* Preliminary report.

We show that a monomial ideal has a minimal resolution supported on a given regular CW-complex precisely when its minimal resolution can be obtained by applying the so-called poset resolution construction to the underlying poset of cells of the CW-complex. Since posets of cells of regular CW-complexes are characterized completely in terms of their internal poset structure, this provides a general combinatorial framework for detecting regular CW-complex support. One application of these results is that stable monomial ideals are supported on a regular CW-complex (a result obtained by different means by Mermin). (Received February 23, 2010)

1059-13-191 **Ian M. Aberbach*** (aberbachi@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, and **Aline Hosry**. *Coefficient and cancellation theorems of Briançon-Skoda type.* Preliminary report.

Let (R,m) be a Noetherian local ring, $I \subseteq R$ an ideal, and $J \subseteq I$ a reduction of I. Let $\ell = \ell(I)$ be the analytic spread of I. When R is sufficiently nice (e.g., regular or F-rational), then the Briançon-Skoda Theorem says that $I^\ell \subseteq J$. Previous work by various authors has shown that under certain hypotheses, one can often get more information on the coefficients of the elements in J, or lower the exponent on I in order to be contained in J. We will examine these results and show that some of the earlier hypotheses can be made less restrictive. (Received February 23, 2010)

1059-13-205 **Lars Winter Christensen**, **David A. Jorgensen**, **Hamid Rahmati**, **Janet Striuli** and **Roger A. Wiegand*** (rwiegand@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *The second Brauer-Thrall conjecture for totally reflexive modules.* Preliminary report.

Abstract: Let $(R,\mathfrak{m},k)$ be a local ring which is not Gorenstein, and assume that R possesses a non-free totally reflexive module. (By definition, this is a finitely generated reflexive R-module such that $\operatorname{Ext}^{\mathrm{i}}_{\mathrm{R}}(\mathrm{M}\oplus\mathrm{M}^*,\mathrm{R})=0$ for every $i>0$.) It is known that then R has an infinite family of pairwise non-isomorphic indecomposable totally reflexive modules. Now assume that k is infinite. The Second Brauer-Thrall Conjecture, in this context, predicts that there are infinitely many integers n for which there are $|k|$ pairwise non-isomorphic indecomposable

totally reflexive R-modules requiring n generators. We verify this conjecture in several situations. (Received February 23, 2010)

1059-13-211 **David A. Jorgensen*** (djorgens@uta.edu), Department of Mathematics, University of Texas at Arlington, Arlington, TX 76012. *On the existence of exact pairs of zero-divisors.* Preliminary report.

Let $(R, \mathfrak{m}, k)$ be a local ring. A *totally reflexive R-module* is a finitely generated R-module whose natural biduality map $M \to M^{**}$ is bijective, and which satisfies $\operatorname{Ext}^i_R(M \oplus M^*, R) = 0$ for all $i > 0$. Recent work on constructing infinitely families of pair-wise non-isomorphic indecomposable totally reflexive modules by Holm, and Christensen et al. have as a common foundation the existence of *exact pairs of zero-divisors*, these being pairs $a, b \in R$ such that $(a) = (0 : b)$ and $(b) = (0 : a)$. In this talk we will discuss the fact that the existence of exact pairs of zero-divisors in R is a non-empty open condition for quadratic algebras satisfying $\mathfrak{m}^3 = 0$. This fact also gives a partial converse to a theorem of Christensen and Veliche. (Received February 23, 2010)

1059-13-213 **David Cox**, **Andrew Kustin*** (kustin@math.sc.edu), **Claudia Polini** and **Bernd Ulrich**. *Singularities of parameterized plane curves.*

We focus on singularities of multiplicity $d/2$ on curves of degree d. There can be at most three such singularities counting both points on the curve and infinitely near points. We describe the Hilbert-Burch matrix for each of the six possible configurations. (Received February 23, 2010)

1059-13-214 **Lars W. Christensen**, **David A. Jorgensen** and **Hamid Rahmati*** (hamid.rahmati@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409, and **Janet Striuli** and **Roger Wiegand**. *Constructing totally reflexive modules.* Preliminary report.

Let R be a commutative local noetherian ring. A finitely generated R-module M is called totally reflexive if it is reflexive and $\operatorname{Ext}^{\mathrm{i}}_{\mathrm{R}}(\mathrm{M}, \mathrm{R}) = \operatorname{Ext}^{\mathrm{i}}_{\mathrm{R}}(\mathrm{M}^*, \mathrm{R}) = 0$ for all $i > 0$. It is known that if a non-Gorenstein ring R admits a non-free totally reflexive module then there exist infinitely many, pairwise non-isomorphic, indecomposable totally reflexive R-modules. We show, in certain cases, how to construct an infinite family of indecomposable totally reflexive modules given that a cyclic one exists. (Received February 23, 2010)

1059-13-216 **Livia Hummel** (hummell@uindy.edu), Department of Mathematics, University of Indianopolis, Indianopolis, IN 46227, and **Tom Marley*** (tmarley1@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Coherent Gorenstein Rings.*

We present a generalization of the concept of Gorenstein dimension for a certain class of finitely generated modules over a commutative (but not necessarily Noetherian) ring. We are able to reprove, using this generalized concept, the Auslander-Bridger formula for modules of finite Gorenstein dimension. This also allows us to define a notion of Gorenstein for coherent rings which extends the usual notion from the Noetherian case. We then are able to show that Coherent regular rings are Gorenstein and coherent Gorenstein rings are Cohen-Macaulay (as defined by Hamilton and the presenter). (Received February 23, 2010)

1059-13-218 **Dan Bates**, **David Eklund** and **Chris Peterson*** (peterson@math.colostate.edu). *Intersection numbers through residual intersections.*

Many invariants of an algebraic variety can be expressed as a function of intersection numbers of Chern classes on the variety. Linear constraints on these intersection numbers can be accessed through various residual intersections combined with either a symbolic or a numeric computation. With enough linear constraints, each of the intersection numbers can be determined. This talk will illustrate, through concrete examples, the relative ease with which these intersection numbers can be computed and the implications of knowing these numbers. (Received February 23, 2010)

1059-13-227 **Jared L Painter*** (jlpainter@uta.edu), Department of Mathematics, University of Texas at Arlington, Arlington, TX 76019. *Comparing the Sizes of the Lower Bass Numbers of a Cohen Macaulay Local Ring.* Preliminary report.

Let (R, m, k) be a local ring. The ith Bass number of R is the number of copies of the injective envelope of k in the ith injective module of a minimal injective resolution of R. In this talk we investigate the question of whether the first Bass number of a zero dimensional ring is always larger than the zeroth. In particular we look at zero dimensional rings defined by monomial ideals and show that the answer to the question is true for a large class of such rings. (Received February 23, 2010)

1059-13-235 **Kristen A Beck*** (kbeck@uta.edu), Box 19408, Arlington, TX 76013. *On the Hilbert series of a local ring with $\mathfrak{m}^4 = 0$ which admits non-trivial totally reflexive modules.* Preliminary report.

A finitely generated module M over a ring R is called *totally reflexive* if and only if the following conditions hold:

1. $\mathrm{Ext}^i_R(M, R) = 0$ for all $i > 0$
2. $\mathrm{Ext}^i_R(M^*, R) = 0$ for all $i > 0$
3. $M \cong M^{**}$ via the canonical biduality map

Such modules are a natural generalization of projective modules, and they form the building blocks of Gorenstein dimension. Furthermore, their non-trivial existence is essential to the computation of Tate (co)homology.

In this talk we will characterize the Hilbert series of a local ring $(R, \mathfrak{m})$, with $\mathfrak{m}^4 = 0$, which admits a totally reflexive module with linear complete resolution. We will consider several examples of such rings, and will finish with some open questions. (Received February 23, 2010)

14 ► Algebraic geometry

1059-14-44 **David R Finston*** (dfinston@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003. *A class of factorial threefolds.* Preliminary report.

The complex factorial affine threefolds $X_{m,n}$, $m, n > 0$, with defining equations $x^n v - y^m u = 1$ have several interesting properties. They carry the structure of total spaces of principal bundles for the additive group over the punctured affine plane $Y = \mathbb{C}^2 - \{0\}$, and the assignment $X_{m,n} \to [\frac{1}{x^m y^n}] \in \check{H}^1(Y, O_Y)$ identifies these varieties with a natural basis for this Čech cohomology group. Every factorial threefold with a locally trivial G_a action looks locally like an $X_{m,n}$, and $X_{m,n} \times \mathbb{C} \cong X_{m',n'} \times \mathbb{C}$ for every pair $(m, n), (m', n')$. It turns out that $X_{m,n} \cong X_{m',n'}$ provided $m + n = m' + n'$, but it is unknown whether this condition is necessary. On the other hand, $X_{m,n} \cong X_{1,1}$ iff $(m, n) = (1, 1)$, so that the $X_{m,n}$ yield counterexamples to the affine cancellation problem. (Received February 09, 2010)

1059-14-58 **Noureen A. Khan*** (noureen.khan@unt.edu), 7300 Houston School Rd., Dallas, TX 56241, and **Mieczyslaw K. Dabkowski**, **Ramanjit K. Sahi** and **Slavik V. Jablan**. *"On 4-move equivalence classes of knots and links of two components".*

Study of equivalence classes of links modulo rational moves is important for development of the theory of invariants based on skein module deformations of rational moves. In particular, knowing equivalence classes of links modulo a chosen rational move provides a valuable insight into the structure of the generating set of the corresponding skein module. While studying a particular instance of tangle replacement moves, it is important to answer whether the move has unknotting property. A tangle replacement move has unknotting property if using the move and isotopies one is able to change every link into the trivial link. In the past it had been shown that the 3-moves and the rational (p/q)-moves (p-prime, p≥5 and q an arbitrary integer) are not unknotting operations. In this paper, we focus on 4-moves and we study its equivalence classes for knots and links of 2 components. In particular, we show that all links of 2 components up to 11 crossings, and alternating links of 2 components up to 11 crossings can be reduced by 4-moves to the trivial link, or to the Hopf link. (Received February 12, 2010)

15 ► Linear and multilinear algebra; matrix theory

1059-15-49 **Petros Drineas*** (drinep@cs.rpi.edu), Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180. *Randomized matrix algorithms and their applications.*

Over the past decade the idea of randomly sampling a small subset of columns, rows, or elements from large matrices and then applying traditional linear algebraic techniques, such as the Singular Value Decomposition or the QR decomposition, has found applications in many fundamental problems of numerical linear algebra, including the low-rank matrix approximation problem and regression problems. In this talk we will present an overview of this area as well as some recent developments on the Column Subset Selection Problem (CSSP) and its applications. (Received February 10, 2010)

18 ► Category theory; homological algebra

1059-18-7 **Guy Roger Biyogmam*** (biyogmam@nmsu.edu), Mathematical Sciences Department 3MB, Box 30001, New Mexico State University, Las Cruces, NM 88003. *On the Leibniz (Co)Homology of an Abelian Extension of the Orthogonal Lie Algebras.* Preliminary report.

The Lie algebra of the affine orthogonal Lie group is an abelian extension of the orthogonal Lie algebra. We compute its Leibniz (co)homology. It is computed via the identification of certain new orthogonal invariants and shown to be an algebra generated by an $n-1$-fold tensor and an n-fold tensor. (Received November 04, 2009)

20 ► Group theory and generalizations

1059-20-13 **Isaac M Goldbring*** (isaac@math.ucla.edu), Department of Mathematics, University of California, Los Angeles, 520 Portola Plaza Box 951555, Los Angeles, CA 90095-1555. *Ends of Finitely Generated Groups from a Nonstandard Perspective.* Preliminary report.

An important geometric invariant of a finitely generated group is its space of ends. The space of ends of an arbitrary topological space may be intuitively described as the set of "path components at infinity." For proper geodesic spaces, I show how to use the language of nonstandard analysis to make the aforementioned heuristic precise. When this description is applied to the case of a Cayley graph of a finitely generated group, one may find it easier to perform calculations and prove theorems, as will be illustrated through a few examples. I will end the talk with some ideas for future applications. (Received December 13, 2009)

1059-20-42 **Martin R. Bridson** and **Daniel P. Groves*** (groves@math.uic.edu), Dept. MSCS, UIC, 322 SEO (M/C 249), 851 S. Morgan St., Chicago, IL 60607, and **Jonathan A. Hillman** and **Gaven J. Martin**. *Cofinitely Hopfian groups, open mappings and knot complements.*

A group G is cofinitely Hopfian if every homomorphism from G to itself with finite-index image is an automorphism. I will discuss some groups which do and do not have this property, and give applications to theory of open mappings between manifolds. (Received February 09, 2010)

1059-20-51 **Timothy R Riley*** (tim.riley@math.cornell.edu), Department of Mathematics, 310 Malott Hall, Cornell University, Ithaca, NY 14850, and **Martin Kassabov**. *On the Dehn functions of Baumslag's metabelian groups.*

In 1972, Baumslag gave an example of a finitely presented metabelian group whose derived subgroup is free abelian of infinite rank. His group contains the wreath product of the integers with themselves. A small variation on his construction changes this subgroup to the lamplighter group. I will explore sharp differences in the geometry of these groups reflected in their Dehn functions. (Received February 10, 2010)

1059-20-67 **Danny Calegari** (dannyc@caltech.edu) and **Dongping Zhuang*** (dongping.zhuang@vanderbilt.edu).
Large Scale Geometry of Commutator Subgroups.

Let G be a group and G' its commutator subgroup. We study large scale geometry of the Cayley graph $C_S(G')$ of the commutator subgroup G' with respect to the canonical generating set S of all commutators. We prove that there exists quasi-isometrically embedded $\mathbb{Z}^n$ in $C_S(G')$, for any $n \in \mathbb{Z}_+$, thus this graph is not δ-hyperbolic, has infinitely asymptotic dimension and has only one end. For a general finitely presented group, we show that this graph is large scale simply connected. (Received February 15, 2010)

1059-20-94 **John M Mackay***, 1409 W. Green Street, Urbana, IL 61801. *Small cancellation, curvature and generic one relator groups.* Preliminary report.

We discuss some connections between small cancellation conditions, coarse upper curvature bounds of Bonk and Foertsch, and conformal dimension for generic one relator groups. (Received February 18, 2010)

1059-20-104 **Sang-hyun Kim*** (i@kim.sh), Department of Mathematics, 1 University Station C1200, Austin, TX 78759. *Surface Subgroups of Graph Products of Groups.*

A simple, but still charming collection of word-hyperbolic groups can be obtained by taking the double of a free group amalgamated along a root-free word. Wilton and I defined polygonal words in a free group, and proved that the double amalgamated along a polygonal word contains a surface group. The Tiling Conjecture asserts that any non-primitive word maps to a polygonal word by an automorphism of the free group. In this talk, I will prove that non-primitive geometric words are polygonal. As a by-product, we obtain a purely graph theoretic

formulation of the Tiling Conjecture, and in particular, the decidability of polygonality. (Received February 19, 2010)

1059-20-109 **Aaron Abrams**, **Noel Brady**, **Pallavi Dani**, **Moon Duchin*** (mduchin@umich.edu) and **Robert Young**. *Higher divergence in right-angled Artin groups.* Preliminary report.

In the study of Hadamard manifolds, Brady and Farb introduced "higher divergence functions" in every dimension which measure rates of filling spheres by balls "at infinity" (i.e., far from a basepoint). It turns out that these filling rates can detect some geometric properties of the space. In joint work with Abrams, Brady, Dani, and Young, we define higher divergence functions for groups, and we study these functions in right-angled Artin groups. (This discussion continues the talk by Pallavi Dani.) (Received February 19, 2010)

1059-20-119 **Khalid Bou-Rabee*** (khalid.math@gmail.com), 5927 Almeda Rd., Apt 22217, Houston, TX 77004. *Number theory on groups.*

This talk will bring ideas from number theory, e.g., the Prime Number Theorem, Bertrand's Postulate, and Cebotarëv's Density Theorem, to study properties of infinite groups. In particular, we will introduce the notion of quantifying the extent to which a finitely generated group is residually finite. This asymptotic study connects word and subgroup growth via a function called the normal divisibility function that measures the size of the smallest finite quotient that a fixed group element maps to nontrivially. In this talk we will investigate such behavior for examples that include free groups and $SL(n, \mathcal{O}_K)$, where K is a number field. Along the way, we will answer a question of Oleg Bogopolski from the Kourovka notebook, concerning finite index subgroups of the free group. This talk uses ideas and methods from combinatorial group theory, number theory, the theory of profinite groups, and topology. Part of this talk covers joint work with B. McReynolds. (Received February 21, 2010)

1059-20-124 **Kevin Wortman*** (wortman@gmath.utah.edu). *Exponential higher dimensional isoperimetric inequalities for some arithmetic groups.*

I'll talk about why most arithmetic subgroups of semisimple groups satisfy an exponential isoperimetric inequality in some dimension. (Received February 21, 2010)

1059-20-132 **A. Abrams**, **N. Brady** and **P. Dani***, Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918, and **M. Duchin** and **R. Young**. *Filling loops far from a basepoint.*

Div_0 is a quasi-isometry invariant for groups which measures the spread of geodesics. The study of Dehn functions looks for optimal isoperimetric inequalities for filling loops with discs. We will define a new quasi-isometry invariant Div_1 that unites these two concepts. This is joint work with A. Abrams, N. Brady, M. Duchin and R. Young. (This discussion will be continued in the talk by Moon Duchin.) (Received February 22, 2010)

1059-20-145 **Claire W Wladis*** (cwladis@gmail.com) and **Jose Burillo**. *Finite presentability for subgroups of the Thompson-Stein groups.* Preliminary report.

In a set of unpublished notes, Bieri and Strebel gave criteria for finite presentability for a large class of groups of piecewise-linear homeomorphisms of the real line which are subgroups of the Thompson-Stein groups $F(n_1, ..., n_k)$. However, some groups failed to meet any of these criteria, and therefore it is not known whether or not they are finitely presentable; one example of such a group is $F(2/3)$. The group $F(2/3)$ is the subgroup of the Thompson-Stein group $F(2, 3)$ consisting only of elements for which all slopes are of the form $\left(\frac{2}{3}\right)^n$ for some $n \in \mathbb{Z}$.

We have developed a non-trivial generating set for $F(2/3)$ which contains all elements whose tree-pair diagrams have trees which consist solely of a long string of tertiary carets terminating in one of three basic subtree type pairs (each of depth 2). It seems intuitively likely that such a generating set cannot be finitely generated, but since certain subtree equivalences in the Thompson-Stein groups $F(n_1, ..., n_k)$ produce complex behavior and non-obvious equivalent tree-pair diagrams, writing a formal proof of this will require further exploration of how this generating set behaves; this is currently work in progress. (Received February 22, 2010)

1059-20-175 **Henry Wilton*** (wilton@caltech.edu), Mathematics 253-37, Caltech, Pasadena, CA 91125, and **Martin R Bridson**. *The difficulty of presenting groups.*

We construct examples of finitely presentable subgroups for which no finite presentation is computable. In particular, we show that there is no algorithm to compute presentations for finitely presentable matrix groups. (Received February 22, 2010)

1059-20-177 **Andrew Putman*** (andyp@math.mit.edu) and **Matthew Day** (mattday@caltech.edu). *A Birman exact sequence for $Aut(F_n)$.*

The Birman exact sequence relates the mapping class group of a surface with boundary to the mapping class group of a closed surface. We will discuss an analogue of this for certain subgroups of the automorphism group of a free group. (Received February 22, 2010)

1059-20-180 **Larsen Louder*** (llouder@umich.edu) and **Ben McReynolds**. *Graphs of subgroups of free groups.*

We construct an efficient model for graphs of finitely generated subgroups of free groups and use it to answer a question of Culler and Shalen on ranks of intersections in free groups. The construction generalizes to certain graphs of limit groups, with consequences for dimension of varieties over free groups. The former has also been done independently by R P Kent IV. (Received February 22, 2010)

1059-20-181 **Tullia Dymarz*** (tullia.dymarz@yale.edu). *Bilipschitz equivalence is not equivalent to quasi-isometric equivalence for finitely generated groups.*

We show that certain lamplighter groups that are quasi-isometric (even commensurable) are not bilipschitz equivalent. The proof involves structure of quasi-isometries from rigidity theorems, analysis of bilipschitz maps of the n-adics and uniformly finite homology. (Received February 22, 2010)

1059-20-188 **Noel P Brady*** (nbrady@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019, and **Dan Guralnik** and **Sang Rae Lee**. *Dehn functions and finiteness properties of subgroups of CAT(0) groups.*

We describe a generalization of right angled Artin groups which use a doubling trick due to Bieri. These provide examples of CAT(0) groups which contain finitely presented subgroups which are not of type FP_3. The Dehn functions of these subgroups are polynomial of degree $n \geq 4$ or exponential. (Received February 23, 2010)

1059-20-192 **Paul E. Schupp*** (schupp@math.uiuc.edu), 310 Eliot Drive, Urbana, IL 61801. *Reflections on Rigidity and Random Groups.*

The following two remarkable statements are theorems about random one-relator quotients of free groups and random m-relator quotients of the modular group for an arbitrary positive integer m. (Work of Kapovich, Schupp and Shpilrain,) The statements are also no doubt true for m-relator quotients of the free group but there is a technical difficulty. The first statement is that random groups have a very strong Mostow-type rigidity: Two random groups are isomorphic if and only if there is a labelled graph isomorphism betwen their Cayley graphs (with respect to the given random presentations). The basic idea of Kolmogorov complexity is that a long random word is its own shortest description. Surprisingly, one can prove that a random group presentation is indeed incompressible: The random presentation is, up to only linear compression, as small as possible over all finite presentations of the given group. We will also speculate on whether or not random groups should have certain other properties. (Received February 23, 2010)

30 ► Functions of a complex variable

1059-30-4 **Steffen Rohde*** (rohde@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195. *Random Conformal Maps.*

I will discuss three somewhat different types of problems that involve random conformal maps, surveying some of the highlights of this theory and discussing open questions. The main part of my talk will be devoted to the most prominent family of random conformal maps, Oded Schramm's Loewner Evolution SLE, which has been instrumental in the solution of several problems originating in mathematical physics. (Received February 23, 2010)

1059-30-40 **Olena Ostapyuk*** (ostapyuk@math.ksu.edu), 138 Cardwell Hall, Manhattan, KS 66506. *Backward iteration in the unit ball.* Preliminary report.

We will consider analytic self-maps f of the unit ball in $\mathbb{C}^N$. Many facts were established about such maps in the 1-dimensional case (i.e. for self-maps of the unit disk), and we will generalize some of them in higher dimension. In particular, in the case when f is hyperbolic, it will be shown that backward-iteration sequences with bounded hyperbolic step will converge to a point on the boundary. These points will be called boundary repelling fixed points and will possess several nice properties. We will construct a (semi) conjugation of f to an automorphism via an analytic intertwining map. Then the result will be improved (a better intertwining map found) under some additional assumption on f near the boundary repelling fixed point. (Received February 08, 2010)

1059-30-77 **John B. Garnett*** (jbg@math.ucla.edu), Dept. of Mathematics, UCLA, 405 Hilgard Aveune, Los Angeles, CA 90095, **Rowan Killip** (killip@math.ucla.edu), Department of Mathematics, UCLA, 405 Hilgard Ave., Los Angeles, CA 90095, and **Rannan Schul** (schul@math.sunysb.edy), Department of Mathematics, Stony Brook University, Srtony Brook,, NY 11794. *A doubling measure in the plane can give mass to a rectifiable curve.*

We present an example of a doubling measure on the plane, i.e. a positive Borel measure μ such that $\mu(A) \leq C\mu(B)$ when A and B are adjacent squares of the same diameter and C is an absolute constant, and a rectifiable curve Γ such that $\mu(\Gamma) > 0$. (Received February 16, 2010)

1059-30-81 **G. Brock Williams*** (brock.williams@ttu.edu), Dept of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409. *Circle Packing Coordinates for Riemann Surfaces.*

Since William Thurston's work in the 1980's, circle packings have been intensely studied for their connection to conformal maps. We will use the combinatorial structure of generalized Brooks packings to describe coordinates for the moduli space (the space of conformal equivalence classes) of Euclidean tori. (Received February 17, 2010)

1059-30-130 **Zair Ibragimov*** (zibragimov@fullerton.edu), 154 McCarthy Hall 154, 800 N. State College Blvd., Fullerton, CA 92831. *A hyperbolic characterization of ultrametric spaces.*

It is known that the boundary at infinity of metric trees as well as more general Gromov 0-hyperbolic spaces are complete bounded ultrametric spaces when equipped with a visual metric. In this talk we will discuss the converse of this statement. Namely, we show that every complete perfect ultrametric space arises as the boundary at infinity of both a Gromov 0-hyperbolic space as well as a metric tree. (Received February 21, 2010)

1059-30-135 **Alexei Poltoratski*** (alexeip@math.tamu.edu). *Spectral gaps for sets and measures.*

For a closed set S on the real line denote by G_S the supremum of the size of the gap in the support of the Fourier transform of a measure, taken over all finite Borel measures supported on S. The gap problem, which stems from the well-known theorem by Beurling, asks for a formula for S in terms of geometric characteristics of S. In my talk I will discuss relations of the gap problem with adjacent fields and present a solution. (Received February 22, 2010)

1059-30-152 **Sergiy Merenkov*** (merenkov@illinois.edu), 1409 W Green St, Urbana, IL 61801, and **Kevin Wildrick** (kewildri@jyu.fi), Department of Mathematics, University of Jyvaskyla, 40014 Jyvaskyla, Finland. *Quasisymmetric Koebe uniformization.*

I will discuss the quasisymmetric uniformization problem of Ahlfors regular surfaces by circle domains. (Received February 22, 2010)

1059-30-167 **Alexander Yu. Solynin*** (alex.solynin@ttu.edu), Department of Mathematics and Statistics, Broadway and Boston, Lubbock, TX 79416. *Quadratic differentials and weighted graphs.*

We will show that every weighted graph (not necessarily connected) embedded in a compact surface can be realized as a critical subgraph of some quadratic differential. This generalizes a previous work of the author where such realization was established for connected graphs. (Received February 22, 2010)

1059-30-171 **Michael T. Lacey** (Lacey@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, **Istvan Prause** (Istvan.Prause@helsinki.fi), Dept. of Mathematics & Statistics, University of Helsinki, P.O. Box 68, 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, Bellaterra, 08193 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, 2009?) 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.

Time permitting, I will mention recent results related to another conjecture of Astala on Hausdorff dimension of quasicircles obtained jointly by Prause, Tolsa and UT. (Received February 22, 2010)

1059-30-202 **Wayne Stewart Smith*** (wayne@math.hawaii.edu), Department of Mathematics, 2565 The Mall, Honolulu, HI 96822, and **Alexander Volberg**. *A conformal mapping problem with applications to composition operators.* Preliminary report.

The following question arose in the study of composition operators acting on certain Hilbert spaces $L^2(\mu_p)$ of analytic functions on the unit disk: Suppose φ and ψ are Riemann maps from the unit disk $\mathbb{D}$ onto the same domain G such that φ'/ψ' is bounded. Does it follow that ψ'/φ' is bounded? An example will be constructed to show the answer to this question is "No". The consequence for composition operators is that there is an automorphism σ of the disk that induces a bounded composition operator on $L^2(\mu_p)$, while its formal inverse, the composition operator induced by σ^{-1}, is not bounded. (Received February 23, 2010)

1059-30-215 **Ilia Binder** and **Hrant Hakobyan*** (hhakob@math.toronto.edu), 40 St. George str., Toronto, Ontario M6G 2N2, Canada. *Conformal dimension of random and deterministic self-affine sets.*

It was shown by the second named author that families of measures of positive Fuglede modulus in a space X sometimes give lower bounds for the conformal dimension of X. We use this result to obtain lower bounds for the conformal dimension of self-affine Bedford-McMullen sets. We also define a self-affine version of Mandelbrot's fractal percolation and show that a random self-affine set is minimal for conformal dimension. (Received February 23, 2010)

1059-30-217 **David Dumas***, 851 S. Morgan St. #322 (M/C 249), Chicago, IL 60607. *Skinning maps are finite-to-one.* Preliminary report.

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 and a stratified Kaehler metric on the space of measured geodesic laminations. (Received February 23, 2010)

1059-30-225 **Joan R Lind*** (joanlind@gmail.com) and **Steffen Rohde**. *Fractal curves and phases of the Loewner equation.*

The Loewner differential equation provides a one-to-one correspondence between continuous real-valued functions (called driving functions) and certain families of growing sets in the upper halfplane (called hulls.) This equation has received significant attention since the introduction of Schramm-Loewner Evolution (SLE) by Oded Schramm in 2000, which has led to the proof of deep open problems in probability. For $\kappa > 0$, the process SLE(κ) can be thought of as the family of hulls that correspond to the random driving term $\sqrt{\kappa}B_t$. As κ increases, the geometry of the hulls change, with two phase transitions: for $\kappa \in (0, 4]$ the hulls are simple curves, for $\kappa \in (4, 8)$ the hulls are curves that hits back on themselves, and for $\kappa \in [8, \infty)$ the hulls are spacefilling curves.

In the deterministic setting, less is known about the relationship between the geometry of the hulls and properties of the driving functions. We will look at several examples of "bad" geometric behavior (such as fractal curves and spacefilling curves) that correspond to "nice" driving functions. Additionally, we show that there are two phase transitions for deterministic functions, analogous to the two phase transitions for SLE. (Received February 23, 2010)

1059-30-234 **Chun Wai Carto Wong*** (carto@u.washington.edu), 1150N 192nd St Apt 305, Shoreline, WA 98133, and **Steffen Rohde** (rohde@math.washington.edu). *An interpretation of half-plane capacity.* Preliminary report.

The half-plane capacity serves as a time-parameter for the chordal Loewner equation, just as the conformal radius is used as the parameter in the classical (radial) Loewner equation. In this talk, we show that half-plane capacity is comparable to the euclidean area of a hyperbolic neighborhood. (Received February 23, 2010)

1059-30-247 **Mohammed A. Qazi*** (qazima@aol.com), Dept of Mathematics, Tuskegee University, Tuskegee, AL 36088, and **Q. I. Rahman**. *An Inequality for Rational Functions.*

Let $\mathcal{P}_n$ be the class of all polynomials of degree at most n. It is known that if $f \in \mathcal{P}_n$ and $|f(z)| \leq 1$ on the unit circle, then $|f'(z)| \leq |z|^{n-1}$ outside the unit disk. We present an 'extension' of this result to rational functions which have all their poles in the open unit disk. (Received February 23, 2010)

31 ► Potential theory

1059-31-28 **Mark Agranovsky** and **Dmitry Khavinson*** (dkhavins@cas.usf.edu), Department of Mathematics, University of South Florida, 4202 E. Fowler Avenue, Tampa, FL 33620, and **Harold S. Shapiro**. *Malmheden's theorem revisited.*

Abstract: In 1934 H. Malmheden discovered an elegant geometric algorithm for solving the Dirichlet problem in a ball. Although his result was rediscovered independently by Duffin 23 years later, it still does not seem to be widely known. In this paper we return to Malmheden's theorem, give an alternative proof of the result that allows generalization to polyharmonic functions and, also, discuss applications of his theorem to geometric properties of harmonic measures in balls in $\mathbb{R}^n$. (Received February 01, 2010)

1059-31-98 **Nageswari Shanmugalingam*** (nages@math.uc.edu), Department of Mathematical Sciences, P.O.Box 210025, University of Cincinnati, Cincinnati, OH 45221-0025, **Estibalitz Durand**, Universidad Complutense de Madrid, Madrid, Spain, and **Jesus Jaramillo**, Universidad Complutense de Madrid, Madrid, Spain. *Geometric characterization of ∞-Poincare inequality in complete doubling metric measure spaces.*

Recent activity in analysis on metric measure spaces considers spaces equipped with a doubling measure supporting a p-Poincaré inequality for some $1 \leq p < \infty$. Some geometric consequences of such an inequality include a Rademacher type theorem and the quasiconvexity property of the metric space supporting the Poincare inequality; these consequences do not seem to depend on the index p. In this talk we will consider the weakest of the Poincaré inequalities, corresponding to $p = \infty$. (Received February 18, 2010)

32 ► Several complex variables and analytic spaces

1059-32-178 **Mirroslav T Yotov*** (yotovm@fiu.edu), 11200 S.W. 8th Street, DM 339B, Miami, FL 33199. *Spaces of holomorphic forms on Riemann surfaces of hyperbolic type.*

The talk is based on a joint work with F. Bogomolov (CIMS) and F. Soloviev (CIMS). We study the existence of complex structures on a Riemann surface which make certain subspaces (of dimension less than 4) of smooth complex forms holomorphic such. (Received February 22, 2010)

1059-32-220 **Song-Ying Li*** (sli@math.uci.edu), Department of Mathematics, University of California, Irvine, 340 Rowlland Hall, Irvine, CA 92697-3875. *Rigidity for solutions of degenerate PDEs.*

The talk will represent some recent works on the rigidity theorems associated to degenerate elliptic operators in Bergman metric as well as complex Monge-Ampere operator. (Received February 23, 2010)

34 ► Ordinary differential equations

1059-34-61 **Osvaldo D. Mendez*** (osmendez@utep.edu), 500W University Ave., 124 Bell Hall, El Paso, TX 79968, and **Liviu Horia Popescu**, Department of Mathematics, Oradea, Str., Armatei Romane, nr 5 JUD Bihor 3700, Oradea, Romania. *Sharp stability results for exponential dichotomy.*

We obtain sharp stability (roughness) results for exponential dichotomy of ODE's on a Banach space. (Received February 13, 2010)

1059-34-154 **Elifalet López*** (elgonzal@uacj.mx), General Monterde 433 interior 2, Partido Escobedo, 32330 Ciudad Juárez, Chihuahua, Mexico. *ALGEBRIZATION OF ORDINARY DIFFERENTIAL EQUATIONS.*

Given a vector field defined in an open subset of the n-dimensional Euclidian space, in this work the question is asked whether there exists a product such that the space can be an algebra and the vector field can be a differentiable map in the Lorch sense. When this is possible, the system can be expressed as a "differential

equation of one variable over the algebra" which could be solved by the known methods for solving ordinary differential equations. In this way the solution of the system is obtained. (Received February 22, 2010)

35 ► Partial differential equations

1059-35-32 **Maria C. Mariani** and **Marc Salas*** (salasm@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001. *Solutions to Integro-Differential Equations arising in models for charged transport in semiconductors.*

The existence of strong and global solutions for a nonlinear parabolic integro-differential system of PDEs arising in models for charged transport in semiconductors is studied. The existence results are proven by using a priori estimates and fixed point theorems. (Received February 03, 2010)

1059-35-33 **Maria C. Mariani** and **Marc Salas*** (salasm@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001. *Solutions to an integro-differential parabolic problem arising on Financial Mathematics.*

We study an integro-differential parabolic problem modeling a process with jumps in Financial Mathematics. Under suitable conditions, we prove the existence of solutions in a general domain using fixed point methods. (Received February 03, 2010)

1059-35-36 **Snehanshu Saha*** (ssaha@utep.edu), Bell Hall, 500 W.University Ave, El paso, TX 79968-0514. *Shallow Water asymptotics And Their Governing Equations: The B Family.*

We talk about several qualitative properties of the classical Korteweg-de Vries, Camassa-Holm and Degasperis-Procesi equations. We first establish the models of the Camassa-Holm and Degasperis-Procesi equations, deriving them from the shallow water wave argument and then compare a large class of properties relating to all three equations. We finally provide a survey of recent results by saha and liu pertaining to the Degasperis-Procesi equation and Camassa-holm equation and state some proposals for future research on this equation.

Keywords:Camassa-Holm(CH) and Degasperis-Procesi(DP) equations ; periodic b-family ;blow-up;local existence;global existence. (Received February 05, 2010)

1059-35-41 **J A Barceló**, **M Folch-Gabayet** and **S Pérez-Esteva*** (salvador@matcuer.unam.mx), Instituto de Matemáticas Unidad Cuernavaca, Av Universidad s/n, Lomas de Chamilpa, 62251 Cuernavaca, Morelos, Mexico, and **A Ruíz** and **M C Vilela**. *Estimates for the resolvent of the spectral Navier operator.* Preliminary report.

Consider the *spectral Navier operator* $L\mathbf{u}(x) = \Delta^*\mathbf{u}(x) + \omega^2\mathbf{u}(x)$, where $\omega > 0,\ x \in \mathbb{R}^n,\ n \geq 2$,

$$\Delta^*\mathbf{u} = \mu\Delta\mathrm{I}\mathbf{u} + (\lambda + \mu)\nabla div\,\mathbf{u},$$

ΔI denotes the diagonal matrix with the Laplace operator on the diagonal, $\mathbf{u}$ is a vector-valued function from $\mathbb{R}^n$ to $\mathbb{C}^n$, and λ, μ are the Lamé constants. We study limiting absortion principles for this operator and extending known results for the Helmhotz equation we give estimates for the resolvent. (Received February 08, 2010)

1059-35-54 **Maria C. Mariani** and **Emmanuel Ncheuguim*** (emmanou@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001. *Solution to a Nonlinear Black-Scholes Equation.*

Option pricing with transaction costs leads to a nonlinear Black-Scholes equation where the nonlinear term reflects the presence of transaction costs. Under suitable conditions, we prove the existence of strong solutions in a bounded domain and extend the results to the whole domain by using a diagonal process. (Received February 11, 2010)

1059-35-55 **jay j. kovats*** (jkovats@fit.edu), 150 West University Blvd., Melbourne, FL 32901. *Integrability properties of second derivatives of solutions of the simplest nonconvex fully nonlinear elliptic equations.*

In this talk, we discuss integrability properties of the second derivatives of viscosity solutions of the simplest constant coefficient Isaacs equation. Isaacs equations come from the theory of stochastic differential games, and are the prototypical example of a class of fully nonlinear elliptic equations which is neither convex nor concave in the second derivative variable. (Received February 12, 2010)

1059-35-56 **Miron Kursa**, **Konrad Bajer** and **Tomasz Lipniacki*** (tlipnia@ippt.gov.pl), Inst. of Fundamental Technological Research, Pawinskiego 5B, 02-106 Warsaw, Poland. *Cascade of vortex loops created after the reconnection of quantum vortices - an efficient mechanism of quantum vortex tangle evaporation at zero temperature.*

In this study we demonstrated that single reconnection of two straight vortex lines at sufficiently small angle (i.e. when vortices at the time of reconnection are locally almost antiparallel) leads to creation of a cascade of vortex loops. Our analysis, motivated by analytical solution obtained in the localized induction approximation, is based on numerical simulations of the vortex line motions in terms of Biot-Savart law and is adequate to the fin vortex filaments in an ideal (inviscid) fluid or to quantized vortices in superfluid helium at low temperatures. In the latter case, we showed that the generation of the vortex loops cascades provides an efficient mechanism of decay or evaporation of vortex tangle in the limit of zero temperature when the other dissipation mechanisms become inefficient. (Received February 12, 2010)

1059-35-57 **Kunio Hidano** and **Chengbo Wang*** (wangcbo@jhu.edu), Department of Mathematics, Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD 21218, and **Kazuyoshi Yokoyama**. *On almost global wellposedness for quasilinear wave equations with radial symmetry.* Preliminary report.

In this talk, we discuss our recent work on the Cauchy problem for 3-dimensional quasi-linear wave equations for initial data with low regularity.

For this purpose, we prove a space-time L^2 estimate of Morawetz/Keel-Smith-Sogge type for the variable coefficient wave equation, which was proved for the flat case in the previous work of K. Hidano and K. Yokoyama.

Assuming radial symmetry and using the space-time estimate, we establish the almost global well posedness for small initial data in $H^2 \times H^1$. (Received February 12, 2010)

1059-35-60 **Matt D Blair** (blair@math.unm.edu), **G Austin Ford** (aford@math.northwestern.edu), **Sebastian Herr** (herr@math.uni-bonn.de) and **Jeremy L Marzuola*** (jm3058@columbia.edu). *Strichartz estimates for Schroedinger equations on polygonal domains.* Preliminary report.

The authors prove Strichartz estimates with a loss of derivatives for the Schrödinger equation with either Dirichlet or Neumann homogeneous boundary conditions on compact, polygonal domains in $\mathbb{R}^2$. The method of proof relies on the established Strichartz estimates for Schrödinger equations on smooth, compact domains without boundary in the works of Burq-Gerard-Tzvetkov and on Euclidean cones as proved by the second author. Then, we use Littlewood-Paley Theory as described in the work of the first author to construct estimates for the relevant domains using the local geometric behavior and in particular that a polygonal domain can be viewed as an Euclidean surface with conical singularities. (Received February 13, 2010)

1059-35-70 **Benjamin James Jaye*** (bjjm93@mizzou.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Harmonic analysis techniques in nonlinear PDE.*

In this talk, we will discuss how some modern harmonic analysis methods can be applied to the study of nonlinear PDE modeled by the quasilinear p-Laplace and fully nonlinear k-Hessian operators.

In particular, we will focus on describing the global behavior of solutions to the following nonlinear equations:

$$-\Delta_p u = \sigma u^{p-1} + \omega, \quad \text{and} \quad \mathrm{F}_k(-u) = \sigma u^k + \omega,$$

where σ and ω are nonnegative Borel measures. Here Δ_p is the quasilinear p-Laplacian operator, defined by $\Delta_p u = \operatorname{div}(|\nabla u|^{p-2}\nabla u)$, and $\mathrm{F}_k(u)$ is the fully nonlinear k-Hessian operator, defined by $\mathrm{F}_k(u) = \sum_{1\le i_1<\cdots<i_k\le n} \lambda_{i_1}\dots\lambda_{i_k}$, where $\lambda_1,\dots,\lambda_n$ are the eigenvalues of the Hessian matrix of u. The results presented are joint work with Igor E. Verbitsky. (Received February 15, 2010)

1059-35-75 **M. Burak Erdogan*** (berdogan@math.uiuc.edu). *Near-linear evolution for NLS and KdV with periodic boundary conditions.*

We will discuss near-linear evolution for KdV and 1-d cubic NLS on the torus for high energy initial data. The results are obtained by the method of normal form reduction. This is a joint work with Tzirakis and Zharnitsky. (Received February 16, 2010)

1059-35-85 **Dean Baskin*** (dbaskin@math.stanford.edu), Stanford University, Department of Mathematics, Building 380, Sloan Hall, Stanford, CA 94305. *The Klein-Gordon Equation on asymptotically de Sitter spaces.*

Asymptotically de Sitter spaces are Lorentzian manifolds that resemble the de Sitter space near infinity and are asymptotic solutions of the Einstein equations with positive cosmological constant. We construct the forward

fundamental solution for the wave and Klein-Gordon equations on these manifolds and describe properties of solutions. (Received February 17, 2010)

1059-35-90 **Peter D Miller*** (millerpd@umich.edu), Dept. of Mathematics, East Hall, 530 Church St., Ann Arbor, MI 48109, and **Zhengjie Xu**, Dept. of Mathematics, East Hall, 530 Church St., Ann Arbor, MI 48109. *The Benjamin-Ono Equation in the Small Dispersion Limit.*

The Benjamin-Ono equation is a model for several physical phenomena, including gravity-driven internal waves in certain density-stratified fluids. It has the features of being a nonlocal equation (the dispersion term involves the Hilbert transform of the disturbance profile) and also of having a Lax pair and an associated inverse-scattering algorithm for the solution of the Cauchy initial-value problem. We will review known phenomena associated with this equation in the limit when the dispersive effects are nominally small, and compare with the better-known Korteweg-de Vries equation. Then we will present a new result establishing the zero-dispersion limit of the solution of the Benjamin-Ono Cauchy problem for certain initial data, in the topology of weak convergence. The proof relies on aspects of the method of moments from probability theory. (Received February 18, 2010)

1059-35-92 **Snehanshu Saha*** (ssaha@utep.edu), Bell Hall,500 W.University Ave, El Paso, TX 79968-0514. *A computational approach to Option pricing models.*

Suppose in 3 months' time, someone has the option to purchase Microsoft shares from a broker for 50 dollars per share. Three months from now, he/she will check their market price and decide whether to exercise that option. This deal has no downside - three months from now you either make a profit or walk away unscathed, On the other hand, the seller have no potential gain and an unlimited potential loss. To compensate, there will be a cost to enter into the option contract. You must pay him some money up front. The option valuation problem is thus to compute a fair value for the option. The Black Scholes model is obtained as a solution to a parabolic PDE (called the Black Scholes PDE) for pricing an option for an underlying asset. If the asset is volatile then pricing the option through a model is particularly helpful to determine the Payoff function. Crank Nicholson implicit scheme is more realistic among the finite difference methods in the sense that it is stable regardless of the parameters. Although it is more complicated to implement Crank Nicholson scheme unconditional stability is too good an issue to compromise and hence used as the numerical technique to solve the PDE in this work. (Received February 18, 2010)

1059-35-107 **Ionut Florescu*** (ifloresc@stevens.edu), Castle Point on the Hudson, Department of Mathematical Sciences, Stevens Institute of Technology, Hoboken, NJ 07030, and **Maria C Mariani** (mcmariani@utep.edu), Dept. of Mathematical Sciences, El Paso, TX 79968. *Study of solution for a PIDE relevant for Mathematical finance using upper and lower solutions.* Preliminary report.

One of the most studied problem in Finance is option pricing when the underlying equity follows a stochastic process. If the underlying process is a regular diffusion the problem is reduced to solving a Partial Differential Equation. However, if the underlying process possesses jumps (or more general a Lévy component) an integral term arises in the defining equation due to the associated Levy measure. This produces a so called Partial Integro-Differential Equation (PIDE). Problems of existence, uniqueness and determination of solutions for such equations are still open. In this report we will present a proof of existence on general domains under suitable conditions on the integral operator. The proof is based on the method of upper and lower solutions and may give rise to an algorithm to approximate the solution of PIDE. A relevant example is also provided. The work is based on the collaboration with Prof. Maria C. Mariani from University of Texas at El Paso. (Received February 19, 2010)

1059-35-111 **B T Nadiga*** (balu@lanl.gov), MS-B296, Los Alamos, NM 87545. *On the Regularization Approach to Modeling Unresolved Scales in Two-Dimensional and Quasi Two-Dimensional Turbulence.*

Motivation, derivation, and application of the regularization approach to modeling unresolved scales in two-dimensional and quasi two-dimensional turbulence will be presented. Additionally we show equivalence of this approach to a more traditional approach in two dimensions; the equivalence breaks down in three dimensions. (very very applied) (Received February 19, 2010)

1059-35-115 **Thomas Chen** and **Natasa Pavlovic*** (natasa@math.utexas.edu), Department of Mathematics, Univeristy of Texas at Austin, 1 University Station, C 1200, Austin, TX 78712, and **Nikolaos Tzirakis**. *On the Cauchy problem for Gross-Pitaevskii hierarchies.*

In this talk we will discuss results on the Cauchy problem for the so called Gross-Pitaevskii hierarchy (GP), which describes a system of infinitely many interacting bosons in a mean field limit.

In particular, we identify an observable corresponding to the average energy per particle, and prove that it is conserved. Furthermore, we prove the virial identity on the level of the GP hierarchy that enables us to obtain an analogue of Glassey's argument from the analysis of focusing NLS equations. As a consequence, we prove that all solutions to the focusing GP hierarchy at the L^2-critical or L^2-supercritical level blow up in finite time if the energy per particle in the initial condition is negative. (Received February 20, 2010)

1059-35-116 **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. *Derivation of the quintic nonlinear Schrödinger equation.*

In this talk we will discuss a derivation of the quintic nonlinear Schrödinger equation (NLS). More precisely, we consider a boson gas with three-body interactions in dimensions d=1,2 and prove that in the limit as the particle number N tends to infinity, the BBGKY hierarchy of k-particle marginals converges to a limiting Gross-Pitaevskii (GP) hierarchy for which we prove existence and uniqueness of solutions. For factorized initial data, the solutions of the GP hierarchy are shown to be determined by solutions of a quintic NLS. (Received February 20, 2010)

1059-35-141 **Jason Metcalfe*** (metcalfe@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Long time existence for quasilinear wave equations in exterior domains.*

We shall explore some new long time existence results for quasilinear wave equations with small initial data in exterior domains. In particular, we focus on results where the nonlinearity is permitted to depend on the solution not just its derivatives. (Received February 22, 2010)

1059-35-150 **J.A. Barcelo** and **M. Folch-Gabayet*** (folchgab@matem.unam.mx), Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, Ciudad Universitaria, 04510 Mexico, D.F, Mexico, and **S. Perez-Esteva**, **A. Ruiz** and **M.C. Vilela**. *Elastic Herglotz functions in the plane.*

We study spaces of solutions of the spectral Navier equation in the plane. We characterize the elastic Herglotz wave functions, namely the entire solutions $\mathbf{u}$ of the Navier equation with L^2 far-field-patterns. (Received February 22, 2010)

1059-35-162 **Kiril Datchev***, 970 Evans Hall #3840, Berkeley, CA 94720-3840. *Quantum decay rates for manifolds with hyperbolic ends.*

Mathematically, quantum decay rates appear as imaginary parts of poles of the meromorphic continuation of Green's functions. As energy grows, decay rates are related to properties of geodesic flow and to the structure at infinity. For a cusp, infinity is "small", which typically slows decay. However, I will present a class of examples for which decay rates go to infinity with energy even in the presence of a cusp. This is part of a more general investigation of resonances on manifolds with hyperbolic ends. (Received February 22, 2010)

1059-35-163 **V. Zharnitsky*** (vz@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801, and **M. B. Erdogan** and **N. Tzirakis**. *Near-linear dynamics in KdV with periodic boundary conditions.*

KdV equation is a standard model of weakly nonlinear long waves on the surface of shallow water. It will be shown that in KdV with periodic boundary conditions, high frequency solutions evolve almost as the linear ones for large time. The integrability properties of KdV are not used, so similar results could be expected for other KdV like equations. The interaction of these high frequency solutions with a cnoidal wave will be discussed, too. This work has been motivated by an attempt to explain certain phenomena in nonlinear optics and fluid dynamics. (Received February 22, 2010)

1059-35-164 **Mihai Tohaneanu*** (mtohanea@math.purdue.edu), 427 S River Rd Apt # 21, West Lafayette, IN 47906. *Strichartz estimates on Kerr spacetimes.*

We prove Strichartz estimates for solutions to the equation $\Box_K u = f$, where K stands for the d'Alembertian associated to the metric of the Kerr spacetime. The proof uses the machinery developed in joint work with Jeremy Marzuola, Jason Metcalfe and Daniel Tataru that allows us to obtain Strichartz estimates provided that a suitable local energy estimate already exists. (Received February 22, 2010)

1059-35-193 **Justin Holmer*** (holmer@math.brown.edu), Department of Mathematics, Box 1917, 151 Thayer St., Providence, RI 02912, and **Galina Perelman** and **Maciej Zworski**. *Effective dynamics of double solitons for perturbed mKdV.*

We show that an interacting double soliton solution to the perturbed modified Koreteweg-de Vries (mKdV) equation is close in H^2 to a double soliton following an effective dynamics obtained as Hamilton's equations

for the restriction of the mKdV Hamiltonian to the submanifold of solitons. The interplay between algebraic aspects of complete integrability of the unperturbed equation and the analytic ideas related to soliton stability is central in the proof. (Received February 23, 2010)

1059-35-194 **Justin Holmer** and **Svetlana Roudenko***, School of Math and Stat Sciences, Arizona State University, Tempe, AZ 85287-1804. *Blow up solutions to the 3d focusing cubic NLS equation.*

For the focusing NLS equation $iu_t + \Delta u + |u|^2 u = 0$, $(x,t) \in \mathbb{R}^3 \times \mathbb{R}$ and $u_0 \in H^1$, we review various conditions for solutions that blow up in finite time and discuss the construction of a family of axially symmetric solutions that blow up on a circle. (Received February 23, 2010)

1059-35-196 **Thomas Dyuckaerts**, **Frank Merle** and **Svetlana Roudenko***, School of Math and Stat Sciences, Arizona State University, Tempe, AZ 85287-1804. *Maximizers for the Strichartz norm for small solutions of mass-critical semilinear Schrödinger equations.*

We consider the mass-critical Schrödinger equation in space dimensions 1 and 2 (both focusing and defocusing cases). By Strichartz estimates for the linear problem, solutions with small L^2 norm are globally defined and belong to an L^p (Strichartz) space (here, $p = 6$ in 1d and $p = 4$ in 2d). We show that for small L^2 norm the maximum of the (Strichartz) L^p-norm is attained, and give a precise estimate of this maximum as the mass tends to 0. In particular, in the focusing case, it is greater than the corresponding maximum for the linear equation, which was computed by Foschi and Hundertmark-Zharnitsky, and it is smaller in the defocusing case. (Received February 23, 2010)

1059-35-203 **Yan Qiu*** (ccsindy@unm.edu). *Analysis of a nonlinear Black Scholes equation.* Preliminary report.

A nonlinear modification of the Black-Scholes equation, where the volatility is assumed to be uncertain constant, leads to a PDE with nonlinearity in its highest space derivative and the nonlinear coefficient function being discontinuous. First we consider the case where the volatility is assumed to be a smooth function and present basic existence and uniqueness results. To study the discontinuity in volatility we simplify the problem to a ODE and perform convergence and perturbation analysis. Last we study numerical feature as a free boundary problem. (Received February 23, 2010)

1059-35-206 **Cristian Rios*** (crios@math.ucalgary.ca), Department of Mathematics, University of Calgary, 2500 University Dr. NW, Calgary, AB T2N1N4, Canada, and **Eric T Sawyer** and **Richard Wheeden**. *Regularity for Quasilinear Equations with non-Hormander vector fields.* Preliminary report.

We consider a class of degenerate elliptic equations with non-isotropic ellipticity which might vanish to infinite order. In particular, the underlying vector fields fail to satisfy the Hormander condition.

We prove a-priori estimates for continuous weak solutions. As a consequence we obtain existence and regularity for solutions of the Dirichlet problem. The regularity theorems are new even in the linear case.

In two dimensions these results may be applied to show regularity for Monge-Ampere equations with infinite vanishing right hand side. (Received February 23, 2010)

1059-35-209 **Pavlo Cherepanov*** (pavel@math.unm.edu), Department of Mathematics and Statistics, University of New Mexico, Albuqeurque, NM 87131. *Shock Formation Properties of the Navier-Stokes and Bhatnagar-Gross-Krook equations.*

The dynamics of compressible viscous flow can be described by the well developed theory of thermodynamics and fluid mechanics leading to a continuum model. At the same time, kinetic models aim to address the same problem from a more fundamental and completely different view point. In contrast to the continuum approach, kinetic theory allows a description of a system and its characteristics from the microscopic picture of the underlying processes based on the microscopic collision dynamics. The task of comparing these approaches and explaining how thy are related is a major challenge for applied mathematics.

In this work we address a small aspect of this problem. It is known that the equations of Navier-Stokes can produce viscous shock profiles. We investigate whether similar types of solutions can be obtained from one of the kinetic models the Bhatnagar-Gross-Krook model introduced in 1954. We evaluate both models numerically and compare the results. (Received February 23, 2010)

1059-35-210 **Stephen Gustafson*** (gustaf@math.ubc.ca). *Singularities and asymptotics for some geometric nonlinear Schroedinger equations.*

I will describe results on singularity (non-)formation and stability, in the energy-critical 2D setting, for some nonlinear Schroedinger-type systems of geometric origin – the Schroedinger map and Landau-Lifshitz equation – which model dynamics of ferromagnets and liquid crystals. (Received February 23, 2010)

1059-35-228 **Xi Ronald Chen*** (xqroy@math.unm.edu). *New development in Hermite Method.* Preliminary report.

We study arbitrary-order Hermite difference methods for the numerical solution of initial-boundary value problems for symmetric hyperbolic systems. We have developed a ghost-cell approach for Hermite method concerning the boundary condition whereby the unknown data is chosen to enforce the boundary conditions for a complete space-time polynomial on the boundary. An alternative explicit approach will also be discussed, in which high derivatives have been truncated to preserve the stability and independence of the time-stepping. We also study order-adaptive implementations of Hermite methods for hyperbolic and singularly perturbed parabolic initial value problems. Exploiting the facts that Hermite methods allow the degree of the local polynomial representation to vary arbitrarily from cell to cell. This allows for extremely accurate simulation of viscous shock waves at low computational cost. We also discuss the Hermite-Taylor methods in a composite overlapping grid framework in order to enable simulations in complex geometries. We present in details how Hermite method works in many different cases. Numerical experiments are included to demonstrate the resolution of the methods for large m as well as illustrate the basic theoretical results. (Received February 23, 2010)

1059-35-232 **Jacob K Sterbenz*** (jsterben@math.ucsd.edu), Department of Mathematics, University of California, San Diego (UCSD), 9500 Gilman Drive # 0112, La Jolla, CA 92093-0112. *Scattering for a Resonant Klein-Gordon Equation.*

This talk will discuss joint work with Hans Lindblad, Igor Rodnianski, and Avi Soffer about global in time estimates for the one dimensional Klein-Gordon equation with inhomogeneous quadratic and cubic non-linearities. This involves several new normal forms transformations which take into account the spatial frequencies of the non-linear coefficients. The problem is motivated by stability questions for kink type equations. (Received February 23, 2010)

1059-35-250 **Bryan J Travis*** (bjtravis@lanl.gov), EES-16/MS-D452, Los Alamos National Laboratory, Los Alamos, NM 87545. *PDEs for Flow and Transport in Porous Media with Fractal Coefficients.* Preliminary report.

Permeability of soils has a fractal character over many orders of magnitude in scale. This presents a challenge for numerical simulations of flow and transport in porous media. To capture subgridscale dynamics in porous media, we are experimenting with partial differential equations having fractal coefficients. Numerical solution of the governing equations is obtained through use of fractal interpolating functions. Examples in two and three dimensions illustrate the method. In a related study, flows over fractal boundaries are compared to flows over corresponding smoothed boundaries. (Received February 24, 2010)

37 ► Dynamical systems and ergodic theory

1059-37-24 **Thomas Koberda*** (koberda@math.harvard.edu), Department of Mathematics, Harvard University, 1 Oxford St., Cambridge, MA 02138. *Skew products of interval exchange transformations and asymptotic homological detection of pseudo-Anosov dilatations.* Preliminary report.

Let T be an interval exchange transformation which gives rise to a pseudo-Anosov foliation upon suspension. We show how skew products of T with torus automorphisms can be used as a tool to compactify an infinite class of homological representations of the given pseudo-Anosov homeomorphism. We conclude that there are many infinite covers for which the homological dilatation of certain pseudo-Anosov homeomorphisms remains bounded away from the geometric dilatation. (Received January 27, 2010)

1059-37-39 **Israel Michael Sigal*** (im.sigal@utoronto.ca). *Statics and Dynamics of Magnetic Vortices.*

In this talk we consider the Ginzburg-Landau equations appearing in the theory of superconductivity and in the Abelean gauge field theory. Magnetic vortices are localized stationary solutions of these equations which play the key role in underlying physics. We review earlier and recent results on existence and stability of single magnetic vortices and lattices built out of them (Abrikosov lattices, for discovery of which A.Abrikosov received

a Nobel prize). (So far these are the only theoretically, experimentally and numerically found solutions of these equations.) If time permits we will also discuss intervortex dynamics. (Received February 08, 2010)

1059-37-84 **Dmitri Scheglov*** (dvs117@gmail.com), 1214-D Crown Point, Norman, OK 73072. *Long arithmetic progressions and triangle billiards.*

We discuss an interesting relation between the possible existence of periodic orbits for irrational triangle billiards and the existence of arbitrarily long monochromatic arithmetic progressions for some pseudo-dynamics of circle rotations. (Received February 17, 2010)

39 ► Difference and functional equations

1059-39-62 **Reza Ahangar*** (reza.ahangar@tamuk.edu), MSC 172 Mathematics Department, 700 University BLVD, Texas A & M University- Kingsville, Kingsville, TX 78363. *Dynamic Behavior of Perturbed Logistic Model.*

- A model that represents the rate of changes of the population with limited environmental resources can be described by,

where a measures the growth rate in the absence of the restriction force and a/b represents the carrying capacity of the environment and b represent a restricted factor. The random perturbation g(t, p) is generated by random change in the environment. The behavior of the solution of this model for continuous and discrete case when g(t,p)=r.p with a random change factor r will be studied. The stability and the behavior of the equilibrium point will also be investigated. A computational approach to the solution and logistic regression applied to the statistical data will be presented. (Received February 14, 2010)

42 ► Fourier analysis

1059-42-6 **Michael T Lacey*** (lacey@math.gatech.edu), Mathematics, Georgia Tech, Atlanta GA 30332, Atlanta, GA 30332, **Eric Sawyer** (sawyer@mcmaster.ca), math, McMaster University, Hamilton, ON L8S 4K1, Canada, **I Uriate-Tuero** (ignacio@math.gatech.edu), math, michigan state, East Lansing, MI 48824, and **Maria Carmen Reguera** (mreguera@math.gatech.edu), math, georgia tech, Atlanta, GA 30332. *Recent results in Weighted Theory.*

Our subject is two-weight inequalities for (discrete analogs of) singular integrals, and their application to questions about sharp dependence on the A_p constant in one weight inequalities. We will discuss recent characterizations of two weight inequalities due to Nazarov-Treil-Volberg and the speaker with Sawyer and Uriate-Tuero. The application of these results to A_p weights yields results on strong and weak-type inequalities that are sharp in the power of the A_p characteristic of the weight. The latter is joint with Maria Carmen Reguera, Armen Vagharshakyan and Tuomas Hytonen. (Received October 01, 2009)

1059-42-9 **Michael Lacey** and **Kabe Moen*** (moen@math.wustl.edu), Mathematics, Washington University in St. Louis, Cupples I hall, One Brookings Dr., St. Louis, MO 63130, and **Carlos Perez** and **Rodolfo Torres**. *Sharp weighted bounds for fractional integral operators.*

The relationship between the operator norms of fractional integral operators acting on weighted Lebesgue spaces and the constant associated to the weights. We obtain analogous results for the fractional integral operator to Petermichl's sharp weighted bounds for singular integral operators. We also obtain analogous results for the fractional integral operator to some difficult open problems in weighted theory for Calderon-Zygmund operators. Our results rely on a sharp off-diagonal version of the extrapolation theorem of Rubio de Francia and a dyadic decomposition of the fractional integral operator. This is a joint work with M. Lacey, C. Perez, and R.H. Torres. (Received November 11, 2009)

1059-42-18 **Daewon Chung*** (dwchung@unm.edu), Dep. of Math. and Stat. MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131-0001. *On sharp bounds for the commutators on weighted Lebesgue spaces $L^p(w)$.* Preliminary report.

We present that the operator norm on weighted Lebesgue space $L^2(w)$ of the commutators of the Hilbert, Riesz and Beurling transforms with a BMO function b depends quadratically on the A_2-characteristic of the weight, as opposed to the linear dependence known to hold for the operators themselves. It is known that the operator norms of these commutators can be controlled by the norm of the commutator with appropriate Haar shift

operators, and we prove the estimate for these commutators. For the shift operator corresponding to the Hilbert transform we use Bellman function methods, however there is now a general theorem for a class of Haar shift operators that can be used instead to deduce similar results. We invoke this general theorem to obtain the corresponding result for the Riesz transforms and the Beurling-Ahlfors operator. We can then extrapolate to $L^p(w)$, and the results are sharp for $1 < p < \infty$. We also present the examples that show the quadratic bounds are sharp for the commutators of the Hilbert, Riesz and Beurling transforms. (Received January 10, 2010)

1059-42-25 **Li-An Daniel Wang*** (lwang3@uoregon.edu), Eugene, OR 97405. *Multiplier theorems on Anisotropic Hardy Space.* Preliminary report.

We study multiplier theorems on the anisotropic Hardy space $H^p_A(\mathbb{R}^n)$ associated with a dilation matrix A. When given a multiplier m satisfying the anisotropic Mihlin condition, we show that it is the Fourier transform of a Calderon-Zygmund operator. Using previous work by M. Bownik, we conclude that such a multiplier gives rise to a bounded operator on H^p. Since the isotropic (classical) case is a special case of setting $A = 2I_n$ as our dilation matrix, this extends the classical results to the anisotropic setting. (Received January 29, 2010)

1059-42-31 **Jill Pipher** and **Lesley A. Ward*** (Lesley.Ward@unisa.edu.au), School of Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, Mawson Lakes, SA, 5095, Australia, and **Xiao Xiao**. *Geometric-arithmetic averaging of dyadic weights.*

The theory of Muckenhoupt weights arises in many areas of analysis, for example in connection with bounds for singular integrals and maximal functions on weighted spaces. We show that a certain averaging process gives a method for constructing A_p weights from a measurably varying family of dyadic A_p weights. This averaging process is suggested by the exponential/logarithmic relationship between the A_p weight class and the space BMO of functions of bounded mean oscillation. The same averaging process also constructs weights satisfying the reverse Hölder (RH_p) condition from families of dyadic RH_p weights. Moreover, it applies to the multiparameter weight classes A_p and RH_p on the polydisc as well. (Received February 03, 2010)

1059-42-37 **Ciprian Demeter*** (demeterc@indiana.edu), Department of Mathematics, Indiana University, 831 East 3rd St., Bloomington, IN 47401. *SINGULAR INTEGRALS ALONG N DIRECTIONS IN R^2.*

We prove optimal bounds in $L^2(R^2)$ for the maximal oper- ator obtained by taking a singular integral along N arbitrary directions in the plane. We also give a new proof for the optimal L^2 bound for the single scale Kakeya maximal function in the plane. (Received February 07, 2010)

1059-42-45 **Marius Beceanu** and **Michael Goldberg*** (goldbeml@ucmail.uc.edu), University of Cincinnati, Department of Mathematical Sciences, 839 Old Chem, Cincinnati, OH 45221-0025. *A Schrödinger Dispersive Estimate in $\mathbf{R^3}$ with Singular Potentials.* Preliminary report.

We prove a dispersive estimate on the linear propagator e^{-itH} for a family of Schrödinger operators $H = -\Delta + V(x)$. The admissible class of potentials is invariant with respect to the Laplacian's natural inverse-square scaling law, and includes singular examples where $V(x)$ is a measure rather than a function. (Received February 09, 2010)

1059-42-59 **Fedor Nazarov**, **Richard Oberlin** and **Christoph Thiele*** (thiele@math.ucla.edu). *A multi-frequency Calderon Zygmund decomposition and applications.* Preliminary report.

We introduce a Calderon Zygmund decomposition both in the dyadic (trivial) and non-dyadic (less trivial) setting, where the bad function has vanishing integral against a number of pure frequencies. We present applications of this Calderon Zygmund decomposition to an extension of a multi-freqeuncy maximal lemma of Bourgain (non-dyadic) and to new uniform bounds for a dyadic model of the bilinear Hilbert transform. (Received February 12, 2010)

1059-42-66 **Camil Muscalu*** (camil@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *Multi-parameter Cauchy integrals on Lipschitz curves.*

The plan would be to talk about a theorem which proves L^p estimates for the T^d generalization of the Cauchy integral on Lipschitz curves, for any $d \geq 1$. The $d = 1$ case is the well known theorem of Coifman, McIntosh and Meyer, while the case $d = 2$ has been understood by Journé in the late eighties. (Received February 15, 2010)

1059-42-78 **Caroline Sweezy*** (csweezy@nmsu.edu), Box 30001, 3MB, Las Cruces, NM 88003-8001. *Almost orthogonality related to weighted inequalities on bounded and unbounded domains.* Preliminary report.

The property of almost orthogonality for a family of functions is a necessary condition for obtaining certain Littlewood-Paley type inequalities, which in turn can be used to establish weighted norm inequalities for solutions to harmonic, elliptic and parabolic equations. The method of proving almost orthogonality for a family of functions which also have minimal smoothness and decay properties, turns out to be interesting in and of itself. This talk will concentrate on different proofs of almost orthogonality discovered by the speaker and J. M. Wilson in the course of their research on weighted inequalities. (Received February 16, 2010)

1059-42-112 **Angel Eduardo Gatto*** (aegatto@depaul.edu), DePaul University, Department of Mathematics, 2320 N. Kenmore Av., Chicago, IL 60614. *"Boundedness of Singular Integrals associated to non-doubling measure metric spaces on Lipschitz spaces and Krein Theorem.*

In this talk we present necessary and sufficient conditions for the boundedness of singular integrals associated to non-doubling measure metric spaces on Lipschitz spaces. We also show how these results imply boundedness in L2 by applying Krein Theorem. (Received February 20, 2010)

1059-42-118 **A. Eduardo Gatto**, **Ebner Pineda** and **Wilfredo O Urbina*** (wurbina@depaul.edu), Department of Mathematical Sciences, DePAul University 2320 N Kenmore Ave, Chicago, IL 60614. *Riesz Potentials, Bessel Potentials and Fractional Derivatives on Gaussian Besov-Lipschitz spaces $B^{\alpha}_{p,q}(\gamma_d)$ and on Triebel-Lizorkin spaces $F^{\alpha}_{p,q}(\gamma_d)$.*

We study the boundedness properties of Riesz Potentials, Bessel potentials and Fractional Derivatives on Gaussian Besov-Lipschitz spaces $B^{\alpha}_{p,q}(\gamma_d)$ and on Triebel-Lizorkin spaces $F^{\alpha}_{p,q}(\gamma_d)$. (Received February 24, 2010)

1059-42-120 **Alex Stokolos*** (astokolos@georgiasouthern.edu), Georgia Southern University, PO Box 8093, Statesboro, GA 30460-8093. *Some properties of strong maximal operator in 3D.*

It is well known that the maximal operator associated to the basis of all 3D rectangles continuously maps $L\log^2 L$ into $L^{1,\infty}$, while the maximal operators associated to the basis of rectangles of dimensions $(t, 1/t, s)$ acts from the larger class $L\log^+ L$ into $L^{1,\infty}$. For a natural class of bases (included the above mentioned) we give a simple geometric condition which guarantees that $L\log^2 L$ class cannot be enlarged. This result is related to the theorems of A.Córdoba, F.Soria, R.Fefferman and J.Pipher. (Received February 21, 2010)

1059-42-122 **Igor Verbitsky***, Department of Mathematics, University of Missouri, Columbia, MO 65203. *Dyadic models in linear and nonlinear elliptic PDE.*

A survey of recent results on linear, quasilinear and fully nonlinear elliptic PDE will be given where dyadic models play an important role. This includes global estimates of Green's functions and the conditional gauge, criteria of solvability, and characterizations of removable singularities. Equations involving the fractional Schrödinger, p-Laplacian or k-Hessian operators, and singular source terms and data, will be considered.

This talk is based on joint work with Michael Frazier, Benjamin Jaye, Fedor Nazarov, and Nguyen Cong Phuc. (Received February 21, 2010)

1059-42-170 **Michael T. Lacey** (Lacey@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, **Eric T. Sawyer** (sawyer@mcmaster.ca), Dept. of Mathematics & Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, and **Ignacio Uriarte-Tuero*** (ignacio@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *A characterization of the two weight norm inequality for the Hilbert transform.*

The two weight inequality for the Hilbert transform for locally finite Borel measures with no point masses in common is characterized in terms of (1) a Poisson A_2 condition on the weights (2) A forward testing condition, in which the two weight inequality is tested on intervals (3) and a backwards testing condition, dual to (2). A critical new concept in the proof is an Energy Condition, which incorporates information about the distribution of the weights in question inside intervals. This condition is a consequence of the three conditions above. The notion of Energy also provides a decisive improvement of a standard 'off-diagonal' estimate on singular integrals, used in the sufficient direction. This new concept is combined with a known proof strategy devised by Nazarov-Treil-Volberg. A counterexample shows that the energy condition must be used in the characterization.

This talk will complement Michael Lacey's. (Received February 22, 2010)

1059-42-186 **Leonid Slavin*** (leonid.slavin@uc.edu) and **Vasily Vasyunin**. *The embedding* $\mathrm{BMO} \subset L^p_{loc}$ *and sharp equivalence of BMO norms.*

The space $\mathrm{BMO}_p(\mathbb{R})$ is defined, for all $p \geq 1$, by

$$\mathrm{BMO}_p = \left\{ \varphi \in L^1_{loc} : \sup_{\text{interval } Q} \langle |\varphi - \langle \varphi \rangle_Q|^p | \rangle_Q \leq C^p < \infty \right\},$$

with $\langle \varphi \rangle_Q \stackrel{\text{def}}{=} \frac{1}{|Q|} \int_Q \varphi$ and the best such C being the corresponding norm. It is known that the norms are equivalent for all p, with one direction following from Hölder's inequality and the other usually regarded as a consequence of the John–Nirenberg inequality. However, the constants of this equivalence are not known.

We find the explicit upper and lower Bellman functions for the embedding $\mathrm{BMO}_2 \subset L^p_{loc}$ thus establishing the sharp embedding constant. As a consequence, we can relate, sharply, all BMO_p norms to the BMO_2 norm. The proof depends on solving a Monge–Ampère equation on a non-convex domain, coupled with a delicate induction argument. As an integral part of the solution, we construct the Bellman foliation of the domain, yielding the extremizers in the inequalities being proved. (Received February 23, 2010)

1059-42-187 **Dmitriy Bilyk*** (bilyk@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *Dyadic analysis in discrepancy theory.*

Discrepancy theory has been utilizing the methods of dyadic analysis essentially since the area emerged. In this talk we shall give a brief overview of the well known ideas in this topic as well as more recent advances, in which the dyadic harmonic analysis is used both to prove uniform lower bounds on the discrepancy in various spaces (L^∞, $\exp(L^\alpha)$, BMO) and to construct point sets with asymptotically small discrepancy. Part of this talk is joint work with M. Lacey, I. Parissis, A. Vagharshakyan. (Received February 23, 2010)

1059-42-201 **Nadine Badr** (badr@math.univ-lyon1.fr), Institut Camille Jordan, Universite Claude Bernard Lyon 1, 43 boulevard du 11 novembre 1918, F-69622 Villeurbanne, France, and **Galia Dafni*** (gdafni@mathstat.concordia.ca), Department of Mathematics & Statistics, Concordia University, 1455 de Maisonneuve Blvd. West, Montreal, Quebec H3G1M8, Canada. *Hardy-Sobolev spaces on manifolds.*

We will discuss Hardy-Sobolev spaces on a Riemannian manifold with a doubling measure, and show that the definitions given by means of atomic decomposition and by means of various maximal functions give the same space, which can be identified with the Hajlasz Sobolev space for $p = 1$, provided we assume a Poincare inequality. (Received February 23, 2010)

1059-42-237 **Yen Q Do*** (qdo@math.ucla.edu), UCLA Department of Mathematics. *A nonlinear stationary phase method for oscillatory Riemann-Hilbert problems.* Preliminary report.

Using the Fourier transform, solutions of a linear PDE with constant coefficients can be written as oscillatory integrals whose long-time asymptotics can be studied using the stationary phase method. A Riemann-Hilbert problem is a factorization problem and it can be used to invert the one-dimensional scattering transform, which is a nonlinear Fourier transform for many nonlinear PDEs. I will describe a nonlinear analogue of the classical stationary phase method which can be used to obtain long-time asymptotics for solutions of such nonlinear PDEs from their oscillatory Riemann-Hilbert formulations. (Received February 23, 2010)

43 ► Abstract harmonic analysis

1059-43-198 **Oleksandra V Beznosova*** (alexbeznosova@yahoo.com), **Dariusz Panek** and **Maria Cristina Pereyra**. *A new sharp version of Buckley's inequality.* Preliminary report.

We show a sharp version of Buckley's inequality for the weights in the Gehring class G_1 and apply it to the two-weight estimate of the norm of the dyadic square function and norms of Haar Multipliers. (Received February 23, 2010)

1059-43-248 **Ricardo A Saenz*** (rasaenz@ucol.mx), Facultad de Ciencias - University of Colima, Ave. Bernal Diaz del Castillo 340, 28045 Colima, Colima, Mexico. *Nontangential limits and Fatou type theorems on PCF sets.*

Let Δ be the Laplacian of the post critically finite (PCF) self-similar set K, and consider the equation

$$\frac{\partial^2 u}{\partial t^2} + \Delta u = 0$$

on $K \times \mathbb{R}_+$, with boundary condition $u(x,0) = f(x)$ on K. In this talk we discuss recent results on the regularity of the Poisson integrals $u(x,t)$ for $f \in L^p(K)$, as well as non-tangential limits of $u(x,t)$ as $t \to 0$. (Received February 23, 2010)

44 ► Integral transforms, operational calculus

1059-44-71 **Raluca Felea*** (rxfsma@rit.edu), Rochester Institute of Technology, School of Mathematical Sciences, Rochester, NY 14623. *FIOs with open umbrellas.*

We consider the composition calculus of Fourier integral operators (FIOs) with cusp singularities which appear in seismic inverse problems. To reconstruct the singularities in the forward operator F, one needs to consider the normal operator F^*F. We will show that artifacts appear since the wave front set of the normal operator is in the union of the diagonal and the open umbrella which is a singular Lagrangian. (Received February 15, 2010)

1059-44-182 **Hanna E Makaruk*** (hanna_m@lanl.gov), MS D410, Los Alamos, NM 87545. *Information provided by volumes of negative density in Inverse Abel method of 3D objects reconstruction from radiographic images.* Preliminary report.

Inverse Abel transform method is a standard method used in various applications for reconstructing densities of axially symmetric objects from a single radiographic image. Real life objects frequently violate the assumption of perfect axial symmetry, what strongly influences reconstruction and in some cases leads to reconstruction of volumes with negative density assigned. This non-physical result provides valuable information about the 3D object. In the talk formulas which allow to reconstruct either location and size, or location and density of the non-axially symmetric part of the object, will be presented. Simple geometrical objects a sphere, a cube, an ellipsoid serve as examples. A radiogram from a real Proton Radiography experiment will be discussed too. (Received February 23, 2010)

46 ► Functional analysis

1059-46-19 **Jan Lang*** (lang@math.ohio-state.edu), Department of Mathematics, OSU, 100 Math Tower, 231 West 18th Avenue, Columbus, OH 43210-1174. *The j-eigenfunctions and s-numbers.*

It is a truth universally acknowledged, that a compact linear map between Hilbert spaces has an excellent structure that can be described by projections on eigenmanifolds. However, until comparatively recently there were no similar results when the action takes place between Banach spaces. The focus of this communication is on these new developments.

Let X and Y be uniformly convex and uniformly smooth Banach spaces, and let $T : X \to Y$ be a compact linear map. Denote by J_X and J_Y normalized duality mappings on X and Y, respectively. We describe a geometric approach for obtaining a "new" class of eigenfunctions and eigenvalues for non-linear equations of the form

$$S^* J_Y S x = \lambda J_X x;$$

where S denotes the restriction of T to subspaces generated by James orthogonality. Our method, which seems to be more direct than the Lusternik-Schnirelmann method, is based use of James (otherwise called Birkhoff) orthogonality as a decomposition tool. Using the Hardy operator, for which we prove that "classical" eigenvalues, eigenvalues obtained by the L-S method and all "strict" s-numbers are same, we give numerical computations indicating that these new eigenfunctions lie outside the family of above classical eigenfunctions. (Received January 24, 2010)

1059-46-63 **Michael W Frazier*** (frazier@math.utk.edu), Math Department, University of Tennessee, 104 Aconda Court, 1534 Cumberland Ave., Knoxville, TN 37996-0614, and **Igor E Verbitsky**. *Estimates for kernels of Neumann series, from the dyadic to the general case.*

We discuss the origin and development of a recent result of Frazier, Nazarov, and Verbitsky, regarding estimates for the kernel of the Neumann series $\sum_{n=0}^{\infty} T^n$ in terms of the kernel K of an integral operator

$$Tf(x) = \int_\Omega K(x,y) f(y)\, d\omega(y)$$

defined on some measure space (Ω, ω). This work began in a paper of Frazier and Verbitsky studying a dyadic model for Schrödinger's equation, where K has the particular form

$$K(x,y) = \sum_{Q \text{ dyadic}} \frac{s_Q}{\omega(Q)} \chi_Q(x) \chi_Q(y),$$

for scalars $\{s_Q\}_Q$. We explain how results in the dyadic case eventually led to general results. We also mention some applications of the general estimates to Schrödinger operators. (Received February 14, 2010)

1059-46-79 **Vida Milani*** (vmilani3@math.gatech.edu), Georgia Institute of Technology, School of Mathematics, Atlanta, GA , and **Seyed M.H. Mansourbeigi** (s.mansourbeigi@ieee.org), Polytechnic University, Department of Electrical Engineering, NY. *Morse Theory: A tool for geometric classification of the noncommutative CW complexes.*

The Modification of Morse theory for C* algebras provides tools for the geometric interpretation and classification of noncommutative CW complexes. Some examples to illustrate this interpretation in practice are given. we show how a modification of the classical Morse theory to the level of C*-algebras will provide an innovative way to explain the geometry of noncommutative CW complexes through the critical ideals of the modified Morse function. This leads to some classification theory. (Received February 16, 2010)

1059-46-173 **Don Hadwin*** (don@unh.edu), MATH DEPT UNH, Durham, NH 03824, and **Qihui Li**, **Weihua Li** and **Junhao Shen**. *A Lower Bound for Topological Free Entropy Dimension.* Preliminary report.

Suppose $\mathcal{A} = \mathcal{C}^* (x_1 \ldots, x_n)$ is an MF-C*-algebra in the sense of Balackadar and Kirchberg. We define a family of traces, called *MF-traces*, on $\mathcal{A}$ in a natural way from the definition of MF-algeba. We prove that the set of MF-traces on $\mathcal{A}$ is nonempty, compact and convex. Suppose τ is an MF-trace on $\mathcal{A}$ and π is the corresponding GNS representation, and suppose X is a selfadjoint operator in $\pi(\mathcal{A})''$. Then the topological free entropy dimension $\delta_{\text{top}}(x_1, \ldots, x_n)$ is no less than the free entropy dimension of X with respect to τ. If $\mathcal{A}$ has no finite-dimensional representation or infinitely many inequivalent finite-dimensional representations, then $\delta_{\text{top}}(x_1, \ldots, x_n) \geq 1$. Let $\mathcal{J}$ be the largest ideal annihilated by all the MF-traces. If $\mathcal{A}/\mathcal{J}$ is finite-dimensional or if $\mathcal{A}$ is nuclear and every trace on $\mathcal{A}$ is an MF-trace, then $\delta_{\text{top}}(x_1, \ldots, x_n) = 1 - 1/d$, where $d = \dim \mathcal{A}/\mathcal{J}$. (Received February 22, 2010)

1059-46-224 **Terry A Loring***, Department of Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131-0001, and **Tatiana Shulman**. *Lifting Problems and Noncommutative Semialgebraic Sets.*

The talk will focus on C*-algebra lifting problems involving approximate polynomial relations (soft polynomial relations).

A projective C*-algebra is the analog of an absolute retract. We demonstrate that various noncommutative semialgebraic sets are absolute retracts. In particular we show a noncommutative absolute retract results from the intersection of the approximate locus of a homogeneous polynomial with the noncommutative unit ball. By unit ball we are referring the C*-algebra of the universal row contraction. We show projectivity of alternative noncommutative unit balls. (Received February 23, 2010)

1059-46-226 **Jack Spielberg*** (spielberg@asu.edu), P.O. Box 871804, Tempe, AZ 85287-1804. *Some lifting results related to purely infinite C*-algebras.*

I will describe some techniques used to prove semiprojectivity for certain Kirchberg algebras. (Received February 23, 2010)

1059-46-251 **Mohamed A Khamsi*** (mohamed@utep.edu), Department of Mathematical Sciences, 500 West University Ave, El Paso, TX 79968. *Reflexive Metric Spaces and The Fixed Point Property.*

As for the linear case, compactness for the strong topology is very restrictive. Since the beginning of the fixed point theory, weak-compactness offered an acceptable alternative in Banach spaces. But when we deal with metric spaces, this natural extension is no longer easy to implement. One has to go back to the linear case and investigate the weak-topology with a new eye. First it is quite striking that convex subsets are closely related to the weak-topology. So it is natural to consider such concept in metric spaces. Two main directions have attracted most of the attention: the Menger convexity, and convexity structures. Depending on the metric space at hand, one of the two concepts rise higher. In this talk we will investigate where what is known so far and present some open related questions. (Received February 24, 2010)

47 ► Operator theory

1059-47-15 **Duane K. Allen*** (duane.allen@navy.mil), NSWC Corona Division (RA 14), P.O. Box 5000, Corona, CA 92507-3132. *A Partial Differential Operator for Boolean Expressions.* Preliminary report.

We define a partial differential operator for Boolean expressions. The operator maps a Boolean expression of n variables into 2n partial differential coefficients, n of which are for "in-phase" relationships and n for "opposite phase." Applications include the generation of test vectors for tests of combinatorial digital logic and the simplification of digital logic design. (Received December 30, 2009)

1059-47-30 **Behzad Djafari Rouhani*** (behzad@utep.edu), Mathematical Sciences Department, University of Texas at El Paso, 500 W. University Ave., El Paso, TX 79968. *Asymptotic behavior of solutions to some second order evolution equations.*

We consider the following class of second order nonhomogeneous evolution equations

$$\begin{cases} u''(t) + cu'(t) \in Au(t) + f(t) \quad \text{a.e.} \quad t \in (0, +\infty) \\ u(0) = u_0, \quad \sup_{t \geq 0} |u(t)| < +\infty \end{cases}$$

where A is a maximal monotone operator in a real Hilbert space H, c is a real number, and $f : \mathbb{R}^+ \to H$ is a given function. We study the asymptotic behavior of bounded solutions to these evolution equations. In particular, with suitable conditions on f, we show that for $c \leq 0$, solutions always converge weakly to an element of $A^{-1}(0)$, and strong convergence may not occur in general. In contrast, for $c > 0$, we show that solutions always converge strongly to an element of $A^{-1}(0)$. Some applications will be also presented. Our results for $c \leq 0$ extend previous results by several authors who assumed that $A^{-1}(0) \neq \phi$. The case of $c > 0$ was not previously studied and is new even for ordinary differential equations in one dimension. (Received February 02, 2010)

1059-47-88 **Rod Freed*** (gauss12@hotmail.com), 12939 Bonaparte #7, Marina Del Rey, CA 90066. *Green's Function and the Inverse of a Differential Operator.*

Let L2m([0,inf)) denote the space of L2 functions on [0,infinity)into Cm, and let F be the differential operator in L2m([0, inf))associated with f'(t) = Df(t), where f(0) is in B, a subspace of Cm. We prove that D has no eigenvalues on the imaginary axis and that Cm is a direct sum of Ker(R) and B (where R is the Riesz projection of D corresponding to the eigenvalues of D in the open left half plane) if and only if F is invertible. Also, we show that the inverse, G(h), of F is the operator which is the integral of g(t,s)h(s)with respect to s, where g(t,s) is exp(-tD)(I-P)exp(sD) for s<t and is -exp(-tD)P exp(sD) for t<s, where P is the projection of Cm along Ker(R) onto B. (Received February 18, 2010)

1059-47-208 **Mihai Putinar*** (mputinar@math.ucsb.edu), Mathematics Department, UCSB, Santa Barbara, CA 93106. *Positivstellensatze in the free-* context.*

A survey of the known decomposition results for positive elements of a free-* algbra (with supports) will be given. Examples and application to optimization will complement the theoretical results. (Received February 23, 2010)

49 ► Calculus of variations and optimal control; optimization

1059-49-143 **Ibrahim Fatkullin*** (ibrahim@math.arizona.edu), 617 N Santa Rita Ave, PO Box 210089, Tucson, AZ 85721. *Diffusive transport in two-dimensional nematics.*

One of the commonly used equations describing dynamics of the orientational degree of freedom in nematic liquid crystals is the so-called Doi equation. In essence, it is a kinetic equation for evolution of the orientation probability density of the system. I will present an analogue of this equation for spatially inhomogeneous systems and will discuss the associated problems of moment closure, reduction to Ginzburg-Landau type dynamics, and vortex dynamics. (Received February 22, 2010)

1059-49-146 **Behzad Djafari Rouhani** (behzad@utep.edu), Mathematical Sciences Department, University of Texas at El Paso, 500 W. University Ave., El Paso, TX 79968, and **Rasoul Azizi*** (razizi@miners.utep.edu), Mathematical Sciences Department, University of Texas at El Paso, 500 W. University Ave., El Paso, TX 79968. *A numerical method for an elliptic optimal control problem.*

We consider the following optimal control problem governed by an elliptic variational inequality:
$minimize\ J(u,y) = \frac{1}{2}\|y - y_d\|_H + \frac{\beta}{2}\|u\|_U$
subject to:
$(Ay - Bu - f,\, z - y) \geq 0\,;\, \forall\, z \in X\,,$
$u \in U\,,\, y \leq \psi\,,\, \psi \in H\,,$
$X = H_0^1(\Omega)\,,\ U = H = L^2(\Omega)$
Where β is a positive constant, y_d is an element of H, and f is in X^*. A is an operator from X to X^*, and B is a compact operator from U toX^*. This problem was considered by K. Ito and K. Kunisch. They showed that the Lagrange multiplier method guarantees the existence of a solution for the optimization problem. Often, these kinds of optimization problems are ill-posed, and we use regularization methods to approximate the solution. They derived necessary and sufficient conditions for the existence of a solution to the regularized problem. Here we extend the Ito and Kunisch's numerical results by analyzing the active-set algorithm they introduced, whose efficiency depends on the strict complementarity condition, and by investigating the convergence of the algorithm either with or without the strict complementarity condition. (Received February 24, 2010)

51 ► Geometry

1059-51-89 **Pierre PY*** (pierre.py@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 S. University Avenue, Chicago, IL 60637. *Actions of Kahler groups on real hyperbolic spaces.* Preliminary report.

We prove that any (Zariski dense) action of the fundamental group of a compact Kahler manifold on the real hyperbolic space of dimension at least 3 factors through a surjection onto the fundamental group of an (orbi) Riemann surface. This generalizes a classical theorem of Carlson and Toledo. This is part of a joint work with T. Delzant (Strasbourg). (Received February 18, 2010)

1059-51-157 **Genevieve S Walsh*** (genevieve.walsh@gmail.com), Tufts University Mathematics, 503 Boston Ave, Medford, MA 02155. *The window of a hyperbolic manifold with boundary.*

We will discuss the window of a hyperbolic manifold with boundary and show how it relates to the combinatorics of the domain of discontinuity. (Received February 22, 2010)

1059-51-161 **Ian P Biringer*** (ianbiringer@gmail.com), 84 Nash St, Apt 2, New Haven, CT 06511, and **Jesse Johnson** and **Yair Minsky**. *Pseudoanosov maps and handlebodies.*

Let f be a pseudoanosov self-homeomorphism of the boundary of a handlebody H. We will sketch a proof that the attracting lamination of f lies outside the Masur domain if and only if f has a power that partially extends to H. The proof relies upon algebraic limits of hyperbolic 3-manifolds. Time permitting, we will also discuss related questions and generalizations. (Received February 22, 2010)

1059-51-229 **Alexandra R Pettet*** (apettet@umich.edu), Department of Mathematics, University of Michigan, East Hall, Ann Arbor, MI 48109, and **James W Anderson** and **Hugo Parlier**. *Small filling sets of curves on a surface.*

We determine the asymptotic growth rate of the smallest size of a filling set of simple closed curves which pairwise intersect at most once on a closed surface of genus g. We then show that this is strictly smaller than the growth rate of a smallest filling set of systoles. This demonstrates that the topological condition that a set of curves pairwise intersect at most once is quite different from the geometric condition that a set of curves can arise as systoles. (Received February 23, 2010)

52 ► Convex and discrete geometry

1059-52-35 **Maria Angeles Alfonseca-Cubero*** (maria.alfonseca@ndsu.edu), Department of Mathematics, NDSU Dept # 2750, PO BOX 6050, Fargo, ND 58108. *Results on regularity of intersection bodies of star bodies.*

The intersection body of a star body B in $\mathbb{R}^n$ is defined as the body IB whose radial function is (up to constant) the Radon transform of the $(n-1)$-th power of the radial function of B. We will show necessary regularity and convexity conditions for a body of revolution to be an intersection body of a star body. (Received February 05, 2010)

1059-52-64 **Le Nhat Tuan*** (kid10462000@yahoo.com), 609 South Bruce St, Anaheim, CA 92804. *On the extremal problem of Polya.* Preliminary report.

The notion of transfinite diameter of planar sets was introduced by M. Fekete around 1920s. This concept plays an important role in the classical complex analysis and is related to other well-known concepts such as the logarithmic capacity and Chebyshev polynomials. For each $n \geq 3$, the n-diameter $d_n(E)$ of E is given by $d_n(E) = max\left\{\prod_{1\leq i<j\leq n} /z_i - z_j/^{\frac{2}{n(n-1)}}\right\}$

The following is the extremal problem of G. Polya: among all n-tuples $E = \{z_1, z_2, \cdots, z_n\}$ with $|z_i| \leq 1$, find one with the largest n-diameter. The solution of this problem, attributed to Polya, is $d_n(E) \leq n^{\frac{1}{n-1}}$ and the equality holds for n-tuples of equally spaced points on the boundary of D. While investigating the transfinite diameter of sets of constant width,Prof. Zair Ibragimov was led to the following weaker version of Polya's problem: among all n-tuples $E = \{z_1, z_2, \cdots, z_n\}$ with $|z_i - z_j| \leq 2$, find one with the largest n-diameter. He conjectured that the maximum is reached when this n-gon is regular, at least when n is odd. In this paper, I will present my solution of Ibragimov's problem for the case $n = 5$ and an "almost completed" approach for $n = 7$. (Received February 17, 2010)

1059-52-123 **Luis A Rademacher*** (lrademac@cse.ohio-state.edu), Dreese Labs 495, 2015 Neil Ave., Columbus, OH 43210. *On the monotonicity of the expected volume of a random simplex.* Preliminary report.

The slicing conjecture is one of the main open questions in asymptotic convex geometry, among other reasons, because of its connections with many other problems in convex geometry, such as isoperimetric inequalities, the Busemann-Petty problem, Sylvester's problem, etc. The conjecture is: every d-dimensional convex body of volume 1 has a hyperplane section of area at least a universal constant. A few years ago, M. Reitzner and M. Meckes asked independently the question below, motivated by the study of random polytopes as well as a strong connection with the slicing conjecture. In this talk we will see some of these problems, connection and applications, as well as a nearly complete answer to the question below:

Let a random simplex in a d-dimensional convex body be the convex hull of $d+1$ random points from the body. We study the following question: As a function of the convex body, is the expected volume of a random simplex monotone non-decreasing under inclusion? We show that this holds if d is 1 or 2, and does not hold if $d \geq 4$. We also prove similar results for the second moment of the volume of a random simplex and the determinant of the covariance matrix of a convex body. (Received February 21, 2010)

1059-52-139 **Catherine Stenson*** (stenson@juniata.edu), Department of Mathematics, Juniata College, 1700 Moore St., Huntingdon, PA 16652. *A Zonotopal Interpretation of Power in Weighted Voting Systems.* Preliminary report.

The states in the U.S. Electoral College, the parties in the Israeli Knesset, and the shareholders in a company are all players in weighted voting systems. Each player has a certain number of votes and casts them all for or against a proposal. The proposal passes if the total number of votes exceeds some quota. A player's influence is measured by the Banzhaf Power Index, which counts the ways in which a player's vote can be critical to passing a proposal. Two weighted voting systems are equivalent if they correspond to the same region in a particular hyperplane arrangement. We connect the Banzhaf Power Index to the coordinates of the vertices of the dual zonotope. We also give a geometric interpretation of changes in the quota. (Received February 22, 2010)

1059-52-245 **Raman Sanyal*** (sanyal@math.berkeley.edu), Department of Mathematics, 970 Evans Hall #3840, Berkeley, CA 94720. *On the geometry and combinatorics of fan arrangements.* Preliminary report.

The combinatorics of hyperplane arrangements is a classical subject in geometric combinatorics. More recent objects of interest are arrangements of tropical hyperplanes which furnish combinatorial structures not dissimilar to the classical setting. Both classical and tropical hyperplane arrangements find a common ground in the notion

of fan arrangements, that is, arrangements of complete, polyhedral fans. In this talk we report on work in progress regarding the geometry and combinatorics of fan arrangements. (Received February 23, 2010)

53 ► Differential geometry

1059-53-82 **Xiangwen Zhang*** (xzhang@math.mcgill.ca), Department of Mathematics and Statistics, McGill University, 805 Sherbrooke W., Montreal, Quebec H3A2K6. *A priori estimates for complex Monge-Ampère equation on Hermitian manifolds.*

I will talk about the regularity of complex Monge-Ampère type equations on Hermitian manifolds. Our main results give the C^1 and C^2 estimates for the solution of the complex Monge-Ampére equation, and also give the gradient estimates for the geometric solution of complex Hessian equation when the background manifold is Hermitian. (Received February 17, 2010)

1059-53-101 **Hugo Parlier*** (hugo.parlier@gmail.com), Department of Mathematics, University of Toronto, 40 St. George street, Toronto, Ontario M5S 2E4, Canada. *Sums of lengths of pants decompositions.*

It is a well known theorem of Bers that complete finite area hyperbolic Riemann surfaces admit short pants decompositions (of length bounded by constants, called Bers' constants, which only depend on genus g and number of cusps n). To measure the length of a pants decomposition, one often looks at the maximum length of curves that it is composed of but one also could consider the sum of the lengths. Both measures give rise to different quantifications of Bers' constants.

The talk will be about new results concerning sums of lengths. In particular the goal will be to show that these constants behave very differently if one lets the genus grow or if instead one lets the number of cusps grow. The results concerning the genus growth are joint with L. Guth and R. Young, and the results concerning cusp growth are joint with F. Balacheff and S. Sabourau. (Received February 19, 2010)

1059-53-106 **J. Davidov** and **G. Grantcharov*** (grantchg@fiu.edu), Department of Mathematics, Florida International University, Miami, FL 33199, and **O. Muskarov** and **M. Yotov**. *Pseudo-Riemannian metrics and para-hypercomplex structures.* Preliminary report.

Para-hypercomplex structure is a triple (I,S,T) of anti-commuting endomorphisms, where I is a complex structure and S and T are product structures. A natural choice of compatible metric is one for which I, S, T are skew-symmetric. Such metric is called para-hyperhermitian and has split signature.

In this talk we discuss the geometry of the para-hyperhermitian structures. First we look at the existence problem on compact complex surfaces. Then we present a quotient construction and show that they also naturally appear on some moduli spaces. (Received February 19, 2010)

1059-53-138 **Eveline Legendre*** (eveline.legendre@cirget.ca), Departement de mathematiques UQAM, C.P. 8888 Succ. Centre-ville, Montreal, Quebec H3C3P8, Canada. *Toric geometry of convex quadrilaterals.*

In the toric case, extremal Kähler and Sasaki metrics correspond to solutions of the Abreu equation on labeled polytopes via the Delzant-Lerman-Tolman correspondence. We will present an explicit resolution of the Abreu equation on convex labeled quadrilaterals. This confirms a conjecture of Donaldson in this particular case and implies a complete classification of the explicit toric Kähler–Einstein and toric Sasaki-Einstein metrics constructed by Gaunlett, Martelli, Sparks and Waldram (Adv. Theor. Math. Phys. 2004). As a byproduct, we show that for a toric orbi–surface with 4 fixed points of the torus action, the vanishing of the Futaki invariant is a necessary and sufficient condition for the existence of a Kähler metric with constant scalar curvature. (Received February 22, 2010)

1059-53-149 **Ralph R Gomez*** (rgomez1@swarthmore.edu), 500 College Avenue, Swarthmore, PA 19081. *Negative Sasakian Geometry In Dimension Five.*

In this talk, we will report on an affirmative answer to an open problem posed by C. Boyer and K. Galicki: Do negative Sasakian structures exist on all connected sums of $S^2 \times S^3$? If time permits, we will address other aspects of negative Sasakian manifolds in dimension five. (Received February 22, 2010)

1059-53-160 **Robert K Hladky*** (robert.hladky@ndsu.edu), Department of Mathematics, NDSU Dept # 2750, PO BOX 6050, Fargo, ND 58108. *Generalizing the Tanaka-Webster connection to subRiemannian manifolds.*

The Tanaka-Webster connection has proved to be a powerful tool in studying strictly pseudoconvex pseudohermitian man- ifolds. In this talk, we shall consider a non-standard definition of this connection that generalizes nicely to subRiemannian geometry. We'll look at how this connection can be used to extend Riemannian results to the subRiemannian setting and consider some consequences of the natural generalizations of the pseudohermitian notion of normality. (Received February 22, 2010)

1059-53-168 **Jaime Cuadros*** (jcuadros@math.mcmaster.ca), Hamilton Hall 311, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada. *Null Sasaki η-Einstein Structures in Five Manifolds.*

We study null Sasakian structures in dimension five. First, we improve previous result of Boyer et al. and prove that simply connected manifolds diffeomorphic to $\#k(S^2 \times S^3)$ admit null Sasaki η-Einstein structures if and only if $3 \leq k \leq 21$. We also determine the moduli space of simply connected null Sasaki η-Einstein structures. This is accomplished using information on the moduli of lattice polarized K3 surfaces of the minimal resolutions of a K3 surface with cyclic singularities. Then, applying the non-degeneracy of the quadratic form in the Sasakian manifold, naturally induced by basic cohomology, we give an explicit expression for the moduli space. (Received February 22, 2010)

1059-53-184 **Weiyong He*** (whe@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *The space of volume forms and the Donaldson equation.*

S.K. Donaldson introduced an interesting nonlinear operator for the geodesic equation in the space of volume forms on a compact Riemannian manifold. First we derive estimates to solve the Dirichlet problem of the geodesic equation with applications to the geometric structure of the space of volume forms set up by Donaldson. This new operator is also relevant to some interesting free boundary problems. We shall also consider this operator on Euclidean space. One should be able to classify entire solutions of nonlinear operator. We show this classification by assuming a technical condition. Moreover, entire solutions we construct also give infinite many nontrivial entire solutions to complex Monge-Ampere equation. (Received February 23, 2010)

1059-53-190 **Justin C Pati*** (jpati@math.unm.edu), Department of Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131-0001. *Invariants of toric contact manifolds.*

We construct and show how to distinguish contact structures on contact manifolds with the action of a compact Lie group of Reeb type. (Received February 23, 2010)

1059-53-199 **Colin Guillarmou** (cguillar@math.unice.fr), Laboratoire J. Dieudonne, CNRS, Universite de Nice, 06100 Parc Valrose, Nice, France, and **Jie Qing*** (qing@ucsc.edu), Department of Mathematics, UC Santa Cruz, Santa Cruz, CA 95064. *Conformal geometry and scattering operators.*

In this talk, we report our work on a sharp spectral characterization of conformally compact Einstein manifolds with conformal infinity of positive Yamabe type. (Received February 23, 2010)

1059-53-219 **Brett L Kotschwar*** (kotschwar@math.mit.edu), 77 Massachusetts Insitute of Technology, Building 2, Room 279, Cambridge, MA 02139. *Some unique continuation results with applications to the Ricci flow.*

We describe some recent work on unique continuation problems for nonlinear weakly-elliptic and weakly-parabolic systems arising in the study of the Ricci flow. (Received February 23, 2010)

1059-53-243 **Vincent Bonini*** (vbonini@calpoly.edu), Mathematics Department, California Polytechnic State University, San Luis Obispo, CA 93407, and **José Espinar** (jespinar@ugr.es) and **Jie Qing** (qing@ucsc.edu). *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 a 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 February 23, 2010)

57 ► Manifolds and cell complexes

1059-57-1 **Kenneth Bromberg*** (bromberg@math.utah.edu), Department of Mathematics, University of Utah, 155 S 1400 E, Salt Lake City, UT 84112. *The topology of deformation spaces of Kleinian groups.*

A Kleinian group is a discrete subgroup of $PSL(2,\mathbb{C})$. They were originally studied by complex analysts but after Thurston's hyperbolization theorem in the seventies they became a central topic in low dimensional topology and hyperbolic geometry. In the last decade many of the classical conjectures for Kleinian groups have been solved: Marden's tameness conjecture, the Bers-Sullivan-Thurston density conjecture and Thurston's ending lamination conjecture. This last conjecture gives a complete classification of finitely generated Kleinian groups. However, the classifying map is not a homeomorphism for any natural topology on the space of classifying objects. We will give an overview of what is known about the topology of spaces of Kleinian groups and discuss some open conjectures. (Received February 23, 2010)

1059-57-22 **Henry Segerman*** (henrys@math.utexas.edu), Department of Mathematics, 1 University Station C1200, Austin, TX 78712. *A generalisation of the deformation variety.*

The deformation variety is similar to the representation variety in that it describes (generally incomplete) hyperbolic structures on 3-manifolds with torus boundary components. However, the deformation variety depends crucially on a triangulation of the manifold: there may be entire components of the representation variety which can be obtained from the deformation variety with one triangulation but not another, and it is unclear how to choose a "good" triangulation that avoids these problems. I will describe the "extended deformation variety", which deals with many situations that the deformation variety cannot. In particular, given a manifold which admits some ideal triangulation we can construct a triangulation such that we can recover any irreducible representation (with some trivial exceptions) from the associated extended deformation variety. (Received January 25, 2010)

1059-57-50 **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, George Washington University, Washington, DC 20057. *Quandles and their Homology.*

Quandles are algebraic structures introduced by David Joyce in his 1979 Ph.D. thesis as a powerful tool for classifying knots (They also were introduced, independently, by S. Matveev). Even earlier, in 1942 Mituhisa Takasaki introduced an algebraic structure he called Kei (in Joyce terminology – involutive quandle). The main example Takasaki was considering was obtained from an abelian group G by defining the binary operation $*$ by $a * b = 2a - b$. We call such a quandle a Takasaki quandle. Rack homology (of racks and quandles) were first defined and studied by Fenn-Rourke-Sanderson in 1995, and a modification to quandle homology theory was given by Carter-Kamada-Saito. We survey in this talk various method of computng homology of quandles. In particular, we discuss the conjecture that for a finite quandle X which is a quasigroup (i.e.$a * x = c$ has the unique solution) the torsion of its homology is annihilated by $|X|$. (Quasigroup condition is needed as there is 6-element connected quandle whose torsion is not annihilated by 6). Another result which will be discussed is my theorem with M.Niebrzydowski that $H_2^Q(R_{4k}) = Z_2^2 \oplus Z^2$, where R_{4k} is the Takasaki quandle of the cyclic group Z_{4k} (i.e. dihedral quandle). (Received February 10, 2010)

1059-57-93 **Matthew B. Day*** (mattday@caltech.edu), Department of Mathematics 253-37, Caltech, Pasadena, CA 91125. *Topological simplification of maps between surfaces.* Preliminary report.

The stable commutator length (scl) of a 1-cycle c in a topological space X is essentially the infimum of the stabilized Euler characteristic of all surfaces mapping to X that virtually bound c. I consider the case where X is a surface, where I show that scl can be computed by taking the same infimum over a restricted class of maps. In particular, we only need maps that are local homeomorphisms away from finitely many branch points and half-twists. A corollary gives new lower bounds for scl on closed surfaces. In some examples these bounds are sharp and lead to new examples of extremal surfaces. (Received February 18, 2010)

1059-57-105 **Aaron Magid***, 1301 Mathematics Building, University of Maryland, College Park, MD 20742. *The Topology of Deformation Spaces of Kleinian Groups.*

For any closed surface S, the deformation space AH(S) is the space of all marked hyperbolic 3-manifolds homotopy equivalent to S. After reviewing some of the classical results that describe topology of the interior of AH(S),

we will show that there are certain points on the boundary where AH(S) is not locally connected. This is a generalization of Ken Bromberg's result that the space of Kleinian punctured torus groups is not locally connected. (Received February 19, 2010)

1059-57-114 **Loretta Bartolini*** (bartolini@math.okstate.edu), Department of Mathematics, 401 Mathematical Sciences, Stillwater, OK 74078-1058. *One-sided Heegaard splittings and Dehn filling.*

Heegaard splittings along orientable surfaces are well-known in 3-manifold theory: the manifold is split into a pair of handlebodies, the embedded discs for which can be used combinatorially to obtain information about both the splitting and the manifold. However, when a non-orientable surface is used in an orientable manifold, the associated Heegaard splitting is one-sided and a single handebody is obtained.

There are many natural parallels between one- and two-sided Heegaard splittings, however there are striking and far-reaching differences: the presence of singular meridian discs; and, the connection with $\mathbb{Z}_2$ homology. Both properties serve to hamper existing methods, whilst offering new approaches.

Given the direct connection between geometrically incompressible splittings and $\mathbb{Z}_2$ homology classes of the manifold, a finer degree of control of one-sided splitting surfaces can be established over their two-sided counterparts. In particular, a recent result determines possible isotopies of incompressible non-orientable surfaces under Dehn filling. (Received February 20, 2010)

1059-57-133 **Ilesanmi Adeboye*** (adeboye@math.ucsb.edu), Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 93106. *On volumes of hyperbolic orbifolds.*

One notable aspect of the study of covolumes of Kleinian groups is the variety in the techniques that have been brought to bear. In this talk, we show how revisiting H. C. Wang's results on discrete subgroups of Lie groups, plus a little differential geometry, leads to an explicit lower bound for the volume of a hyperbolic orbifold in any given dimension. This is joint work with Guofang Wei. (Received February 22, 2010)

1059-57-137 **Louis H. Kauffman*** (kauffman@uic.edu), 5530 South Shore Drive, Apartment 7C, Chicago, IL 60637-1946. *Topological Quantum Information, Khovanov Homology and the Jones Polynomial.*

In this paper we give a quantum statistical interpretation for the bracket polynomial state sum $< K >$ and correspondingly for the Jones polynomial. We use this quantum mechanical interpretation to give a new quantum algorithm for computing the Jones polynomial. This algorithm is useful for its conceptual simplicity, and it applies to all values of the polynomial variable that lie on the unit circle in the complex plane. Letting $C(K)$ denote the Hilbert space for this model, there is a natural unitary transformation U from $C(K)$ to itself such that $< K >=< \phi|U|\phi >$ where $|\phi >$ is a sum over basis states for $C(K)$. The quantum algorithm arises directly from this formula via the Hadamard Test. We then show that the framework for our quantum model for the bracket polynomial is a natural setting for Khovanov homology in which the unitary transformation U takes the role of the Jones polynomial, and the eigenvalues of U determine the decomposition of the chain complex for the Khovanov homology. (Received February 22, 2010)

1059-57-144 **Jason DeBlois*** (jdeblois@math.uic.edu) and **Peter B. Shalen**. *Volume and topology of hyperbolic 3-manifolds with totally geodesic boundary.*

I will speak about joint work with Peter Shalen relating the geometry of a hyperbolic 3-manifold with totally geodesic boundary to its topology, and also about work in progress on improving our estimates. (Received February 22, 2010)

1059-57-172 **Mangahas Johanna*** (mangahas@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *A Recipe for Short-word Pseudo-Anosovs.*

Suppose some subset of the mapping class group of a surface generates a subgroup containing a pseudo-Anosov. One can find a particular pseudo-Anosov with bounded length in the word metric induced by this subset, where the bound depends only on the surface. We describe how one goes about this. (Received February 22, 2010)

58 ► Global analysis, analysis on manifolds

1059-58-16 **Daniel F Cibotaru** (cibotaru.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556, and **Liviu I Nicolaescu*** (nicolaescu.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Riemann-Roch and Morse theory.*

To each Morse function f on a Riemann surface Σ and any level set $\Sigma_t = f^{-1}(t)$ of f we associate an integer i_t such that i_t is zero for all by finitely many t's and $\sum_t i_t$ equals the index of the Dolbeault operator on Σ. When t is a regular value of f the integer i_t is described as a local spectral flow, and can be expressed in terms of the mean curvature of Σ_t. When t is a critical value, then i_t is equal to the Kashiwara-Wall index of a triplet of lagrangians spaces canonically and explicitly determined by the geometry of the singular level set Σ_t. The proof is based on a degenerative study of Atiyah-Patodi-Singer boundary value problems of "short" cobordisms of the form $f^{-1}\big([t-\varepsilon, t+\varepsilon]\big)$, $\varepsilon \searrow 0$. (Received January 06, 2010)

1059-58-23 **Martin J Schmoll*** (schmoll@clemson.edu), Clemson University, Martin Hall O-017, Clemson, SC 29634. *Veech groups for cyclic covers of translation surfaces.*

We talk about ongoing work on infinite genus abelian differentials, also known as translation surfaces. For surfaces with cyclic automorphism groups, like $\mathbb{Z}^n$, we try to describe the zero holonomy locus in a certain parameter space. The zero holonomy locus eventually contains lattice surfaces. We give a precise description for cyclic covers of the standard translation torus branched over finitely many points. In particular we calculate many Veech groups for the torus case explicitly. (Received January 26, 2010)

60 ► Probability theory and stochastic processes

1059-60-26 **Junyue Xu** (jxu2@tigers.lsu.edu), Department of Economics, Louisiana State University, Baton Rouge, LA 70803, **Eric Hillebrand** (erhil@lsu.edu), Department of Economics, Louisiana State University, Baton Rouge, LA 70803, and **Ambar Niel Sengupta*** (sengupta@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Temporal Correlation of Defaults in Subprime Securitization.* Preliminary report.

We use Gaussian copula methods to study temporal correlation of defaults of subprime mortgages and corresponding tranche losses in securitized structures. (Received January 31, 2010)

1059-60-47 **Tiefeng Jiang*** (tjiang@stat.umn.edu), 313 Ford Hall, 224 Church Street, Minneapolis, MN 55110. *Moments of Traces for Beta-circular Ensembles.*

Let $\theta_1, \cdots, \theta_n$ be random variables from Dyson's β-circular ensemble with density $Const \cdot \prod_{1\le j<k\le n} |e^{i\theta_j} - e^{i\theta_k}|^\beta$. For each $n \ge 2$ and $\beta > 0$, we obtain inequalities on $\mathbb{E}\big[p_\mu(Z_n)\overline{p_\nu(Z_n)}\big]$, where $Z_n = (e^{i\theta_1}, \cdots, e^{i\theta_n})$ and p_μ is the power-sum symmetric function for partition μ. When $\beta = 2$, our inequalities recover an identity by Diaconis and Evans for Haar-invariant unitary matrices. Further, we have

(a) $\lim_{n\to\infty} \mathbb{E}\Big[p_\mu(Z_n)\overline{p_\nu(Z_n)}\Big] = \delta_{\mu\nu}\left(\frac{2}{\beta}\right)^{l(\mu)} z_\mu$ for any $\beta > 0$;

(b) $\lim_{m\to\infty} \mathbb{E}|p_m(Z_n)|^2 = n$ for any $n \ge 2$ and $\beta > 0$,

where $l(\mu)$ is the length of μ and z_μ is explicit on μ. These results apply to the three important ensembles: COE ($\beta = 1$), CUE ($\beta = 2$) and CSE ($\beta = 4$). The tool is Jack function. This is a joint work with Sho Matsumoto. (Received February 09, 2010)

1059-60-53 **Hasanjan Sayit*** (hs7@wpi.edu), 100 Institute road, Worcester, MA 01609, and **Viens Frederi** (viens@stat.purdue.edu), Purdue University, West Lafayette, IN 47907. *Arbitrage free models in markets with transaction costs.*

In this note, we study no-arbitrage conditions in a market with multiple risky assets and proportional transaction costs. We present a condition which is sufficient for the market to be arbitrage-free and investigate its properties. In particular, we provide examples of price processes that are not semimartingales but are consistent with absense of arbitrage. (Received February 11, 2010)

1059-60-80 **Soumik Pal*** (soumikpal@gmail.com), C-547 Padelford Hall, University of Washington, Seattle, WA 98195. *Spectral properties of large regular random graphs.*

Regular random graphs are important models in probabilistic combinatorics and have sustained interest for decades. Recent theory, spurred in part by the study of Expanders, have focussed on spectral properties of the adjacency matrices of a sequence of regular random graphs with a fixed degree and a growing number of vertices (order). A striking example in this vein is the celebrated proof of the Alon Conjecture by Joel Friedman. We will talk about the case when the degree also grows, albeit slowly, with the order. Although the graphs remain sparse, their spectral properties begin to resemble those of the Gaussian Orthogonal Ensemble, or real Wigner matrices. This can be seen in the convergence of the empirical spectral distribution to the semicircular law and theorems that indicate that their eigenvectors are approximately uniformly distributed over the sphere. This is consistent with already existing empirical evidence of spectral properties of regular random graphs of "not-small" degrees. Our methods are a combination of analytical tools such as Stieltjes transforms and combinatorial ideas such as local tree approximation. This is based on joint work with Ioana Dumitriu. (Received February 17, 2010)

1059-60-91 **Hongzhong Zhang** (union4v@yahoo.com), 365 5th ave, New York, NY 10016, and **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu), 365 5th ave, New York, NY 10016. *Drawdowns, drawups and financial risk management.*

In this work we study drawdowns and drawups of general diffusion processes. The drawdown process is defined as the current drop of the process from its running maximum, while the drawup process is defined as the current increase over its running minimum. The drawdown and the drawup stopping times are the first hitting times of the drawdown and the drawup processes respectively. We derive a closed-form formula for the Laplace transform of the probability density of the drawdown of a units when it precedes the drawup of b units. We then discuss an application of these results in financial risk management. In particular, consider a digital with a unit payoff on the event that a drawdown precedes a drawup. Such an instrument would provide insurance against adverse movements in the market and could thus be of interest to an investor. Using model-free relationships derived in this work, we are able to provide a robust replication of this instrument using One-touch knockouts. Under extra assumptions on the underlying process we show that it is also possible to derive semi-static replication using single-barrier and plain digital options. (Received February 18, 2010)

1059-60-96 **Dapeng Zhan*** (zhan@math.msu.edu), Department of Mathematics, East Lansing, MI 48824. *Reversibility of Whole Plane SLE.*

Whole plane SLE is viewed as the limit of radial SLE if the target, say b, is fixed and the domain tends to the whole Riemann sphere without a single point, say a. It describes a random curve in the Riemann sphere that grows from a to b. The curve is simple if the parameter $\kappa \leq 4$. In this talk I will explain my recent work: whole plane SLE satisfies reversibility if $\kappa \leq 4$, which means that the reversal of the whole plane SLE curve from a to b agrees with the whole plane SLE curve from b to a, after suitable reparametrization. The proof uses two tools: one is the stochastic coupling technique, which was used to prove the reversibility of chordal SLE when $\kappa \leq 4$, and the duality of SLE; the other is the annulus Loewner equation, which was introduced to define SLE in doubly connected domains. The main idea of the proof is to grow a pair of whole plane SLE, one is from a to b, the other is from b to a, such that they are weakly independent before they meet, and every point on one curve is visited by the other curve, and so the two curves overlap. From this result, we see that the radial SLE curve near its target point behaves similarly to the whole plane SLE curve near its initial point. (Received February 18, 2010)

1059-60-100 **Elizabeth Meckes*** (ese3@case.edu), Department of Mathematics, CWRU, 10900 Euclid Ave., Cleveland, OH 44122. *Another observation about operator compressions.*

Let T be a self-adjoint operator on a finite dimensional Hilbert space. It is shown that the distribution of the eigenvalues of a compression of T to a subspace of a given dimension is almost the same for almost all subspaces. This is a coordinate-free analogue of a recent result of Chatterjee and Ledoux on principal submatrices. The proof is based on measure concentration and entropy techniques, and the result improves on some aspects of the result of Chatterjee and Ledoux. This is joint work with Mark Meckes. (Received February 19, 2010)

1059-60-121 **Dan Romik***, UC Davis. *The oriented swap process.*

In the oriented swap process, particles numbered 1 through N are arranged on the integer lattice, originally in increasing order. Subsequently, each pair of adjacent particles try to swap with exponential rate 1 and independently of all other pairs, succeeding iff the particle to the left has a lower index than the particle to the right. I will discuss the recent analysis of the asymptotic behavior of this interacting particle system in joint work

with Omer Angel and Alexander Holroyd. The Tracy-Widom distribution from random matrix theory appears as the limiting distribution of the "finishing times" of individual particles. An interesting open question, whose answer will also probably come from random matrix theory, is to find the limiting distribution of the termination time of the entire system. (Received February 21, 2010)

1059-60-134 **Robert O. Bauer*** (rbauer13@illinois.edu), Department of Mathematics, Altgeld Hall, 1409 W. Green St., Urbana, IL 61801. *3D SLE and models for protein folding.*

We discuss a 3 dimensional analogue of a "decorated" SLE process and its motivation in terms of the molecular biology of protein folding. (Received February 22, 2010)

1059-60-140 **Dragos Bozdog*** (Dragos.Bozdog@stevens.edu), Stevens Institute of Technology, Dept. of Mathematical Sciences, 1 Castle Point on Hudson, Hoboken, NJ 07030, and **Ionut Florescu**, **Khaldoun Khashanah** and **Jim Wang**. *Rare Events Detection and Analysis of High-Frequency Financial Data.*

In this work we present a methodology to detect rare events defined as large price movement relative to the volume traded. We analyze the behavior of equities after these detected rare events. We provide methods to calibrate trading rules based on the detection of these events and we exemplify for a particular trading rule. We apply the methodology to tick data for thousands of equities over a period of five days. In order to draw comprehensive conclusions we group the equity into classes and we calculate probabilities of price recovery after these rare events for each class. The methodology developed is based on non-parametric statistics and makes no assumption about the distribution of the random variables in the study. (Received February 22, 2010)

1059-60-142 **Paul Gassiat**, **Huyen Pham** and **Mihai Sirbu*** (sirbu@math.utexas.edu), 1 University Avenue, C1200, Austin, TX 78712. *Optimal investment on finite horizon with random discrete order flow in il liquid markets.*

We study the problem of optimal portfolio selection in an illiquid market with discrete order flow. In this market, bids and offers are not available at any time but trading occurs more frequently near a terminal horizon. The investor can observe and trade the risky asset only at exogenous random times corresponding to the order flow given by an inhomogenous Poisson process. By using a direct dynamic programming approach, we first derive and solve the fixed point dynamic programming equation and then perform a verification argument which provides the existence and characterization of optimal trading strategies. We prove the convergence of the optimal performance, when the deterministicintensity of the order flow approaches infinity at any time, to the optimal expected utility for an investor trading continuously in a perfectly liquid market model with no-short sale constraints. (Received February 22, 2010)

1059-60-166 **Tom Kennedy*** (tgk@math.arizona.edu) and **Gregory Lawler**. *Conformal invariance and covariance of the two-dimensional self-avoiding walk.*

The probability measure for the self-avoiding walk (SAW) in a planar domain between two boundary points is conjectured to be conformally invariant. If one considers the "total mass" of SAW's between two boundary points, then one is led to consider SLE partition functions which are conjectured to be conformally covariant. In this talk we first show that by considering bridges or cut lines for SAW's in the half plane, one can efficiently simulate SAW's that are not constrained to end at a fixed point. This allows Monte Carlo tests of the conjecture involving SLE partition functions. These tests show that the predictions of SLE partition functions for hitting densities must be corrected for lattice effects that persist in the scaling limit. We study these lattice effects by simulation and formulate a precise conjecture for them. (Received February 22, 2010)

1059-60-195 **Torben G. Andersen** (t-andersen@kellogg.northwestern.edu), 2001 Sheridan Road, Evanston, IL 60208, **Oleg Bondarenko** (olegb@uic.edu), 601 South Morgan Street, Room 2431, Chicago, IL 60607-7124, and **Maria T. Gonzalez-Perez*** (m-gonzalezperez@kellogg.northwestern.edu), 2001 Sheridan Road, Evanston, IL 60208. *The Corridor Implied Volatility and the VIX during the financial crisis: October 2008 - April 2009.*

The new CBOE's VIX index is estimated as a weighted average of SPX call and put option prices over a range of strikes. Nevertheless, the official strike range does not consistently cover a regular density mass of the underlying density function, which can produce substantial errors in measuring the expected risk in the US market, especially when the underlying price changes significantly. In this article, (i) we estimate an ultra-high frequency Corridor Implied Volatility (CIV) index, that considers an invariant feature of the underlying (SPX) density function, (ii) and compare its information content with the VIX's from October 2008 to April 2009. Our results reveal that

this CIV measure includes useful information for risk managers that is not included on the VIX. An empirical exercise is included to show this. (Received February 23, 2010)

1059-60-204 **Libor Pospisil**, Department of Statistics, New York, NY 10027, and **Jan Vecer***, Department of Statistics, New York, NY 10027. *Maximum Drawdown of a Jump-Diffusion Process and the Corresponding Partial Integro-Differential Equations.* Preliminary report.

In this talk, we assume that the price of an asset can be modeled as a diffusion process plus a compound Poisson process. Subsequently, we address the question of pricing contracts involving maximum drawdown of the asset. Given the complexity of the underlying model, the most suitable method is deriving the partial integro-differential equations and solving them numerically. The special feature of the equations is the presence of the running maximum and the running maximum drawdown, which may be discontinuous due to the jumps in the asset price. We will also discuss the question of hedging. (Received February 23, 2010)

1059-60-239 **Igor Rumanov*** (igorrumanov@math.ucdavis.edu), UC Davis, Department of Mathematics, 1 Shields Avenue, Davis, CA 95616. *PDE for spectral gap probabilities of random single and coupled matrices and Toda lattice.* Preliminary report.

Direct connection is exposed between the equations in random matrix (RM) theory, derived by different - Tracy-Widom and Adler-Shiota-van Moerbeke - methods. Simple relations hold between the gap probabilities considered as ratios of 1-dim. Toda lattice τ-functions and functions in the resolvent kernel of Fredholm operator approach to the probabilities. A unified description of RM unitary ensembles (UE) is found in terms of universal, i.e. independent of the specific ensemble, PDE for gap probabilities. At the core of our study was the tie of orthogonal polynomials (OP) with 1-Toda lattice. Toda-AKNS system provides a common structure of PDE for UE, appearing in different guises: one arises from OP-Toda lattice relations, while the other comes from Schlesinger equations. Similar relations for coupled matrices, based on 2-dim. Toda lattice, exist and help the harder treatment of the case. The joint probability for largest eigenvalues of two coupled Gaussian matrices satisfies a number of different PDE, besides the previously known Adler-van Moerbeke equation (AvM). Some of the new equations have Painlevé IV equation as 1-matrix limit, in contrast to the AvM equation, trivial in this limit. The situation resembles the case of several endpoints for the 1-matrix ensemble. (Received February 23, 2010)

62 ► Statistics

1059-62-46 **Raj Rao Nadakuditi*** (rajnrao@umich.edu), Department of EECS, 1301 Beal Avenue, Ann Arbor, MI 48109, and **Florent Benaych-Georges**. *Phase transitions in the eigenvalues and eigenvectors of perturbed random matrices.*

Motivated by applications in statistical signal processing and randomized numerical linear algebra, we consider the eigenvalues and eigenvectors of finite, low rank perturbations of random matrices. We uncover a remarkable phase transition phenomenon whereby the large matrix limit of the extreme eigenvalues of the perturbed matrix differs from that of the original matrix if and only if the eigenvalues of the perturbing matrix are above a certain critical threshold. This critical threshold is intimately related to the integral transforms of the spectral measure in a manner that we make explicit. Various extensions of our results are discussed. (Received February 09, 2010)

1059-62-153 **Carlos A. Ulibarri*** (ulibarri@nmt.edu), Department of Management, New Mexico Tech, 801 Leroy Place, Socorro, NM 87131. *EGARCH analysis of 'naked' short-selling constraints.*

This paper uses EGARCH methods to examine the efficacy of recent policy initiatives taken by the U.S. Securities and Exchange Commission (SEC) banning naked 'short-selling' of specific financial stocks (SEC, 2008 a,b,c). The EGARCH results indicate the constraints on short-selling had non-uniform impacts on the persistence and leverage-effects associated with price volatility. These findings suggest a "focused approach" to market regulation would be a more efficient means of safeguarding price discovery and market liquidity. This conclusion is largely in accord with recent policy analysis and proposals outlined in Avgouleas (2009). (Received February 22, 2010)

1059-62-230 **Wai Kong J Pang*** (wpang@monmouth.edu). *Hypothesis Testings in Hilbert Spaces.*

The one-sample problem will be considered in this talk. Generalization to Euclidean spaces can be obtained by applying Roy's union - intersection principle in combination with the univariate technique; this yields a studentized statistic based on the sample covariance matrix which is referred to as Hotelling's statistic. It will be shown that a further extension to Hilbert spaces along similar lines will break down. One alternative is to project

the data on a Euclidean space of sufficiently high dimension and construct a Hotelling T^2. This procedure leaves the question of how to decide on the dimension open. Another alternative is to regularize the sample covariance operator but this turns out to yield a statistic whose asymptotic distribution depends on the unknown eigenvalues of the population covariance operator. A better alternative regards modifying the hypothesis which will be called the "neighborhood hypothesis". An example of a neighborhood hypothesis would be the assumption that the mean value function is approximately zero, rather than exactly zero. This assumption may not only be more realistic, but the natural test statistic now simply has a normal distribution in the limit and only the variance of this distribution remains to be estimated. (Received February 23, 2010)

1059-62-240 **Jean M Foster*** (jean.foster@alumni.duke.edu), MS D446, Los Alamos, NM 87545, **Jasper Vrugt** (jasper@uci.edu), 4130 Engineering Gateway, Irvine, CA 92697, **Cathy Wilson** (cjw@lanl.gov), MS D446, Los Alamos, NM 87545, and **Joel Rowland** (jrowland@lanl.gov), MS D401, Los Alamos, NM 87545. *Application of Markov Chain Monte Carlo simulations to detect the impact of climate change on river discharge time series records of arctic rivers.*

There is a wealth of river discharge data that can be used to assess changes in Arctic hydrology resulting from climate change. In this talk, I will present preliminary findings of a Markov Chain Monte Carlo (MCMC) data analysis framework that is used to detect changes in the active layer in permafrost dominated landscapes. (Received February 23, 2010)

65 ► Numerical analysis

1059-65-3 **Ioana Dumitriu*** (dumitriu@math.washington.edu), University of Washington, Department of Mathematics, BOX 354350, Seattle, WA 98195. *Random matrix theory, numerical linear algebra, and scientific computing: border interactions.*

The connection between numerical linear algebra and random matrix theory is simple but deep: the latter solves stochastically one of the most important problems of the former—computing eigenvalues (singular values) and eigenvectors (singular vectors). Naturally, methods from (numerical) linear algebra have been applied successfully to the study of large random matrices, and random matrices have been used as "average case" tests for algorithms known in practice to vastly outperform their worst-case theoretical bounds.

The connections between these fields, however, are even deeper, and lead in one direction to the discovery and study of new matrix models for well-known (theoretical) eigenvalue ensembles. In the other direction, these connections lead to applications in scientific computing, involving the use of randomization and random matrix theory to obtain faster and more reliable algorithms for eigenvalue/singular value computations. As a bonus, these algorithms prove to also be, communication-wise, within a constant factor of optimal.

We will survey some of the new results in the area and examine further opportunities for research using such "border interactions" between these fields of mathematics and computational science. (Received February 23, 2010)

1059-65-48 **Grey Ballard*** (ballard@eecs.berkeley.edu), **James Demmel** and **Ioana Dumitriu**. *Communication Bounds for Sequential and Parallel Eigenvalue Problems.*

We propose a set of divide-and-conquer eigenvalue algorithms that minimize communication (between levels of memory on a sequential computer and between processors on a parallel computer) in an asymptotic sense. The algorithms use as building blocks matrix multiplication and QR decomposition, each of which can be implemented by communication-optimal algorithms. The algorithms depend on a randomized rank-revealing QR decomposition to minimize the communication complexity while keeping the algorithms stable. (Received February 09, 2010)

1059-65-99 **Andrzej Marcin Pownuk*** (ampownuk@utep.edu), Department of Mathematical Sciences, The University of Texas at El Paso, 500 West University Avenue, El Paso, TX 79968-0514, and **Michal Betkowski**. *Calculating Risk of Cost in Civil Engineering Projects by Using Imprecise Probability and HPC Computing.*

There is a difference between the real and the estimated cost of the civil engineering projects. Unfortunately, in civil engineering usually we do not have enough data to calculate reliable probabilistic characteristics. In such situation it is possible to apply interval parameters, fuzzy parameters, random sets or subjective probability. Probabilistic characteristics can be modeled by random numbers (which are defined by the expert) with the uncertain parameters. The total cost is described by probability density functions with the interval parameters

(for example interval mean or interval standard deviation), p-boxes (if the type of the PDF is unknown) or fuzzy random probability distribution function. Using assessment from different (or even one) experts it is possible to estimate the uncertainty of the probability density function of the partial costs. Using modified Monte-Carlo simulation it is possible to calculate the uncertain risk curve.

In order to solve large scale and complex problems it is necessary to apply parallel HPC computing. Calculations were done on 42 core MPICH2 MPI cluster. (Received February 19, 2010)

70 ► Mechanics of particles and systems

1059-70-244 **xiantao Li*** (xli@math.psu.edu), 219C McAllister Bld, University Park, PA 17802. *Numerical simulations of crack propagation.*

The dynamics of cracks is typically modeled at the level of continuum scales, modeled by elastodynamics equations. However, many important issues in fracture is related to the atomic interactions at the microscopic scale. We will present a coupled model, combining traditional continuum PDEs with atomic level descriptions. Based on the coupled model, we study crack initiations under shock loading. (Received February 23, 2010)

76 ► Fluid mechanics

1059-76-68 **Huidan Yu*** (yudh123@yahoo.com), 148 Murdock Rd., Baltimore, MD 21212. *Lagrangian Refined Kolmogorov Similarity Hypothesis for Gradient Time-Evolution and Correlation in Turbulent Flows.*

We study the time evolution of velocity and pressure gradients in isotropic turbulence, by quantifying their auto-correlation functions and decorrelation time scales as one follows fluid particles in the flow. The Lagrangian analysis uses data in a public database generated using direct numerical simulation of the Navier-Stokes equations, at a Reynolds number $Re_\lambda = 430$. It is confirmed that when averaging over the entire domain, correlation functions decay on timescales on the order of the mean Kolmogorov turnover time scale, computed from the globally averaged rate of dissipation. However, when performing the analysis in different subregions of the flow, turbulence intermittency leads to large spatial variability in the decay time scales. Remarkably, excellent collapse of the auto-correlation functions is recovered when using the 'local Kolmogorov time-scale' defined using the locally averaged, rather than the global, dissipation-rate. This provides new evidence for the validity of Kolmogorov's Refined Similarity Hypothesis, but from a Lagrangian viewpoint that provides a natural frame to describe the dynamical time evolution of turbulence. (Received February 15, 2010)

1059-76-147 **Kenneth M. Golden*** (golden@math.utah.edu), University of Utah, Department of Mathematics, 155 S 1400 E RM 233, Salt Lake City, UT 84112-0090. *Random microstructures and phase transitions in composite materials.* Preliminary report.

Composite materials can exhibit sharp transitions in their effective behavior as some parameter of the system is varied. For example, sea ice is a composite of pure ice with brine inclusions. The volume fraction and connectedness of these inclusions change significantly with temperature. Below a critical brine volume fraction of around 5%, sea ice is effectively impermeable to fluid flow, and is increasingly permeable above this threshold. This critical behavior controls a broad range of processes in sea ice which are important for studies of climate change, as well as for microbial ecosystems living in sea ice. Similarly, electrorheological fluids, which are suspensions of particles in a viscous fluid, undergo a sharp fluid/solid transition as an applied electric field exceeds a critical value. In this talk we'll discuss some mathematical approaches to describing the behavior of such systems. (Received February 22, 2010)

1059-76-169 **Konstantin S. Turitsyn*** (turitsyn@lanl.gov), T-4, Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, and **Lipeng Lai** and **Wendy W. Zhang**. *Bubble break-up as a two-dimensional free surface hydrodynamics problem.*

Break-up of gas bubbles immersed in liquid is a natural event occurring in multiple multiphase systems. Associated to this event is a process of gas neck reconnection. Recent experiments performed in University of Chicago have shown that neck reconnection is a non-universal process with the outcome strongly dependent on the initial conditions. In this talk I will show how the neck reconnection dynamics can be described by a two-dimensional free surface hydrodynamic model. This model can be effectively solved numerically with conformal mapping techniques that were introduced in the works of S. Tanveer and V. Zakharov et.al. I will present the results of numerical simulations which show that the smooth contact of gas-liquid interface is a generic outcome of the

dynamics, however the final shape of the neck is strongly dependent on the initial conditions. I will also discuss possible extensions of the model that include the effect of large scale fluid velocity structure and non-trivial topology of the interface. (Received February 22, 2010)

78 ► Optics, electromagnetic theory

1059-78-52 **Alejandro Aceves*** (aaceves@smu.edu), Department of Mathematics, Clements Hall, Southern Methodist University, Dallas, TX 75275. *Modeling fiber laser arrays.* Preliminary report.

Novel lasers consisting of suitable coupling of fiber amplifiers are currently been investigated since they have the potential of generating high power coherent outputs. In this talk we first present a brief survey of the modeling of fiber laser arrays and we present a progress report on our own research in this area. (Received February 11, 2010)

1059-78-87 **Yeo-jin Chung** and **Pavel M Lushnikov***, University of New Mexico, Department of Mathematics and Statistics, MSC03 2150, Albuquerque, NM 87131-1141, and **Natalia Vladimirova**. *Strong Collapse Turbulence in Nonlinear Schrödinger Equation.*

We consider a nonlinear Schrödinger equation (NLS) with dissipation and forcing in critical dimension. Without both linear and nonlinear dissipation NLS results in a finite-time singularity (collapse) for any initial conditions. Dissipation ensures collapse regularization. If dissipation is small then multiple near-singular collapses are randomly distributed in space and time forming collapse turbulence. Collapses are responsible for non-Gaussian tails in the probability distribution function of amplitude fluctuations which makes turbulence strong. Power law of non-Gaussian tails is obtained for strong NLS turbulence. (Received February 18, 2010)

1059-78-200 **Natalia M Litchinitser*** (natashal@buffalo.edu), SUNY at Buffalo, EE Dept., 332 Bonner Hall, Buffalo, NY 14260, **Tolanya Gibson** (tjgibson@buffalo.edu), SUNY at Buffalo, EE Dept., 418 Furnas Hall, Buffalo, NY 14260, **Gayatri Venugopal** (gv8@buffalo.edu), SUNY at Buffalo, EE Dept., 418 Furnas Hall, Buffalo, NY 14260, **Matthew Pennybacker** (pennybacker@math.arizona.edu), University of Arizona, Dept. of Mathematics, 617 N. Santa Rita Ave., Tucson, AZ 85721, **Irene Mozjerin** (irenemoz@buffalo.edu), SUNY at Buffalo, EE Dept., 418 Furnas Hall, Buffalo, NY 14260, and **Ildar R Gabitov** (gabitov@math.arizona.edu), Univ. of Arizona, Dept. of Mathematics, 617 N. Santa Rita Ave., Tucson, AZ 85721. *Nonlinear Optics in Transition and Negative Index Metamaterials.*

We investigate a new class of graded-index metamaterial with the effective dielectric permittivity and magnetic permeability gradually changing from positive to negative values, referred to as transition metamaterials. In this talk we discuss our current research focused on several peculiar optical phenomena taking place in such transition metamaterials, including anomalous electromagnetic field enhancement and resonant absorption and their potential applications for linear and especially nonlinear optics. We will also discuss an entirely new regime of nonlinear optical light propagation in guided wave structures " couplers made of positive and negative index metamaterials. Oppositely directed phase and energy velocities in a negative index channel enable such nonlinear optical phenomena as optical bistability, gap solitons, self-oscillations, and novel regimes of modulation instability in these couplers. These effects have no analogies in conventional nonlinear directional couplers with no external feedback mechanism, and thus open new opportunities for the development of optical storage and logic applications. (Received February 23, 2010)

1059-78-222 **Ildar R Gabitov*** (gabitov@math.arizona.edu), Deparetment of Mathematics, University of Arizona, 617 N. Santa Rita, Tucson, AZ 85721, **Bridget Kennedy** (bkennedy@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721, and **Andrei Maimistov** (aimaimistov@gmail.com), National Research Nuclear University, 31 Kashirskoe Shosse, Moscow, Russia. *Gain- added metallic nanostructures as optical meta-atoms.*

Split ring resonators with added Josephson junctions (rf-SQUIDS) are known to be acting as meta-atoms in the radio frequency regime. We consider a mathematical model of a nanoscale metallic resonator with two level resonant atoms which could operate in optical regime. Josepson junctions are well described by a sin-Gordon type of equation. The Maxwell-Bloch system is known to be a good model for two-level atoms and represents the generalization of a sin-Gordon equation. We derive a system of equations describing the electrodynamics of a metallic nano-resonator with active atoms and analyze the response of such an object to an external

electromagnetic field. The main feature of this meta-atom is a large magnetic dipole moment, which is much larger than electric dipole moment in natural atoms. (Received February 23, 2010)

1059-78-223 **Ildar R Gabitov*** (gabitov@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721, **Zhaxylyk A Kudyshev** (z.kudyshev@gmail.com), Department of Physics, al-Farabi Kazakh National University, 96a Tole-bi str, Almaty, 050038, Kazakhstan, and **Andrei I Maimistov** (aimaimistov@gmail.com), National Research Nuclear University, 31 Kashirskoe Shosse, Moscow, Russia. *Three wave parametric amplification in negative index materials.*

We investigate three wave interaction when the medium is responding to pump and idler waves as a positive index and to the signal as a negative index material (backward pumping). Depletion of the pump signal and detuning from phase matching are taken into account. We found analytic solutions in both cases and analyzed specific properties of backward pumping based amplification. Amplification in lossy material was analyzed numerically. Second harmonic generation, which occurs in the particular case of three wave interaction in a negative index material, is also considered. (Received February 23, 2010)

81 ► Quantum theory

1059-81-14 **A M Abdurrahman*** (ababdu@ship.edu), Department of Physics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257, **A Cresswell** (alcres@ship.edu), Department of Physics, Shippensburg University, 1871 Old Main Drive, Shippensburg, PA 17257, and **M A Gassem** (mgassem@southtexascollege.edu), Department of Mathematical Sciences, South Texas College, 3201 W. Pecan, McAllen, TX 78501. *Ward-like identities in the comma theory.*

The first part of the proof of the bose-fermi equivalence in the comma interacting string field theory has been constructed by Abdurrahman, et al. Here we will establish that the bosonic ghost realization of the three interacting vertex in the comma theory satisfies the Ward-like identities; hence completing the proof of equivalence between the bosonic and fermionic ghost realizations of the three interacting vertex in the comma theory. (Received December 15, 2009)

82 ► Statistical mechanics, structure of matter

1059-82-10 **Gregory Falkovich*** (gregory.falkovich@weizmann.ac.il), Physics, WIS, 76100 Rehovot, Israel. *Broken and emerging symmetries in turbulence.*

I will review the symmetry aspect of statistics for different cases of turbulence. This will include anomalies (i.e. symmetries broken by an infitesimal perturbations) in the direct cascades and symmetries emerging in the inverse cascade. I will also discuss symmetries broken when the condensate appears in the system. (Received November 18, 2009)

83 ► Relativity and gravitational theory

1059-83-165 **Geoffrey Lovelace*** (geoffrey@astro.cornell.edu), 613 Space Sciences Bldg., Cornell University, Ithaca, NY 14853, **Stephen Lau** (lau@unm.edu), Mathematics and Statistics, University of New Mexico, Albuquerque, NM 87131, and **Harald Pfeiffer** (pfeiffer@cita.utoronto.ca), Canadian Inst. for Theoretical Astrophysics, University of Toronto, Toronto, Ontario M5S 3H8, Canada. *Implicit-explicit time-stepping in numerical simulations of black holes.* Preliminary report.

Numerical simulations of black holes generally divide the spacetime into a set of three-dimensional spatial slices. The initial slice must satisfy the Einstein constraint equation; subsequent slices are obtained by numerically solving the Einstein evolution equations. The evolutions typically use explicit time-stepping methods with the time step size subject to the Courant limit, which is often orders of magnitude smaller than the relevant physical timescales. If larger time steps could be taken stably, the computational cost of black-hole simulations could be significantly reduced. In this talk, I will discuss the application of implicit-explicit time-stepping—which can be stable for time steps significantly larger than the Courant limit—to simulations of perturbed black holes. (Received February 22, 2010)

1059-83-189 **Harald P Pfeiffer*** (pfeiffer@cita.utoronto.ca), Cdn. Institute for Theoretical Astrophysics, University of Toronto, 60 St. George Street, Toronto, ON M5S 3H8, Canada. *Black hole simulations using spectral methods.*

Einstein's equations of General Relativity have several challenging properties that need to be overcome for numerical solutions, among them the existence of constraints, the freedom to choose coordinates, and the presence of singularities inside black hole horizons. Nevertheless, remarkable progress has been achieved over the last years that now allows to study binary black hole systems. This talk reviews some basic properties of Einstein's equations, describes the numerical implementation with a multi-domain pseudo-spectral collocation method, and presents some recent results for binary black hole systems. (Received February 23, 2010)

1059-83-246 **S R Lau*** (lau@unm.edu), Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131, and **R H Price**. *Multidomain spectral-tau method for the three-dimensional helically reduced wave equation.* Preliminary report.

Helical reduction of the ordinary wave equation yields a problem of mixed type. The associated operator is also featured in Beetle, Bromley, and Price's formulation of the helically reduced Einstein equations. We describe an iterative, multidomain, sparse, and spectral-tau method for solving the helically reduced wave equation on a doubly punctured domain in three-dimensions. On all subdomains we achieve a sparse representation of the relevant operator through the "integration preconditioning" of Coutsias, Hagstrom, Hesthaven, and Torres. We also describe further preconditioning techniques necessary to improve performance of the underlying iterative solver. (Received February 23, 2010)

86 ► Geophysics

1059-86-34 **Robert M Owczarek*** (rmo@lanl.gov), MS D443, Los Alamos National Laboratory, Los Alamos, NM 87545. *On some problems in environmental research.* Preliminary report.

I will talk about some mathematical problems of interest to environmental research. (Received February 05, 2010)

1059-86-110 **B T Nadiga*** (balu@lanl.gov), LANL, MS-B296, Los Alamos, NM 87545. *Initial Condition Sensitivity and Modal Interactions in Realistic Ocean Models.*

Given its dynamical inertia, the slower components of global ocean circulation are expected to be predictable on the interannual to decadal timescale. Furthermore, for interannual to decadal simulations of ocean circulation at resolutions that allow for mesoscale eddies, it is anticipated that with data assimilation, the initial state can be estimated such that the slower components have the right phase and amplitude, and that such initializations will improve predictability. Towards better understanding the consequences and limitations of such an initialization, we report on preliminary numerical experiments. We note that a fundamental question underlying these issues is the nature of scale interactions in these high resolution simulations. (Received February 19, 2010)

1059-86-183 **Vladimir E Zakharov** and **Alexander O Korotkevich*** (alexkor@math.unm.edu), Department of Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131-0001, and **Alexander O Prokofiev**. *On Dissipation Function of Ocean Waves due to Whitecapping.*

Most of the current forecasting models for ocean waves are based on Hasselmann kinetic equation. This is equation describing the dynamics of waves distribution function. Coherent phenomena, like wave breaking, white capping, and solitons are out of the scope of statistical description. At the same time, some of them are extremely important for relevant description of water waves dynamics. Fortunately such catastrophic events like wave breaking and whitecapping can be taken into account by adding phenomenological dissipation terms. The formulae for these terms are still an open question. Experimental observation does not give us full information about the wave field. At the same time, numerical experiments can be completely controlled and provide all necessary information. We performed two numerical experiments in order to get enough information and compare currently popular formulae for dissipation terms with results of simulation. Our statement is the following: terms currently used in forecasting models have to be significantly corrected. Wave breaking and whitecapping dissipation are threshold-like phenomena. This fact is in good concordance with recent experimental observations. (Received February 23, 2010)

1059-86-197 **Vladimir E. Zakharov*** (zakharov@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721, and **Roman Shamin**. *Probability of the occurrence of freak waves.*

The statistics of the occurrence of freak waves on the surface of an ideal heavy fluid is studied. The freak (rogue, extreme) waves appear in the course of evolution of a statistically homogeneous random Gaussian wave field. The mean steepness of initial data varies from small ($\mu^2 = 1.54 \cdot 10^{-3}$) to moderate ($\mu^2 = 3.08 \cdot 10^{-3}$) values. The frequency of freak wave occurrence decreases with growth of the spectral width of initial distribution, however it remains relatively high even for the broad spectra ($\frac{\Delta_k}{k} \sim 1$). (Received February 23, 2010)

90 ► Operations research, mathematical programming

1059-90-5 **Shafiu Jibrin*** (Shafiu.Jibrin@nau.edu), Northern Arizona University, Flagstaff, AZ 86001, **Richard J Caron**, University of Windsor, Windsor, Ontario N9B 3P4, Canada, and **Tim Traynor**, University of Windsor, Windsor, Ontario N9B 3P4, Canada. *Feasibility and Constraint Analysis of Sets of Linear Matrix Inequalities.*

In this talk we show how the framework for constraint analysis given by Caron and Traynor, which builds on the work by Boneh, can be applied to Linear Matrix Inequality (LMI) constraint sets. An implementation of the analysis requires a method to collect points, and to determine which constraints are satisfied at each point, in the ambient space. Much of this paper will be devoted to the development of such a methodology based on hit and run sampling. Test results show that our approach not only provides information required for constraint analysis, but will also, if the feasible region is non-void, with probability one, find a feasible point. (Received August 21, 2009)

1059-90-72 **Salisu Mohammed Garba*** (garba@cc.umanitoba.ca), Department of Mathematics, 342 Machray Hall, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada. *Dengue Treatment Model with Variable Viral Load.*

A deterministic model for the transmission dynamics of dengue, which accounts for its viral load variability upon infection, is designed and rigorously analyzed. The model, consisting of mutually-exclusive epidemiological compartments representing the human and vector dynamics, has a locally-asymptotically stable, disease-free equilibrium (DFE) whenever the associated reproduction number (Ro) is less than unity. It is shown, using a Lyapunov function and LaSalle Invariance Principle that the DFE of the model, in the absence of dengue-induced mortality, is globally-asymptotically stable whenever the threshold is less than unity. Using a Krasnoselskii sub-linearity trick, it is shown that the associated unique endemic equilibrium is locally-asymptotically stable when it exists. Various treatment strategies based on the use of present (limited) control measures are considered. Numerical simulations of the model show that for high treatment rates, a universal strategy, with high level of effectiveness, can lead to dengue elimination in a community. (Received February 16, 2010)

1059-90-159 **Frederi G Viens*** (viens@purdue.edu), Dept. Statistics, Purdue University, 150 N University St, West Lafayette, IN 47907-2067, and **Ha-Young Kim** (hykim@math.purdue.edu). *Portfolio Optimization in Discrete Time with Proportional Transaction Costs under Stochastic Volatility.*

This paper is devoted to evaluating the optimal self-financing strategy and the optimal trading frequency for a portfolio with a risky asset and a risk-free asset. The objective is to maximize the expected future utility of the terminal wealth in a stochastic volatility setting, when transaction costs are incurred at each discrete trading time. A HARA utility function is used, allowing a simple approximation of the optimization problem, which is implementable forward in time. For each of various transaction cost rates, we find the optimal trading frequency, i.e. the one that attains the maximum of the expected utility at time zero. We study the relation between transaction cost rate and optimal trading frequency. The numerical method used is based on a stochastic volatility particle filtering algorithm, combined with a Monte-Carlo method. The filtering algorithm updates the estimate of the volatility distribution forward in time, as new stock observations arrive; these updates are used at each of these discrete times to compute the new portfolio allocation. (Received February 22, 2010)

91 ► Game theory, economics, social and behavioral sciences

1059-91-38 **Simina Branzei*** (sbranzei@uwaterloo.ca), School of Computer Science, University of Waterloo, 200 University Avenue West, Waterloo, Ontario N2L3G1, Canada, and **Kate Larson**. *Coalitional Affinity Games.*

We present and analyze coalitional affinity games, a family of hedonic games that explicitly model the value that an agent receives from being associated with other agents. We provide a characterization of the social-welfare maximizing coalition structures, and study the stability properties of affinity games, using the core solution concept. We observe that members of the core do not necessarily maximize social welfare and introduce a new measure, the stability-gap to capture this difference. Using the stability gap, we show that for the class of symmetric affinity games, the difference between the social welfare of a stable coalition structure and a social welfare maximizing coalition structure is bounded by a factor of two, and that this bound is tight. (Received February 08, 2010)

1059-91-73 **Natalia E. Romero***, Physics Department, 777 Glades Rd., Boca Raton, FL 33432, and **Qianli D.Y. Ma**, **Larry S. Liebovitch**, **T. Brown Clifford** and **Ch. Ivanov Plamen**. *Correlated walks down the Babylonian markets.*

To investigate the evolution of market dynamics in different stages of historical development, we analyze commodity prices from two distinct periods – ancient Babylon, and medieval and early modern England. We find that the first digit distributions of both Babylon and England commodity prices follow Benford's law, indicating that the data represent empirical observations typically arising from a free market. Further, we find that the normalized prices of both Babylon and England agricultural commodities are characterized by stretched exponential distributions, and exhibit persistent correlations of a power-law type over long periods of up to several centuries, in contrast to contemporary markets. Our findings suggest that similar market interactions may underlie the dynamics of ancient agricultural commodity prices, and that these interactions may remain stable across centuries in two distinct historical periods. (Received February 16, 2010)

1059-91-125 **Patrick Cheridito*** (dito@princeton.edu), ORFE, Princeton University, Princeton, NJ 08544. *Equilibrium pricing in incomplete markets under translation invariant preferences.*

Conditions are given for the existence and uniqueness of equilibria in incomplete dynamic market models when agents have translation invariant preferences. This includes mean-variance type preferences and expected exponential utility. General results are provided in discrete time. Then a special case is discussed where equilibrium prices can be calculated as solutions to a system of backward stochastic difference equations. In the continuous-time limit, a system of coupled backward stochastic differential equations with drivers of quadratic growth appears. (Received February 21, 2010)

1059-91-128 **Matthew C Harding*** (mch@stanford.edu), 579 Serra Mall, Stanford, CA 94305, and **Krishnan K Nair**. *Estimating the Number Of Factors And Lags in High Dimensional Dynamic Factor Models.* Preliminary report.

In this paper, we derive identification results for the number of factors and lags in high dimensional dynamic factor models using eigenvalue methods. The new approach does not require using the complex valued spectral covariance matrix and can be easily performed using a generalization of the traditional scree plot methodology. We employ Random Matrix Theory and the properties of the Stieltjes transform to characterize the eigenvalue distribution of symmetric time-delayed covariance matrices which will be used to derive a consistent moment-based estimation procedure for the number of factors and lags in the data. Additionally, we employ perturbation theory to assess the robustness of the identification results and show the importance of the separation of eigenvalues. The proposed consistent estimation procedures are shown to have excellent finite sample performance and outperform competing estimators in a series of Monte Carlo simulations. We also apply the methods to data reduction in macroeconomic time series and risk analysis in a large portfolio of stocks. (Received February 21, 2010)

1059-91-131 **Bogdan Grechuk** (bgrechuk@stevens.edu), **Anton Molyboha*** (amolyboh@stevens.edu) and **Michael Zabarankin** (mzabaran@stevens.edu). *Cooperative games of investors with general deviation measures.*

Cooperative games with players using different law-invariant deviation measures as numerical representations for their attitudes towards risk in investing to a stock market have been formulated and investigated. As a central result, it has been shown that players (investors) form a coalition (cooperative portfolio) that behaves similar to

a single player (investor) with a certain deviation measure. An explicit formula for that deviation measure has been obtained. An approach to optimal risk sharing among investors has been developed, and a "fair" division of the cooperative portfolio's expected gain, belonging to the core of a corresponding cooperative game, has been suggested. (Received February 21, 2010)

1059-91-241 **Germán G Creamer*** (gcreamer@stevens.edu), Castle Point on Hudson, Jersey City, NJ 07302. *Black Litterman model: investors' expectations and social networks.*

The Black Litterman model (BL) for portfolio optimization combines investors' expectations with the Markowitz framework. The BL model is designed for investors with private information or with knowledge of market behavior. In this paper we propose a method where investors' expectations are simulated based on accounting variables, recommendations of financial analysts, and social network indicators of financial analysts and corporate directors. The results show promise when compared to those of an investor that only uses market price information. We also provide recommendations about trading strategies using the results of our model. (Received February 23, 2010)

92 ► Biology and other natural sciences

1059-92-20 **Alan C. Newell***, 617 N. Santa Rita, Tucson, AZ 85721, and **Matt Pennybacker** (pennybacker@math.arizona.edu), 617 N. Santa Rita, Tucson, AZ 85721. *The universal nature of Fibonacci patterns.*

In planar geometries with rotational symmetry, the natural pattern planform occuring near onset in systems with broken up-down symmetry is hexagonal. Under the same conditions, if the geometry is circular and the pattern gets laid down annulus by annulus so that the choice of each new pattern is strongly influenced by the bias of the previously formed pattern in the neighboring annulus, patterns with a fibonacci signature are preferred. We will explain why and suggest an experiment in fluid convection can mimic all the Fibonacci patterns one sees in the plant kingdom. (Received January 25, 2010)

1059-92-158 **Maxim S Shkarayev*** (shkarm@rpi.edu), Dept. of Mathematical Sciences Amos Eaton 301, 110 8th Street, Troy, NY 12180. *Functional connectivity in disassortative scale-free neuronal networks.*

We present a study of scale-free networks of identical, conductance-based, integrate-and-fire excitatory neurons. We show that dynamics on a complex network can be controlled by the topology of the network, in particular, scale-free functional connectivity can arise from scale-free architectural connectivity, in which the architectural degree-correlation plays a crucial role. The analytical results are confirmed by the direct numerical simulations of the coupled integrate-and-fire neuronal networks. (Received February 22, 2010)

00 ► General

1060-00-65 **Huizeng Qin** (qinhz@hotmail.com), Institute of Mathematics, Shandong University of Technology, Zibo, Shandong , Peoples Rep of China, and **Youmin Lu*** (ylu@bloomu.edu), Department of Mathematics and Computer Scienc, Bloomsburg University, Bloomsburg, PA 17821. *Euler's Constant and Integrals of Fractional Parts.*

In this paper, we calculate the values of the integrals $\int_0^1 \{\frac{1}{x}\}^m dx$, $\int\int_{0\le x,y\le 1} \{\frac{1}{x+y}\}^m dxdy$, $\int\int\int_{0\le x,y,z\le 1} \{\frac{1}{x+y+z}\}^m dxdydz$ and $\int_0^1 \{\frac{1}{x}\}^m \{\frac{1}{1-x}\}^n dx$, where m and n are positive integers and $\{u\}$ is the fractional part of u, and express their values in terms of Euler's constant and Riemann-Zeta function. We also obtained a set of identities involving the Bernoulli and Harmonic numbers. (Received March 18, 2010)

1060-00-121 **Moira Chas*** (moira@math.sunysb.edu), Department of Mathematics, Stony Brook University, Stony Brook, NY 11794, **Anthony V. Phillips**, NY , and **Steve Lalley**, NY. *Structures related to intersection of curves on surfaces.*

Consider the set of free homotopy classes of oriented closed curves on a surface. This is the set of equivalence classes of maps from the circle into the surface, where two such maps are equivalent if the corresponding directed curves can be deformed one into the other. There is a canonical bijection from this set to the set of conjugacy classes of the fundamental group of the surface.

Given a free homotopy class one can ask what is the minimum number of times, counted with multiplicity, a curve in that class intersects itself. We study how this minimal self-intersection number may vary with the word length. (The word length is the minimal number of letters required for a description of the class in terms of the standard generators of the fundamental group and their inverses.)

In these talk, several problems (and some solutions) related to minimal self-intersection will be discussed. We will address such questions as: the possible maximal self-intersection for a given length, the number of conjugacy classes with given self-intersection and given length, distribution of the number of classes given self-intersection and length.

One part of this work is joint with Anthony Phillips and another part is joint with Steve Lalley. (Received March 25, 2010)

1060-00-193 **Sanjay M Dharmavaram*** (sd282@cornell.edu), 112, Kimball Hall, Cornell University, Ithaca, NY 14850, and **Timothy J Healey** (tjh10@cornell.edu). *Phase Separation in Two Phase Lipid Membrane Vesicle.*

The aim of our work is to propose a model for two-phase lipid bilayers and use the Giant Unilamellar Vesicles (GUVs) as an example to test our theory (motivated by the experiments of Baumgart, et. al. - Nature, 425, (2003) p. 821). Although mean-field theories have been proposed to explain phase separation in multi-phase lipid bilayers, these theories usually introduce an ad-hoc curvature-phase coupling energy. Here, we instead, propose a model using a non-convex potential for in-plane effects and a bending potential energy which takes into consideration the change in thickness associated with each phase. The latter introduces a natural coupling between curvature and phase. We interpret the question of phase transition in the context of bifurcation theory and use group-theoretic strategies to show the existence of non-spherical bifurcated equilibria. These equilibria represent phase-separated states from the homogeneous vesicle and bear striking similarity to many of the non-spherical states observed in experiments. We further, perform numerical continuation and present results for some axisymmetric two-phase configurations. (Received March 30, 2010)

03 ► Mathematical logic and foundations

1060-03-22 **Joel David Hamkins*** (jhamkins@gc.cuny.edu), The CUNY Graduate Center, Mathematics, 365 Fifth Avenue, New York, NY 10016. *How tall is the automorphism tower of a group?*

The automorphism tower of a group is obtained by computing its automorphism group, the automorphism group of *that* group, and so on, iterating transfinitely. Each group maps into the next using inner automorphisms and

one takes a direct limit at limit stages. The automorphism tower problem is the question whether this process ever terminates, whether one ever arrives at a group that is isomorphic to its automorphism group by the natural map. Wielandt (1939) proved the classical result that the automorphism tower of any finite centerless group terminates in finitely many steps. This was gradually generalized to successively larger collections of groups until Thomas (1985) proved that every centerless group has a terminating automorphism tower. Building on this, I proved (1998) that in fact every group has a terminating transfinite automorphism tower. In this talk, I will describe the proof. In addition, I will discuss some joint work with Thomas and Fuchs that tends to reveal the set-theoretic essence of the automorphism tower of a group: the very same group can have wildly different automorphism towers in different models of set theory. Numerous easy-to-state questions remain open. (Received January 22, 2010)

1060-03-29 **Elena Y. Nogina*** (e.nogina@gmail.com), 199 Chambers Street, Department of Mathematics, BMCC/CUNY, New York, NY 10007. *Symmetric Logic of Proofs and Provability.*

The logic of proofs and provability, GLA ([4]), is an arithmetically complete logic in the joint language of the provability logic GL [3] and the logic of proofs LP [1]. A stronger logic of proofs, SLP, introduced in [2], augments LP by the **Symmetry Principles**:

$$(u+v):F \leftrightarrow u:F \vee v:F, \quad t(u+v):F \leftrightarrow tu:F \vee tv:F, \text{ and } (u+v)t:F \leftrightarrow ut:F \vee vt:F.$$

In this talk, we introduce the symmetric logic SGLA of proof and provability consisting of GLA plus the Symmetry Principles. Logic SGLA is correct with respect to the standard Gödel proof predicate for Peano Arithmetic. We supply SGLA with a corresponding Kripke-Fitting semantics and show completeness of SGLA with respect to this semantics.

References: [1] S. Artemov, Explicit provability and constructive semantics, *Bulletin of Symbolic Logic*, 7(1):1-36, 2001. [2] S. Artemov, Symmetric Logic of Proofs, *Lecture Notes in Computer Science*, 4800:58-71, 2008. [3] G. Boolos, *The Logic of Provability*, Cambridge University Press, 1993. [4] E. Nogina, On logic of proofs and provability, *Bulletin of Symbolic Logic*, 12(2):356, 2006. (Received February 21, 2010)

1060-03-160 **Roman Kossak*** (rkossak@gc.cuny.edu). *Automorphism groups of nonstandard models of arithmetic.*

By a remarkable theorem of Jim Schmerl, there is nothing special about automorphism groups of models of Peano Arithmetic (PA); more precisely, if $\mathcal{A}$ is a linearly ordered structure, then there is a model $M \models$PA such that $\mathrm{Aut}(M) \cong \mathrm{Aut}(\mathcal{A})$. However, there is still much one can say about automorphism groups of certain classes of models of PA. Particularly interesting is the case of countable recursively saturated models. There are continuum many automorphism groups of such models, and each group is of power continuum. I will briefly survey the main results in the area, concentrating on group theoretic properties (like cofinality of a group, and existence of maximal automorphisms) which separate levels of saturation of nonstandard models. (Received March 29, 2010)

1060-03-182 **Russell Miller*** (Russell.Miller@qc.cuny.edu), Mathematics Dept., Queens College, 65-30 Kissena Blvd., Flushing, NY 11367. *Comparing Free Abelian Groups and Purely Transcendental Fields.* Preliminary report.

In computable model theory, there are close connections between the notion of a basis for a computable abelian group and the notion of a transcendence basis for a computable field. Every such group has a Π^0_1 basis (that is, definable by a formula with only $\forall$-quantifiers), and every such field has a Π^0_1 transcendence basis; moreover, these constructions are essentially the same.

We consider the difficulty of computing a pure transcendence basis for a computable field F, i.e. a transcendence basis which generates F as a field over $\mathbb{Q}$ or over $\mathbb{F}_p$. The analogous question for abelian groups involves a basis which generates the entire group. Of course, the group must be free abelian, and the field purely transcendental, in order for the questions to make sense. The construction of a free generating set for a computable free abelian group does not carry over to computable fields, and we use computability theory to compare the difficulty of these two constructions.

Most of this work is joint with Fokina, Harizanov, Knight, Montalban, McCoy, and Semukhin. (Received March 29, 2010)

05 ► Combinatorics

1060-05-15 **David Galvin*** (dgalvin1@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556, and **John Engbers**. *The typical structure of H-colourings of regular bipartite graphs.* Preliminary report.

For a graph H (perhaps with loops), an *H-colouring* of a simple graph G is a function from the vertices of G to the vertices of H which maps adjacent vertices to adjacent vertices. With suitable choices of H, H-colourings can encode, for example, weighted independent sets and proper colourings of G. H-colourings are also referred to as *graph homomorphisms*.

We address the following question: in a typical (uniformly chosen) H-colouring of a regular bipartite graph G, what proportion of the vertices of G get mapped to each vertex of H? For a very large class of graphs H, we can give a quite precise answer to this question. For example, we can say that in almost all proper $2k$-colourings of a regular bipartite graph on N vertices, each colour will appear very close to $N/2k$ times.

The approach is through entropy, and extends work of J. Kahn from 2001 (who considered the size of randomly chosen independent sets of a regular bipartite graph). (Received January 14, 2010)

1060-05-21 **Patrick Bahls*** (pbahls@unca.edu), CPO #2350, One University Heights, Asheville, NC 28804-8511. *Channel assignment on Cayley graphs.*

A common problem in communication networks is *channel assignment*, the assignment of frequencies to transmitters in a given network in such a fashion that transmitters which are close to one another are given frequencies sufficiently different to ensure non-interference of the transmitters' signals. A network can be modeled by a graph in which the graph's vertices represent the transmitters and the path metric on the graph can be used to measure proximity of the transmitters to one another.

We discuss various channel assignment problems on the Cayley graphs of certain groups, applying elementary group theoretic techniques to compute the frequency span of certain Cayley graphs. In particular, we show that if G is the Cayley graph of an n-generated group Γ with a certain kind of presentation, then $\lambda(G;k,1) = 2(k+n-1)$. For some values of k this is the obvious optimal value for any $2n$-regular graph. A large number of groups (for instance, even Artin groups and a number of Baumslag-Solitar groups) satisfy this condition. We indicate some conjectures concerning the Cayley graphs corresponding to generic group presentations. (Received January 21, 2010)

1060-05-27 **Daniel W. Cranston*** (dcranston@vcu.edu), Department of Math & Applied Math, 1015 Floyd Avenue, Richmond, VA 23284, and **Joan Hutchinson**, **Anja Pruchnewski**, **Michael Stiebitz**, **Zsolt Tuza** and **Margit Voigt**. *List colorings of K_5-minor-free graphs with special list assignments.*

A *list assignment* L of G is a function that assigns to every vertex v of G a set (list) $L(v)$ of colors. The graph G is called *L-list colorable* if there is a coloring φ of the vertices of G such that $\varphi(v) \in L(v)$ for all $v \in V(G)$ and $\varphi(v) \neq \varphi(w)$ for all $vw \in E(G)$.

We consider the following question of Bruce Richter, where $d(v)$ denotes the degree of v in G:

Let G be a planar, 3-connected graph that is not a complete graph. Is G L-list colorable for every list assignment L with $|L(v)| = \min\{d(v), 6\}$ for all $v \in V$?

More generally, we ask for which pairs (r,k) the following question is answered in the affirmative. Let r and k be integers and let G be a K_5-minor-free r-connected graph that is not a Gallai tree. Is G L-list colorable for every list assignment L with $|L(v)| = \min\{d(v), k\}$? Recall that a *Gallai tree* is a graph G such that every block of G is either a complete graph or an odd cycle.

We study this question by considering the components of $G[S_k]$, where $S_k := \{v \in V(G) \mid d(v) < k\}$ is the set of vertices with small degree in G. We are especially interested in the minimum distance $d(S_k)$ in G between the components of $G[S_k]$. (Received February 12, 2010)

1060-05-33 **Eddie Cheng** (echeng@oakland.edu), Dept. of Mathematics and Statistics, Oakland University, Rochester, MI 48309, **Ke Qiu** (kqiu@brocku.ca), Dept. of Computer Science, Brock University, St. Catharines, Ontario L2S 3A1, and **Zhizhang Shen*** (zshen@plymouth.edu), Dept. of Computer Science and Technology, Plymouth State Univestiy, Plymouth, NH 03264. *The Number of Shortest Paths in the (n,k)-Star Graphs.* Preliminary report.

Given a graph G, a well-known problem is to find *the number of the shortest paths* between a pair of vertices in G. A solution to this counting problem can serve as an important topological property for an interconnection

network in terms of strong connectivity, effective fault-tolerance, lower communication cost and desired routing flexibility.

It turns out that the number of the shortest paths between v and e_k in an (n,k)-star graph equals the number of minimum factorizations of v in terms of (n,k)-star transpositions, which we enumerate in this talk. (Received February 26, 2010)

1060-05-35 **Joanna A. Ellis-Monaghan*** (jellis-monaghan@smcvt.edu), One Winooski Park, Colchester, VT 05439, and **Iain Moffatt** (imoffatt@jaguar1.usouthal.edu), Mobile, AL 36688. *Ribbon graphs and twisted duality.*

We consider two operations on the edge of an embedded (*i.e.* ribbon) graph: giving a half-twist to the edge and taking the partial dual with respect to the edge. These two operations give rise to an action of ${S_3}^{e(G)}$, the *ribbon group of* G, on G. We show that this ribbon group action gives a complete characterization of duality in that if G is any cellularly embedded graph with medial graph G_m, then the orbit of G under the group action is precisely the set of all graphs with medial graphs isomorphic (as abstract graphs) to G_m. We then show how this group action leads to a deeper understanding of the properties of, and relationships between, various graph polynomials such as the generalized transition polynomial, an extension of the Penrose polynomial to embedded graphs, and the topological Tutte polynomials of Las Vergnas and also Bollobás and Riordan, as well as various knot and link invariants.

This work is motivated by a problem in self-assembling DNA nanostructures, and the results include a possible self-assembly design strategy based on a medial graph template. (Received March 02, 2010)

1060-05-44 **Joy Morris*** (joy.morris@uleth.ca), Department of Math & CS, University of Lethbridge, 4401 University Dr., Lethbridge, AB T1K 3M4, Canada. *The normal quotient method for analysing the structure of highly symmetric graphs.*

One method of analysing families of highly symmetric graphs, is to find a method of reducing such graphs to smaller graphs within the family, and then to analyse the irreducible graphs. Cheryl Praeger and others have made much use of normal quotients as the reduction method in this strategy.

I will demonstrate the method of normal quotient reduction and survey its use in analysing families of vertex-transitive, edge-transitive graphs. In addition to giving an overview, I will present some recent work on analysing the structure of vertex-transitive, edge-transitive strongly regular graphs.

This talk is based on joint work with Cheryl Praeger and Pablo Spiga. (Received March 08, 2010)

1060-05-46 **Lynne L. Doty*** (lynne.doty@marist.edu), Mathematics Department, Marist College, 3399 North Rd., Poughkeepsie, NY 12601. *Using cosets to bound neighbor-connectivity of abelian Cayley graphs.*

If a graph is being used to model a communication network, the failure ("subversion", in the terminology originated by Gunther and Hartnell) of a vertex causes the failure (or purposeful shut-down) of all its immediate neighbors as well. Thus whenever a vertex is subverted the entire closed neighborhood of the vertex is deleted from the graph. The minimum number of vertices whose subversion results in an empty, complete, or disconnected subgraph is called the neighbor-connectivity of the graph. Although neighbor-connectivity uses the language of spy networks it can be applied as well to electronic or physical networks in which failure of one node causes neighboring nodes to be shut down. The unambiguous coset structure of quotient groups can be used effectively to analyze neighbor connectivity of abelian Cayley graphs. Specifically coset structure has been used 1) to characterize abelian Cayley graphs with neighbor-connectivity equal to one and 2) to determine upper bounds for neighbor connectivity of abelian Cayley graphs. This talk will outline how the coset structure is used to achieve these results. Other possibly useful avenues of research will be identified. (Received March 08, 2010)

1060-05-47 **Michael R. Yatauro*** (myatauro@stevens.edu), Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ 07030. *Degree Improvements to Bounds on the Binding Number and Toughness of a Graph.*

It can sometimes be shown that all realizations of a degree sequence must have a certain property. A well-known theorem of V. Chvátal provides a "best monotone" degree condition for a graph to be hamiltonian. Similarly, it is possible to find a bound on a graph parameter so that in all realizations of a degree sequence the parameter will satisfy the given bound. Such a "best monotone" degree condition for graph connectivity was given by F. Boesch and J.A. Bondy. We will discuss what it means for a set of degree conditions to be best monotone. We then present such conditions for the binding number and the toughness of a graph. We also look at recent bounds on toughness and binding number. We then show how some of these bounds can be improved if we know that the degree sequence of a graph satisfies the given best monotone conditions. (Received March 09, 2010)

1060-05-58 **Guantao Chen**, **Michael J. Ferrara**, **Ron Gould**, **Colton Magnant** and **John R. Schmitt*** (jschmitt@middlebury.edu), Mathematics Department, Middlebury College, Warner Hall, Middlebury, VT 05753. *Minimum Saturated Graphs and Ramsey Graphs.*

Given a family of graphs $\mathcal{F}$, a graph G is $\mathcal{F}$-saturated if no member of $\mathcal{F}$ is a subgraph of G but the addition of any new edge to G creates a copy of some member of $\mathcal{F}$. Let $sat(n, \mathcal{F})$ denote the minimum number of edges in an $\mathcal{F}$-saturated graph of order n. We say that a graph F arrows a t-tuple $(F_1, \ldots, F_t)$ if any t-coloring of the edges of F contains a monochromatic F_i-subgraph in color i for some $i \in [t]$. We consider saturated graphs with respect to the family of graphs that arrow (K_3, K_3) and precisely determine the value of the *sat*-function for this family. In doing the latter, we confirm the smallest non-trivial case of a conjecture of Hanson and Toft. (Received March 16, 2010)

1060-05-66 **Andrzej Dudek***, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213, and **Vojta Rödl**. *On generalized Ramsey numbers of Erdős and Rogers.*

A classical Ramsey theorem states that in any coloring of the edges of a sufficiently large complete graph, one will always find a monochromatic complete subgraph. Since the publication of the seminal paper of Ramsey in 1930, the subject has grown and many interesting applications has been established, these include results in number theory, algebra, geometry, topology, set theory, logic, ergodic theory, information theory, and theoretical computer science.

In this talk, we are interested in quantitative extensions of Ramsey's theorem introduced by Erdős and Rogers. (Received March 18, 2010)

1060-05-69 **Shinya Fujita**, **Aydin Gerek** and **Colton Magnant*** (dr.colton.magnant@gmail.com), Christmas-Saucon Hall, 14 E. Packer Ave., Bethlehem, PA 18015. *Proper and rainbow paths and cycles.*

An edge-colored path or cycle will be called *proper* if no two consecutive edges receive the same color and *rainbow* if every edge receives a distinct color. In this talk, we will discuss conditions on edge-colored graphs for the existence of rainbow and properly colored paths and cycles. (Received March 19, 2010)

1060-05-74 **Cheng-Kuan Lin**, **Jimmy J.M. Tan**, **Lih-Hsing Hsu** and **Eddie Cheng*** (echeng@oakland.edu), Department of Mathematics and Statistics, Oakland University, Rochester, MI 48309, and **Laszlo Liptak**.
Conditional fault Hamiltonicity of the star graph.

Fault tolerance is an important property on network performance. A graph G is *k-edge-fault conditional Hamiltonian* if $G - F$ is Hamiltonian for every $F \subseteq E(G)$ with $|F| \leq k$ and $\delta(G - F) \geq 2$. We show that for $n \geq 4$, the n-dimensional star graph S_n is $(3n - 10)$-edge-fault conditional Hamiltonian. (Received March 20, 2010)

1060-05-75 **Dave Witte Morris***, Dept of Math and Comp Sci, University of Lethbridge, Lethbridge, AB T1K 3M4, Canada. *Survey of hamiltonian cycles in Cayley graphs.* Preliminary report.

It was conjectured about 40 years ago that every connected Cayley graph has a hamiltonian cycle. This is easy to prove for Cayley graphs on abelian groups, but we are nowhere near a proof of the general case. The talk will discuss some of the progress that has been made, and some of the many open problems. (Received March 20, 2010)

1060-05-81 **Thomas Bliem*** (bliem@math.sfsu.edu), Department of Mathematics, San Francisco State University, 1600 Holloway Ave, San Francisco, CA 94132. *Determining multivariate quasi-polynomials for weight multiplicities and Clebsch–Gordan coefficients.*

For a symmetrizable Kac–Moody algebra, we study the weight multiplicity of a weight μ in a Demazure module of highest weight λ as a function of λ and μ, i.e., as a function of $2r$ variables if r is the rank of the Kac–Moody algebra. Similarly, for a semisimple Lie algebra, we study Clebsch–Gordan coefficients $c_{\mu,\nu}^{\lambda}$ as a function of λ, μ, ν, i.e., as a function of $3r$ variables. We show that each of these functions is piecewise quasi-polynomial and we give an algorithm to determine the quasi-polynomials. We use this algorithm to explicitly determine the regions of quasi-polynomiality and all quasi-polynomials for some examples.

The crucial ingredients are the following: We use polyhedral models of representations to reduce both problems to counting integral points in multi-parametric families of polytopes. This allows for an expression of the functions with vector partition functions. We then use an algorithm based on a residue formula by Szenes/Vergne to compute quasi-polynomials for these vector partition functions. (Received March 21, 2010)

1060-05-85 **Daniel J Gross*** (Daniel.Gross@shu.edu), Seton Hall University, Department of Mathematics and Comp Sci, 400 South Orange Avenue, South Orange, NJ 07079, and **Nathan W Kahl** and **John T Saccoman**. *Graphs with the Maximum or Minimum Number of 1-Factors.*

Alon and Friedland have shown that graphs which are the union of complete regular bipartite graphs have the maximum number of 1-factors over all graphs with the same degree sequence. In our work we consider all graphs with the same number of vertices and edges. We identify two families of graphs that have the maximum number of 1-factors: the almost regular graphs which are unions of complete regular bi-partite graphs, and complete graphs with a matching removed. The first family is determined using Alon and Friedland's bound. For the second family, we show that a graph transformation which is known to increase network reliability also increases the number of 1-factors. Applying the transformation in reverse we also identify the threshold graph that has the fewest number of 1-factors (Received March 22, 2010)

1060-05-87 **Lazaros D Kikas*** (lazkikas@gmail.com), University of Detroit Mercy, Dept. of Mathematics and Computer Science, 4001 W.McNichols, Detroit, MI 48221. *An Algebraic Approach to Finding Disjoint Paths in the Alternating Group Graph.*

Large symmetric interconnection networks are not only interesting in their own right, but they have practical applications in the area of large scale computing. Research into their graph theoretic properties have yielded many interesting results. Suppose that we have k pairs of vertices $(s_1, t_1), (s_2, t_2), ..., (s_k, t_k)$ and we wish to find k-disjoint paths each connecting exactly one pair. If in a graph G we can do this for any k pairs of vertices then we say that G has the k-**Disjoint Path Property**. A necessary condition for G to have the k-Disjoint Path Property is that G is $(2k-1)$-connected. In 2005, Cheng, Kikas, and Kruk showed that the alternating group graph AG_n has the $(n-1)$-Disjoint Path Property. In this talk we will give two algorithms for finding these paths. One algorithm exploits the algebraic properties of the alternating group graph and reduces routing to the factoring of elements while the other exploits the structure of AG_n. (Received March 22, 2010)

1060-05-91 **Dominique Buset*** (dbuset@ulb.ac.be), Université Libre de Bruxelles, Service Beams CP165/14, 50 Avenue F. Roosevelt, B-1050, Bruxelles, Belgium. *Applications of the Cayley graphs to the Degree/Diameter Problem.*

The construction of large interconnection or microprocessor networks gave rise to the "degree/diameter problem" also called "(Δ, D)-graph problem": given two positive integers Δ and D, construct a connected (Δ, D)-graph (i.e. a graph of degree Δ and diameter D) with maximum number of vertices. The largest integer n such that there exists a (Δ, D)-graph with n vertices will be denoted by $n(\Delta, D)$. Since the 1960's the (Δ, D)-graph problem has been studied by many authors but very little is known about the exact values of $n(\Delta, D)$. Upper bounds for $n(\Delta, D)$ are given by Moore in 1958 and by Bannai and Ito in 1981. For $\Delta \geq 3$ and $D \geq 2$, only six maximal (Δ, D)-graphs are know. Most of the recent results concern effective constructions of large (Δ, D) -graphs. Many of them use Cayley graphs. In this talk, we give a survey of what is known about this problem with some last improvements and provide many open problems which can give rise to further research in the field of construction of large interconnection networks. (Received March 23, 2010)

1060-05-93 **Eddie Cheng** and **Christopher C Melekian*** (chris.melekian@gmail.com), 2200 N. Squirrel Rd., Department of Mathematics and Statistics, Oakland University, Rochester, MI 48309. *Matching preclusion and condition matching preclusion of folded Petersen Cubes.* Preliminary report.

The matching preclusion number of a graph is the minimum number of edges whose deletion results in a graph that has neither perfect matchings nor almost-perfect matchings. For many interconnection networks, the optimal sets are precisely those induced by a single vertex. Recently, the conditional matching preclusion number of a graph was introduced to look for obstruction sets beyond those induced by a single vertex. It is defined to be the minimum number of edges whose deletion results in a graph *with no isolated vertices* that has neither perfect matchings nor almost-perfect matchings. We find this number and classify all optimal sets for the folded Petersen cubes. Moreover, some general results regarding Cartesian product are also presented. (Received March 23, 2010)

1060-05-104 **Stephen G. Hartke*** (hartke@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130, and **Tyler Seacrest**, Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Balanced bipartite subgraphs with at least half the degree of each vertex.* 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 in G? We will discuss partial results on this question, including 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 March 24, 2010)

1060-05-110 **John T. Saccoman*** (saccomjt@shu.edu), Seton Hall University Dept. of Math and CS, 400 South Orange Ave, South Orange, NJ 07079. *A surgery reducing the All-Terminal Reliability of threshold graphs having a specified degree condition.*

A graph G is a threshold graph if, for all pairs of nodes u and v in G, the neighborhood of u excluding v is completely contained in the neighborhood of v excluding u whenever $deg(u) \leq deg(v)$.
We define All_Terminal Reliability (ATR) of a network modeled by a graph as follows: the edges of a graph are assumed to have equal and independent probabilities of operation p, and the ATR of the graph is defined to be the probability that a spanning connected subgraph operates. It is believed that threshold graphs provide the best lower bound on the ATR for graphs in a particular class. There exist surgeries that lower ATR for some threshold graphs, but they do not work in all cases. In "A surgery reducing the number of spanning trees for certain threshold graphs" (Congressus Numerantium 178, pp. 15-31), the author, along with Sarah Bleiler, present a surgery that transforms a threshold graph into one having fewer spanning trees under certain conditions. In this paper, that surgery is shown to create a threshold graph with lower ATR.
(Received March 24, 2010)

1060-05-113 **Jicheng Ma*** (j.ma@math.auckland.ac.nz), Department of Mathematics, University of Auckland, Private Bag 92019, Auckland, New Zealand. *Cubic graphs with diameter k.*

The degree/diameter problem is to determine the largest graphs of given degree and diameter. The general upper bound for such graphs is the Moore bound, denoted $M_{d,k}$. We consider cubic graphs. Finding better upper bounds for the maximum number of vertices, is an important field of research.

Among cubic graphs, only the Petersen graph achieves the Moore bound. Define a $(3, k, \varepsilon)$-graph to be a cubic graph with diameter k and $M_{3,k} - \varepsilon$ vertices, where ε is called the *defect*. Finding $(3, k, \varepsilon)$ -graphs helps reduce the upper bound. It is known that the (3,3,2)-graph and the (3,4,8)-graph are optimal graphs.

There are many different ways of constructing large graphs, such as by use of *Replacement Product, Graph lifting, Cayley graphs*, etc.

We try to prove that $(3, k, \varepsilon)$-graphs do not exist for larger values of ε. For example, it is known that for $k \geq 4$ and $\varepsilon = 2, 4, 6$, there are no $(3, k, \varepsilon)$-graphs.

I will discuss using *Graph lifting* to find larger cubic graphs. To find a larger covering graph, the choice of proper base (quotient) graph and voltage group is very important. Also I will talk about some properties of (3,k,6)-graphs for $k \geq 5$. (Received March 25, 2010)

1060-05-140 **Jonathan Cutler*** (cutlerjo@mail.montclair.edu), Montclair State University, Department of Mathematical Sciences, Montclair, NJ 07030, and **A. J. Radcliffe**. *Extremal problems for homomorphisms.*

There is a close connection between graph homomorphisms and a variety of natural graph theoretic notions: independent sets, colorings, etc. In this talk, we will discuss the extremal problem for homomorphisms from graphs of a fixed size and order to a fully-looped path of length two. In the complement, this corresponds to maximizing the number of complete bipartite subgraphs of a graph. (Received March 28, 2010)

1060-05-159 **Frank Hsu*** (hsu@cis.fordham.edu), Fordham University, Depart. of Computer & Information Sciences, 441 East Fordham Road, Bronx, NY, NY 10458. *The use of de Bruijn graphs in ChIP-sequencing.*

I will speak on the use of de Bruijn graphs in ChIP-sequencing. (Received March 29, 2010)

1060-05-173 **Michael O Albertson**, **Debra L Boutin** and **Ellen Gethner*** (ellen.gethner@ucdenver.edu). *The Thickness and Chromatic Number of r-Inflated Graphs.*

A graph has thickness t if the edges can be decomposed into t and no fewer planar layers. We study one aspect of a generalization of Ringel's famous Earth-Moon problem: what is the largest chromatic number of any thickness-2 graph? In particular, given a graph G we consider the r-inflation of G and find bounds on both the thickness and the chromatic number of the inflated graphs. In some instances the best possible bounds on both

the chromatic number and thickness are achieved. We end with several open problems. (Received March 29, 2010)

1060-05-202 **Breeann Tonnsen***, 2302 Braun Court, Golden, CO 80401, and **Michael Ferrara** and **Ellen Gethner**. *List-Distinguishing Colorings of Graphs.* Preliminary report.

A labeling of the vertices of a graph G is said to be *distinguishing* provided that no nontrivial automorphism of G preserves all of the vertex labels. The *distinguishing number* of G, denoted $D(G)$, is the minimum number of labels in a distinguishing labeling of G. The distinguishing number, first introduced by Albertson and Collins in 1996, has been widely studied and a number of interesting results exist throughout the literature.

Here, we extend this notion to list-distinguishing colorings. Given a family L of lists assigning available colors to the vertices of G, we say that G is L-distinguishable if there is a distinguishing coloring f of G such that $f(v) \in L(v)$ for all v. The *list-distinguishing number* of G, $D_\ell(G)$, is the minimum integer k such that G is L-distinguishable for any assignment L of lists with $|L(v)| = k$ for all v. In this talk, we will discuss several results and open problems concerning the list-distinguishing number. (Received March 30, 2010)

1060-05-210 **Hemanshu Kaul*** (kaul@iit.edu), Dept. of Applied Mathematics, Illinois Institute of Technology, Chicago, IL 60616. *Finding Large Subgraphs.*

The maximum subgraph problem for a fixed graph property P asks: Given a graph, find a subgraph satisfying property P that has the maximum number of edges. This property can be planarity, acyclicity, bipartiteness, etc. We will discuss some old and new problems of this flavor with special emphasis on properties defined in terms of forbidden minors. In particular, we will describe some new algorithmic results on the maximum K_4 - minor-free subgraph problem (joint work with Calinescu and Fernandes). (Received March 30, 2010)

1060-05-213 **Daniela Ferrero*** (dferrero@txstate.edu), Department of Mathematics, Texas State University, San Marcos, TX 78666, **Seema Varguese**, Department of Mathematics, Cochin University of Science and Technology, Cochin, India, and **A Vijaykumar**, Department of Mathematics, Cochin University of Science and Technology, Cochin, India. *Power domination of honeycomb mesh networks.*

Electric power networks must be continuously monitored. Such monitoring can be efficiently accomplished by placing phase measurement units (PMUs)at selected network locations. Due to the high cost of the PMUs, their number must be minimized. The power domination problem consists of finding the minimum number of PMUs needed to monitor a given electric power system. The power domination problem is NP-hard, but closed formulas for the power domination number of certain networks, such as rectangular meshes have been found. In this work we extend the results for rectangular meshes to honeycomb meshes, subgraphs of Cayley graphs. (Received March 30, 2010)

1060-05-216 **Rinovia Simanjuntak***, Combinatorial Mathematics Research Group, Institut Teknologi Bandung, Jalan Ganesa 10, Bandung, 40132, Indonesia, and **Miller Mirka** and **Tomas Vetrik**. *Large graphs of given degree and diameter.* Preliminary report.

The degree/diameter problem is to determine the largest graphs of given maximum degree and given diameter. General upper bounds - called *Moore bounds* - for the order of such graphs are attainable only for certain special graphs.

Finding tighter upper bounds for the maximum possible number of vertices, given the other two parameters, and thus attacking the degree/diameter problem 'from above', remains a largely unexplored area. On the other hand, constructions producing large graphs of given degree and diameter represent a way of attacking the degree/diameter problem 'from below'.

In this talk, we will discuss two methods to attack the two above mainstreams of research. The talk will conclude by considering Moore-like bounds for a special type of graph - the bipartite Cayley graphs. (Received March 30, 2010)

1060-05-219 **C L Suffel*** (csuffel@stevens.edu), Castle Point Terrace, EAS Building (Rm 409), Hoboken, NJ 07030, and **L Iswara Chandra**, **A Suhartomo** and **D Gross**. *On the Weighted Component Line Connectivity of Trees and Unicycles.*

Given n and k such that $2 < n < k$ and a graph on n nodes with positive weights on the nodes, the k-weighted component line connectivity of the graph is the minimum number of lines that must be removed from the graph so that each component of the resulting subgraph has total weight no greater than $k - 1$. We present efficient algorithms for determining the value of this parameter for trees and unicycles. (Received March 30, 2010)

1060-05-225 **Debra L Boutin*** (dboutin@hamilton.edu), Department of Mathematics, Hamilton College, Clinton, NY 13323. *The Cost of 2-Distinguishing.*

A graph G is said to be 2-*distinguishable* if there is a coloring of the vertices with two colors so that only the trivial automorphism preserves the vertex colors. Denote the minimum size of a color class in such a coloring by $\rho(G)$. If we consider 2-distinguishing the graph by coloring one label class of vertices red and not coloring the other, ρ tells us the minimum number of vertices we need to color to break all symmetry. Thus we call $\rho(G)$ the *cost of 2-distinguishing* G. There is a natural relationship between a smallest color class in a 2-distinguishing coloring and a determining set for the graph. (A *determining set* is a set of vertices whose pointwise stabilizer is trivial.) In this talk we will define the cost of 2-distinguishing, explore some examples, relate the cost to the minimum size of a determining set, and ultimately show that $\rho(Q_n) = \Theta(\log n)$. (Received March 30, 2010)

1060-05-226 **Spencer N. Tofts*** (tofts@udel.edu), 6 Spring Hill Lane, Newark, DE 19711, and **Felix Lazebnik**. *Another Extremal Property of Turán Graphs.*

For an integer $n \geq 3$, let $T_n(v)$ denote the Turán n-partite graph of order v, and let $t_n(v)$ denote the number of edges of $T_n(v)$. For a simple graph G and a positive integer λ, let $P_G(\lambda)$ denote the number of proper vertex colorings of G in at most λ colors. We prove that for every graph G of order v and size $t_n(v)$, $P_G(n+1) \leq P_{T_n(v)}(n+1)$, with the equality attained if and only if $G = T_n(v)$. The work extends some other related results, old and new. (Received March 30, 2010)

1060-05-236 **Stefaan De Winter**, Department of Mathematics and Computer Algebr, Ghent University, 9000 Gent, Belgium, **Felix Lazebnik*** (lazebnik@math.udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 191716, and **Jacques Verstraëte** (jacques@ucsd.edu), Department of Mathematics, University of California, 9500 Gilman Drive, La Jolla, CA 92093-0112. *An Extremal Characterization of Projective Planes.*

We prove that amongst all n by n bipartite graphs of girth at least six, where $n = q^2+q+1 \geq 157$, the incidence graph of a projective plane of order q, when it exists, has the maximum number of cycles of length eight. This characterizes projective planes as the partial planes with the maximum number of quadrilaterals. (Received March 30, 2010)

11 ► Number theory

1060-11-68 **Joseph Andrew Hundley*** (jhundley@math.siu.edu), Department of Mathematics, Mailcode 4408, Southern Illinois University, 1245 Lincoln Drive, Carbondale, IL 62901. *The adjoint L function for SU(2,1).*

A construction for the adjoint L function of a quasi-split unitary group in three variables will be described. The construction is a generalization of a construction of Ginzburg's for SL(3). Time permitting, the prospects for extending the result to unitary groups in 4 or 5 variables will be discussed. (Received March 18, 2010)

1060-11-72 **Christian A Zorn*** (czorn@math.ohio-state.edu), 630 Mathematics Tower, 231 West 18th Avenue, Columbus, OH 43235. *Some Explicit Results Regarding Theta Dichotomy for Metaplectic/Orthogonal Dual Pairs.*

Let F be a finite extension of $\mathbb{Q}_p$ with $p \neq 2$, $(\pi, \mathcal{V}_\pi)$ a genuine irreducible admissible representation of $\widetilde{\mathrm{Sp}_n}(F)$, and $\mathrm{O}(V_\kappa^\pm)$ the orthogonal groups for the pair of quadratic spaces $(V_\kappa^\pm, Q_\kappa^\pm)$ having dimension $2n+1$ and discriminant $(-1)^n\kappa$. According to the Theta Dichotomy Conjecture, there exists a non-vanishing local theta lift $\theta_\psi(\pi, V_\kappa^\pm)$ (in the sense of Howe) to precisely one of the two groups $\mathrm{O}(V_\kappa^\pm)$. We discuss the proof of this conjecture. We then specialize to the case that $n = 2$ and $(\pi, \mathcal{V}_\pi)$ is an irreducible constituent of the genuine unramified principal series of $\widetilde{\mathrm{Sp}_2}(F)$ to discuss the existence of an irreducible admissible representation $(\pi'_\kappa, \mathcal{V}_{\pi'_\kappa})$ of $\mathrm{SO}_5(F) \simeq \mathrm{PGSp}_2(F)$ for which $\epsilon(\frac{1}{2}, \pi'_\kappa, \psi)$ (from Local Langlands Correspondence for $\mathrm{GSp}_2(F)$) determines which group $\mathrm{O}(V_\kappa^\pm)$ has the non-vanishing theta lift. These results are a partial analogue to some results of Waldspurger regarding the theta dichotomy for $\widetilde{\mathrm{SL}_2}(F)$. (Received March 19, 2010)

1060-11-80 **Brooke Feigon*** (bfeigon@math.toronto.edu), Department of Mathematics, University of Toronto, 40 St. George Street, Toronto, Ontario M5R 2E4, Canada, and **David Whitehouse**. *Exact averages of central values of triple product L-functions.*

In this talk, I will discuss exact formulas for averages of central L-values obtained using the relative trace formula and relations between periods and L-functions. I will focus on an example involving triple product L-functions. (Received March 21, 2010)

1060-11-100 **Sheng-Chi Liu*** (scliu@math.tamu.edu), Department of Math, Texas A&M University, College Station, TX 77843-3368. *Determination of GL(3) cusp forms by central values of GL(3) × GL(2) L-functions.*

The converse theorems by Weil, Cogdell and Piatetski-Shapiro assert that the modularity of an L-series can be determined by infinitely many twisted L-series. Assuming the modularity of an L-function, we prove that the corresponding self-dual GL(3) Hecke-Maass form is uniquely determined by the central values of GL(2) twists of its L-function. This generalizes a theorem of Luo and Ramakrishnan to GL(3). (Received March 24, 2010)

1060-11-105 **Jim Brown*** (jimlb@clemson.edu), Clemson, SC 29634. *Congruence primes of Saito-Kurokawa lifts.*

There is a conjectural description of the congruence primes of a classic Saito-Kurokawa lift of full level in terms of the primes dividing a special value of the L-function associated to the elliptic modular form giving rise to the Saito-Kurokawa lift. This conjecture was proposed by Katsurada. We will recall the conjecture, state the known evidence for this conjecture as well as explain recent work on the conjecture. In particular, congruences between Saito-Kurokawa lifts and Siegel modular forms that are not "lifts" are constructed using recent work of Pitale-Schmidt and Saha. (Received March 24, 2010)

1060-11-116 **Abhishek Saha*** (abhishek.saha@math.ethz.ch), HG G 68.1, Raemistrasse 101, ETH Zurich, 8004 Zurich, Switzerland. *Average formulas for Rankin-Selberg L-functions.*

An important tool to prove results relating to the subconvexity, non-vanishing and arithmeticity of special values of L-functions is to consider their average over an appropriate family. I will briefly survey various methods that have been employed to prove such average formulas for special values of the Rankin-Selberg L-function and will then describe my recent work on the same lines that uses the Garrett pullback formula. (Received March 25, 2010)

1060-11-136 **Steven T Spallone*** (sspallone@gmail.com), 1925 Cherry Stone St, Apt #6, Norman, OK 73072. *Stable Trace Formulas and Discrete Series Multiplicities.* Preliminary report.

In Arthur's 1989 paper "L^2-Lefschetz numbers of Hecke operators", he gives an expression for a stable sum of multiplicities of discrete series representations in terms of orbital integrals and character values. We present a stabilized version of this, due to Kottwitz, which seems to give the individual multiplicities. We focus on GSp_4. (Received March 28, 2010)

1060-11-139 **James W. Cogdell*** (cogdell@math.ohio-state.edu), Department of Mathematics, 231 West 18th Avenue, Columbus, OH 43210. *On Certain Bessel Functions.*

In the proofs of functoriality using the converse theorem, the lack of a "Local Langlands Conjecture" is finessed via the stability of the local gamma factor under highly ramified twists. This stability result in turn relies on understanding certain Bessel functions attached to generic representations and their asymptotics. In this talk I would first like to explain these Bessel functions and what we know and expect about their asymptotics. Then I will explain a general framework for defining and analyzing these types of functions. This is joint work with F. Shahidi. (Received March 28, 2010)

1060-11-148 **Mahesh Agarwal*** (mkagarwa@umd.umich.edu), Dept. of Mathematics and Statistics, 4901 Evergreen Rd, Dearborn, MI 42128. *Bloch-Kato conjecture for convolution L-functions.*

We give evidence for the Bloch-Kato conjecture for the convolution L-function of two elliptic modular forms. Let f be a newform of weight 2 and g be a newform of weight $k+2$, $k \in \{2,4,6,8,12\}$, of level $\Gamma_0(q)$ for an odd prime q such that they are ordinary at p and residually absolutely irreducible Galois representations mod p for p an odd prime different from q. Under some additional conditions on p we show that if

$$p^n \mid L^{\mathrm{alg}}(2+k/2, f\times g) \implies p^n \mid \#H^1_f(G_{\mathbf{Q}}, \rho_f \times \rho_g(-k/2-1))$$

This is carried out by studying congruences between Yoshida lift of f, g and stable forms on $GSp(4)$. This is a report on joint work with Krzysztof Klosin. (Received March 29, 2010)

1060-11-157 **Daniel W File*** (file@math.ohio-state.edu), 100 Math Tower, 231 W. 18th Avenue, Columbus, OH 43210-1174. *On the degree 5 L-function for GSp(4).*

I will describe a new integral representation for the degree five L-function of a cuspidal automorphic representation of GSp(4). The integral makes use of the Bessel model for GSp(4). (Received March 29, 2010)

1060-11-176 **Jonathan Sondow*** (jsondow@alumni.princeton.edu), 209 West 97th Street, New York, NY 10025, and **Cristian Dumitrescu** (cristiand43@gmail.com), 119 Young Street, Kitchener, Ontario N2H4Z3, Canada. *A monotonicity property of Riemann's xi function and a reformulation of the Riemann Hypothesis.*

We prove that Riemann's xi function is strictly increasing (respectively, strictly decreasing) in modulus along every horizontal half-line in any zero-free, open right (respectively, left) half-plane. The proof uses the Hadamard product representation of the xi function and the functional equation. A corollary is a reformulation of the Riemann Hypothesis (a slight improvement of a known result). Our paper is to appear in *Period. Math. Hungar.* (Received March 29, 2010)

1060-11-178 **Paul B Garrett*** (garrett@math.umn.edu), 127 Vincent Hall, 206 Church St. SE, Minneapolis, MN 55455. *Examples illustrating basic analytic issues in the spectral theory of automorphic forms.*

Automorphic spectral theory is subtle and a little dangerous, due to proximity to fundamental, intractable questions (from Selberg, Ramanujan, Lindelof, Riemann, Langlands, Arthur, et alia). Indeed, this proximity lends interest, all the more reason to cultivate means to make fine distinctions.

For example, it is well known and immediate that sharp point-wise estimates on Eisenstein series on GL(2) imply Lindelof. This might appear to impede a coherent discussion of pointwise convergence of automorphic spectral expansions. Yet, as observed many times in the last few decades, if we ask for no more than we need, questions about pointwise convergence in fairly general circumstances admit clear resolutions in the context of Schwartz and Sobolev.

Example computations, concerning finer details about resolvents and other aspects of geometric analysis of automorphic forms, are convenient in SL(2,C) and its arithmetic quotients, due to its peculiar advantage of being both complex and real split-rank one. Higher-rank complex groups afford further examples, with predictable complications. (Received March 29, 2010)

1060-11-180 **Ralf Schmidt*** (rschmidt@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019-0315. *Local newforms for the metaplectic group.*

The connection between elliptic modular forms and automorphic representations of the group GL(2) is well understood. A similar connection exists between modular forms of half-integral weight and automorphic representations of the metaplectic group (double cover of SL(2)). The connection in the half-integral weight case is less clear, partly due to the fact that p-adic representations of the metaplectic group do not admit a simple theory of local newforms as in the GL(2) case. We will present a newform theory for the metaplectic group in which the number of local newforms is related to the number of Whittaker models of a representation. This is joint work with Brooks Roberts. (Received March 29, 2010)

1060-11-217 **Justin N Young*** (jyoung@math.ohio-state.edu), 231 W. 18th Ave., Columbus, OH 43210. *The Twisted Tensor L-function of* GSp_4.

I will give an integral representation for the twisted tensor or Asai L-function for a generic cuspidal representation of GSp_4 and discuss the method of proof using a branching result, namely, restriction from GL_4 to Sp_4. I will also illustrate a cuspidal period arising as a residue of this integral and discuss its connection with quadratic base change for GSp_4. (Received March 30, 2010)

1060-11-247 **Yusuf Danisman*** (danisman@math.ohio-state.edu), 231 West 18th Avenue, Columbus, OH 43210. *L factors for the p-adic Group GSP(4).*

In this talk, we will compute L-factors for nongeneric supercuspidal representations of $GSp(4,k)$ which has Bessel model and k is a nonarchemedian local field of characteric not equal to 2. As a definition of L-factors, Piatetski-Shapiro's construction, which is based on Bessel models, will be used. After finding the Bessel models by using theta liftings, first of all we will compute γ-factors and then by using them L-factors will be computed. (Received March 30, 2010)

1060-11-254 **Jonathan P. Hanke*** (jonhanke@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *On the Berkovich-Jagy S-genus identites.*

We will discuss some very recent conjectures of Alexander Berkovich and Will Jagy which express linear combinations of certain theta series of ternary quadratic forms in terms of a single theta function (for the sum of three squares), how they arose, and various techniques for understanding them. (Received March 31, 2010)

14 ► Algebraic geometry

1060-14-123 **Miroslav Kramar*** (miroslav@math.rutgers.edu), 1050 George str Apt 3A, New Brunswick, NJ, and **Konstantin Mischaikow** and **Lou Kondic**. *Topology of force chains in dense granular materials.*

We will present a novel approach to study force chain structures of dense particulate systems. These structures are very important in understanding static and dynamic features of dense particulate systems. However, so far there is no well defined approach towards understanding them. Our approach deploys algebraic topology techniques which allow us to distinguish between the systems exposed to shear and compression. We use our method to compare experimental and theoretical results in a well defined and precise manner. We will also discuss how the topological measures can be used to understand the dynamic features of the system and correlate these measures to the phenomena such as jamming. (Received March 26, 2010)

16 ► Associative rings and algebras

1060-16-5 **Aleks Kleyn*** (Aleks_Kleyn@MailAPS.org), 2709 Brown str, Brooklyn, NY 11235. *The Gâteaux Derivative and Integral over Division Ring.*

Let $Z(D)$ be center of division ring D. Map

$$f : D \to D$$

is linear if for any $a, b \in D$ and any $c \in Z(D)$

$$f(a+b) = f(a) + f(b)$$
$$f(ca) = cf(a)$$

Map

$$f : D \to D$$

is called differentiable in the Gâteaux sense,if

$$f(x+a) - f(x) = \partial f(x)(a) + o(a)$$

where the Gâteaux derivative $\partial f(x)$ of map f is linear map of increment a and o is such continuous map that

$$\lim_{a \to 0} \frac{|o(a)|}{|a|} = 0$$

For instance

$$\partial(x^2)(h) = xh + hx$$
$$\partial(x^{-1})(h) = -x^{-1}hx^{-1}$$

Assuming that we defined the Gâteaux derivative $\partial^{n-1} f(x)$ of order $n-1$,we define

$$\partial^n f(x)(a_1; ...; a_n) = \partial(\partial^{n-1} f(x)(a_1; ...; a_{n-1}))(a_n)$$

the Gâteaux derivative of order n of map f. When $h_1 = ... = h_n = h$, we assume

$$\partial^n f(x)(h) = \partial^n f(x)(h_1; ...; h_n)$$

Function $f(x)$ has Taylor series expansion

$$f(x) = \sum_{n=0}^{\infty} (n!)^{-1} \partial^n f(x_0)(x - x_0)$$

Differential equation over division ring

$$\partial(y)(h) = hx^2 + xhx + x^2 h$$
$$y(0) = 0$$

has solution

$$y = x^3$$

The solution of differential equation

$$\partial(y)(h) = \frac{1}{2}(yh + hy)$$
$$y(0) = 1$$

is exponent $y = e^x$ that has following Taylor series expansion

$$e^x = \sum_{n=0}^{\infty} (n!)^{-1} x^n$$

The equation

$$e^{a+b} = e^a e^b$$

is true iff $ab = ba$ (Received August 25, 2009)

1060-16-45 **Murray R. Bremner*** (bremner@math.usask.ca), Mathematics and Statistics, University of Saskatchewan, Saskatoon, SK S7N 5E6, Canada. *How to compute the Wedderburn decomposition of an associative algebra.*

This will be an expository talk on algorithms that have been developed since the 1980's for explicit computation of the Wedderburn decomposition of a finite-dimensional associative algebra given a basis and structure constants. The first problem is to determine the radical; by a theorem of Dickson this can be reduced, in characteristic 0, to computing the nullspace of a matrix. Once a basis for the radical has been found, it is easy to determine the structure constants for the semisimple quotient. The center of the quotient is a commutative semisimple algebra, and hence is isomorphic to a direct product of fields; its dimension is the number of simple ideals in the quotient. The second problem is to split the center: to find a basis consisting of orthogonal primitive idempotents. These basis elements correspond to the identity matrices in the simple ideals. The third problem is to compute an explicit isomorphism of each simple ideal with a matrix algebra: that is, to determine a basis of matrix units. I will illustrate these computations with the 27-dimensional rational semigroup algebra of the full transformation semigroup on three letters: the semigroup of all functions from a set with three elements to itself under the operation of function composition. (Received March 08, 2010)

1060-16-78 **Uma N Iyer*** (uma.iyer@bcc.cuny.edu), 2155 University Avenue, Bronx, NY 10453, and **Timothy C McCune**. *Differential Operators on the free algebra.*

Following the definition of the algebra of differential operators (respectively, beta-differential operators and quantum differential operators) on non-commutative algebras (respectively, non-commutative algebras graded by an abelian group) given by Lunts and Rosenberg we study these various algebras of differential operators on the free algebra. We present the generators of these algebras of differential operators and present further questions to be investigated. (Received March 21, 2010)

1060-16-84 **Bogdan Ion*** (bion@pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *On PBW bases.*

Virtually all the proofs of the Poincare-Birkhoff-Witt theorem (and its generalizations) are of combinatorial nature, reducing one way or another to the knowledge of generators and relations for the algebras in question. I will present a PBW theorem for irreducible Hopf algebras (of which enveloping algebras of Lie algebras, in characteristic zero, or restricted Lie algebras, in positive characteristic, are examples) in arbitrary characteristic. The proof does not require any information about generators and relations and works as well for irreducible Hopf algebras in symmetrically braided categories. Furthermore, the irreducibility hypothesis may be weakened to show that any Hopf algebra with (braided) central Hopf algebra has a PBW basis over the coradical. (Received March 22, 2010)

17 ► Nonassociative rings and algebras

1060-17-26 **Choonkil Park*** (baak@hanyang.ac.kr), Department of Mathematics, Hanyang University, Seoul, 133-791, South Korea, and **Zaman G. Eskandani** (zamani@tabrizu.ac.i), Faculty of Mathematical Science, University of Tabriz, Tabriz, Iran. *Homomorphisms and derivations in proper Lie CQ^*-algebras.*

In this paper, we investigate homomorphisms in proper Lie CQ^*-algebras and derivations on proper Lie CQ^*-algebras associated with the following Pexiderized functional equation

$$f(x+y) = f_0(x) + f_1(y).$$

Moreover, we prove the Hyers-Ulam-Rassias stability of homomorphisms in proper Lie CQ^*-algebras and of derivations on proper Lie CQ^*-algebras. (Received February 12, 2010)

1060-17-42 **Murray R. Bremner*** (bremner@math.usask.ca), Mathematics and Statistics, University of Saskatchewan, Saskatoon, SK S7N 5E6, Canada, and **Hader A. Elgendy**. *Universal enveloping algebras of n-Lie algebras.* Preliminary report.

An n-Lie algebra is a vector space L with a multilinear product $L^n \to L$ satisfying n-ary anticommutativity and the n-ary Jacobi identity. These structures were introduced by Filippov in 1985; in the case $n = 2$ we obtain the definition of a Lie algebra. Ling proved in 1993 that for $n \geq 3$, there is only one simple finite-dimensional n-Lie algebra; it has dimension $n+1$ and generalizes the cross product on $\mathbb{R}^3$ to an n-ary product on $\mathbb{R}^{n+1}$. We study representations of n-Lie algebras in associative algebras by means of the n-ary alternating sum. This leads to the problem of determining the universal enveloping algebra $U(L)$ of an n-Lie algebra L. Using the theory of Gröbner bases, we determine a basis for $U(L)$ when n is even and L is the simple n-Lie algebra. As a corollary,

we find that the natural map from L to $U(L)$ is injective; this is a partial generalization of the PBW theorem to n-Lie algebras. (For odd n the situation is much more complicated.) We obtain a new proof of some results of Pozhidaev from 2003 for $n \leq 6$, but our results seem to be new for $n \geq 8$. This is joint work with my Ph.D. student Hader Elgendy. (Received March 08, 2010)

1060-17-43 **Juana Sanchez Ortega*** (jsanchez@agt.cie.uma.es), Dpto. Algebra, Geometria y Topologia, Facultad de Ciencias, Campus de Teatinos, Universidad de Malaga, Malaga, Malaga 29071. *Quotients for graded Lie algebras.*

The theory of quotients of associative algebras has a rich history and is still an active research area. Recently, notions of quotients for Jordan systems have appeared (see [3, 1, 2]). In [4] M. Siles Molina introduced the notion of a general algebra of quotients of a Lie algebra, and built a maximal algebra of quotients for every semiprime Lie algebra. We study here quotients for graded Lie algebras. The relationship between the graded and the non-graded quotients is analyzed and important examples are given. We build a graded maximal algebra of quotients for every graded semiprime Lie algebra and we show that the study of maximal Jordan systems of quotients in the sense of [2] can be seen under the umbrella of Lie quotients, via the Tits-Kantor-Koecher construction.

[1] Anquela, J. A., Garcia, E., Gomez Lozano, M., Maximal algebras of Martindale-like quotients of strongly prime linear Jordan algebras, J. Algebra 280 (2004), 367-383. [2] Garcia, E., Gomez Lozano, M., Jordan System of Martindale-like Quotients. J. Pure Appl. Algebra 194 (2004), no. 1-2, 127-145. [3] Martinez, C., The ring of fractions of a Jordan algebra, J. Algebra 237 (2001), 798-812. [4] Siles Molina, M., Algebras of quotients of Lie algebras. J. Pure Appl. Algebra 188 (2004), 175-188. (Received March 08, 2010)

1060-17-63 **Erhard Neher*** (neher@uottawa.ca), Department of Mathematics and Statistics, University of Ottawa, 585 King Edward, Ottawa, Ontario K1N 6N5, Canada, and **Alistair Savage** and **Prasad Senesi**. *Finite-dimensional representations of equivariant map algebras.*

We consider an affine algebraic variety X, a finite-dimensional simple Lie algebra L and a finite group G acting on both X and L by by automorphisms. The space of G-equivariant regular maps from X to L is a Lie algebra under pointwise multiplication, called an equivariant map algebra. Examples of equivariant map algebras are (twisted or untwisted) multiloop algebras, current algebras, and the Onsager (Lie) algebra.

In this talk I will present a classification of finite-dimensional irreducible representations of equivariant map algebras: They are (almost) all evaluation representations. This result recovers previously known classifications, for example for the multiloop, current and Onsager algebras. In addition, we can easily derive the precise structure of the finite-dimensional irreducible representations in previously unknown cases. This part of the talk is joint work with Alistair Savage and Prasad Senesi.

I will also discuss the structure of extensions between these representations (work in progress with Alistair Savage). (Received March 18, 2010)

1060-17-67 **Marina Tvalavadze*** (marina@math.usask.ca), Department of Mathematics and Statistics, University of Saskatchewan, Saskatoon, SK S7N5E6, Canada. *Superinvolutions on graded superalgebras.*

In this paper we describe graded superinvolutions on matrix superalgebras endowed with a group grading over an algebraically closed field F of characteristic zero. These results are necessary for the determination of the gradings on simple Lie and Jordan superalgebras that can be realized as skew-symmetric (resp. symmetric) elements of $R = M_{n,m}(F)$ under the superinvolution. (Received March 18, 2010)

1060-17-76 **Dijana Jakelic*** (jakelicd@uncw.edu), Department of Mathematics and Statistics, University of North Carolina Wilmington, 601 S. College Rd, Wilmington, NC 28401, and **Adriano Adrega de Moura** (aamoura@ime.unicamp.br). *Tensor products and blocks of finite-dimensional representations of quantum affine algebras at roots of unity.*

The category of finite-dimensional representations of quantum affine algebras is not semisimple. For generic values of the quantization parameter, results of V. Chari and M. Kashiwara provide a way of obtaining indecomposable objects 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 to describe 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. (Received March 21, 2010)

1060-17-127 **Samuel Herron Chamberlin*** (samcham@math.ucr.edu), University of Califnornia, Riverside, 900 University Ave., Department of Mathematics, Riverside, CA 92521. *A realization of the general global Weyl module for* $\mathfrak{sl}_2$.

Let A be a finitely generated commutative associative algebra over $\mathbb{C}$. Given a finite dimensional simple Lie algebra $\mathfrak{g}$ The global Weyl module for $\mathfrak{g} \otimes A$ is well known in terms of generators and relations. In the case where $\mathfrak{g} = \mathfrak{sl}_2$ and $A = \mathbb{C}[t]$ a realization of this module was given by V. Chari and A. Pressley. We will show that the same realization holds for $\mathfrak{g} = \mathfrak{sl}_2$ but arbitrary A using a new proof technique. (Received March 26, 2010)

1060-17-218 **James Lepowsky*** (lepowsky@math.rutgers.edu), Dept. of Mathematics, Rutgers University, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019. *Recent developments on logarithmic tensor category theory for generalized modules for a conformal vertex algebra.*

In joint work with Yi-Zhi Huang and Lin Zhang, we have developed a "logarithmic tensor category theory" for suitable categories of generalized modules for a vertex operator algebra, and more generally, for a conformal or Möbius vertex algebra, incorporating natural actions of the Virasoro algebra or of sl(2) and allowing for the grading restrictions for a vertex operator algebra to be relaxed. The source of the logarithms is the allowability of generalized weight spaces rather than ordinary weight spaces for the generalized modules, along with the nonsemisimplicity of the module category. Vertex operator algebras are analogues of Lie algebras in a certain subtle sense, and the present theory is the analogue of the consideration of the usual tensor category of modules for a given Lie algebra whose module category need not be semisimple. But in contrast with the classical Lie algebra situation, this vertex-algebraic analogue is an an extensive theory, requiring the development and use of subtle methods, both algebraic and analytic. In recent work, we have generalized and strengthened our results, permitting their applicability under more relaxed, natural conditions. I will sketch these recent developments. (Received March 30, 2010)

1060-17-224 **Andrew Douglas*** (afdouglas@gmail.com), Department of Mathematics, New York City College of Technology (CUNY), 300 Jay Street, Brooklyn, NY 11201, and **Murray Bremner**. *Nonassociative algebra structures on sl(2)-modules.*

The irreducible sl(2)-module V=V(n) with n= 6 (mod 4) occurs in its exterior square along with the adjoint representation with multiplicity 1. By projecting the exterior square of V onto itself and onto the adjoint representation, we may define a binary-ternary structure on V. We will describe how computer algebra was implemented to determine the polynomial identities satisfied by this structure for V(6), V(10), V(14), and V(18) in degrees less than or equal to 7. This is joint work with Murray Bremner. (Received March 30, 2010)

18 ► Category theory; homological algebra

1060-18-246 **Radmila Sazdanovic*** (radmilas@gmail.com), MSRI, 17 Gauss Way, Berkeley, CA 94720-507, and **Mikhail Khovanov**. *A categorification of the polynomial ring.*

We introduce a categorification of the one-variable polynomial ring Z[x], based on the geometrically defined graded algebra. This construction is generalized to the categorification of some basic special functions. (Received March 30, 2010)

20 ► Group theory and generalizations

1060-20-18 **Anthony M Gaglione*** (amg@usna.edu), Mathematics Department, U.S. Naval Academy, 572C Holloway Road, Annapolis, MD 21402, **Seymour Lipschutz**, Department of Mathematics, Temple University, Philadephia, PA 19122, and **Dennis M Spellman**, Department of Mathematics, Temple University, Philadelphia, PA 19122. *Almost Locally Free Groups and a Theorem of Magnus.*

Ben Fine observed that a theorem of Magnus on normal closures of elements in free groups is first order expressible and thus holds in every elementarily free group. This classical theorem, vintage 1931, asserts that if two elements in a free group have the same normal closure, then either they are conjugate or one is conjugate to the inverse of the other in the free group. An examination of a set of sentences capturing this theorem reveals that the sentences are universal-existential. Consequently the theorem holds in the almost locally free groups of Gaglione and Spellman. We give a sufficient condition for the theorem to hold in every fully residually free group as well

as a sufficient condition for the theorem to hold, even more generally, in every residually free group. (Received January 24, 2010)

1060-20-70 **Paul E Gunnells*** (gunnells@math.umass.edu), Dept. of Math. and Stat., University of Massachusetts Amherst, Amherst, MA 01003. *Automata and affine Kazhdan–Lusztig cells.*

Let (W, S) be an affine Weyl group, and let $C \subset W$ be a Kazhdan–Lusztig cell (left, right, or two-sided). Let $R(C)$ be the set of all reduced expressions of elements of C in the generators S, regarded as a language over the alphabet S in the sense of formal language theory. Our main result is that $R(C)$ is a regular language. This implies, for instance, that one can tell if a reduced expression represents an element of C simply by checking if the expression contains a subword from a finite list depending on C. (Received March 19, 2010)

1060-20-98 **Lisa Carbone*** (carbonel@math.rutgers.edu), Department of Mathematics, Hill Center, Busch Campus, 110 Frelinghuysen Rd, Piscataway, NJ 08854. *$\mathbb{Z}$-forms of Kac-Moody groups.* Preliminary report.

We discuss the problem of constructing explicit $\mathbb{Z}$-forms of the Tits functor for Kac-Moody groups $G_A(K)$, where K is a field and A is an arbitrary generalized Cartan matrix. We propose a representation theoretic construction of $G_A(\mathbb{Z})$ and we present various minimal generating sets for $G_A(\mathbb{Z})$. (Received March 24, 2010)

1060-20-99 **Anthony E Clement*** (aclement@brooklyn.cuny.edu), Mathematics Department, 1156 Ingersoll Hall, Brooklyn College, 2900 Bedford Avenue, Brooklyn, NY 11210. *Factor Groups of the Baumslag-Solitar Groups and Subgroups of the Additive Group of Rational Numbers.*

We will discuss isomorphisms among certain torsion-free abelian factor groups of the Baumslag-Solitar groups and subgroups of the additive group of rational numbers. (Received March 24, 2010)

1060-20-120 **Andrew J Duncan*** (a.duncan@ncl.ac.uk), School of Mathematics and Statistics, Newcastle University, Newcastle upon Tyne, NE46 4LF, England. *Graphs of groups and the Grzegorczyk hierarchy.* Preliminary report.

A group is defined by Rabin to be computable if it has an indexing function, that is a map from the group to the natural numbers, which is decidable and relative to which the multiplication function of the group is computable. Cannonito and Gatterdam refined Rabin's notion by giving each computable group a level on the Grzegorczyk hierarchy. This hierarchy is a stratification of primitive recursive functions into levels such that the rate of growth of values of functions is slower lower down and increases on each succesive level.

Cannonito and Gatterdam show, among other things, that the level of a free product with amalgamation or of an HNN extentsion is no higher than the level of the factor groups plus 1. In this talk I shall describe joint work with Christian Perfect giving analagous results for fundamental groups of graphs of groups. (Received March 25, 2010)

1060-20-128 **Maggie Habeeb*** (mhabeeb@gc.cuny.edu), Mathematics Department, 365 Fifth Ave., New York, NY 10016, and **Delaram Kahrobaei** (dkahrobaei@gc.cuny.edu) and **Vladmir Shpilrain** (shpil@groups.sci.ccny.cuny.edu). *A public key exchange using semidirect products of groups.*

We propose a key exchange protocol whose platform is a semidirect product of two groups. (Received March 26, 2010)

1060-20-131 **David Garber*** (garber@hit.ac.il), Holon Institute of Technology, 52 Golomb St., PO Box 305, 58102 Holon, Israel. *Length-based attack on a cryptosystem based on polycyclic groups.* Preliminary report.

In many situations, we need to transfer data in a secure way: credit cards information, health data, security uses, etc. The idea of public key cryptography in general is to make it possible for two parties to agree on a shared secret key, which they can use to transfer data in a secure way.

Combinatorial group theory is a fertile ground for finding hard problems which can serve as a base for a cryptosystem. Eick and Kahrobaei (2004) have suggested a possible cryptosystem based on polycyclic groups.

In the talk, we will present the cryptosystem, our implementation of the length-based attack for this case, and some preliminary results. Joint work with Assaf Balleli. (Received March 27, 2010)

1060-20-133 **Jay R. Williams*** (jaywil@math.rutgers.edu), Department of Mathematics, Rutgers University, Hill Center for the Mathematical Sciences, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019. *A negative result regarding the construction of groups with word problem of a given Turing degree.*

It is well-known that given a subset $X \subseteq \mathbb{N}$ with Turing degree $\mathbf{d}$, one can construct a finitely generated group G_X whose word problem also has Turing degree $\mathbf{d}$. The usual constructions are highly dependent on the set X, in the sense that distinct sets X, Y with the same Turing degree usually give rise to non-isomorphic groups G_X, G_Y; and it is natural to ask if there is a more uniform construction with the property that sets of the same Turing degree give rise to isomorphic groups. In this talk, I will discuss some joint work with Simon Thomas which implies that no such construction exists. (Received March 27, 2010)

1060-20-135 **Gilbert Baumslag** and **Benjamin Fine*** (fine@fairfield.edu), Department of Mathematics, Fairfield University, Fairfield, CT 06824, and **Douglas Troeger**. *Adapting Hilbert's Tenth Problem to Group Based Cryptography.*

The determination of the security of a group based cryptosystem most often involves tying the security to a known hard problem. Hilbert's tenth problem asked whether there is an algorithm to decide whether a given integral polynomial in any number of variables has a zero. In 1970 Davis,Putnam,Robinson and Matiyasevich showed that the answer is no. There exists a polynomial, the zeroes of which are aribtrarily large in abolsute value. In this talk we show how to combine the negative solution of Hilbert's tenth problem with certain properties of augmented rings and certain properties of the classical modular group to develop a public key cryptosystem. (Received March 28, 2010)

1060-20-138 **Benjamin Fine*** (fine@fairfield.edu), Department of Mathematics, Fairfield, CT 06824, and **Gerhard Rosenberger**. *Something for Nothing: Some Consequences of the Solution to the Tarski Problems.* Preliminary report.

From the positive solution to the Tarsksi problems by Kharlampovich and Myasnikov and independently by Sela it follows that every first order theorem in a nonabelian free group is true in every elementary free group. An elementary free group is agroup that shares the first order theory of the class of nonabelian free groups. The class of elementary free groups extends beyond the class of free groups. In particular orientable surface groups are elementary free. In particular Magnus' theorem concerning the normal closures of elements in free groups is true in surface groups. This was proved directly by J. Howie and independently by O. Bogopolski in a quite difficult manner. This type of result opens up several different types of questions. The first is which additional nontrivial free gorup results are true in surface groups but difficult to obtain directly. Secondly what first order properties of nonabelian free groups are true beyond the class of elementary free groups. In regard to this second question we consider groups satisfying certain quadratic properties that we call Lyndon properties and show that the class of groups satisfying these are closed under many amalgam constructions. (Received March 28, 2010)

1060-20-143 **Lev M Shneerson*** (Lev.Shneerson@hunter.cuny.edu), Department of Mathematics and Statistics, Hunter College, 695 Park Avenue, New York, NY 10065. *On the Growth of Finitely Presented Rees Quotients of Free Inverse Semigroups.* Preliminary report.

We present an inverse semigroup analogue of a classical result that characterizes polynomial growth of finitely presented Rees quotients of free semigroups in terms of primitive words that label loops of the Ufnarovskij graph of the presentation.

This is joint work with David Easdown (School of Mathematics and Statistics, the University of Sydney, Australia). (Received March 28, 2010)

1060-20-144 **Tim Hsu*** (hsu@math.sjsu.edu), Department of Mathematics, San Jose State University, San Jose, CA 95192-0103, and **Daniel T. Wise** (wise@math.mcgill.ca), Department of Mathematics and Statistics, McGill University, Montreal, Quebec H3A 2K6, Canada. *How to cubulate a group.* Preliminary report.

We say that a group G is *cubulated* if it acts properly and cocompactly on a CAT(0) cube complex. We discuss general techniques, from work of Sageev and Hruska/Wise, for proving that a group G is cubulated. We also give examples and applications from recent work and work in progress. (Received March 28, 2010)

1060-20-145 **Lisa Carbone**, **Leigh Cobbs** and **Scott H. Murray*** (scott.murray@canberra.edu.au), Discipline of Mathematics and Statistics, University of Canberra, Canberra, ACT 2601, Australia. *Computing fundamental domains for congruence subgroups of SL_2.*

The Bass-Serre theory of groups acting on trees is vital to the structure theory of certain infinite groups. In this talk, I consider the action of $\mathrm{SL}_2(\mathbb{F}_q((t)))$ and $\mathrm{PGL}_2(\mathbb{F}_q((t)))$ on their Bruhat-Tits graph (or building). By

quotienting out the action of congruence subgroups, we get a class of graphs called *fundamental domains*. In addition to their importance in group theory, this construction is believed to give families of *expander* graphs.

Before our work, very few of these graphs had been explicitly constructed. We used the Magma computer algebra system to construct them. This was an ideal problem for an integrated algebra system. We made nontrivial use of code for finite matrix groups, graph isomorphism, and finite geometry. These constructions allowed us to make new conjectures on the structure of these graphs, some of which we have been able to prove.

I will also discuss potential extensions of this work to groups other than SL_2. (Received March 28, 2010)

1060-20-146 **Philipp Rothmaler*** (philipp.rothmaler@bcc.cuny.edu). *Pseudofinite abelian groups.*

It is by now quite standard in model theory to call a structure in an axiomatizable class V pseudofinite if it is a model of the first-order theory of all finite structures from V. Equivalently, a structure G in V is pseudofinite iff every first-order sentence true in G is true in some finite structure from V. Yet another way of saying this is that G be elementarily equivalent to an ultraproduct of finite structures from V. Prominent examples are pseudofinite fields as described by Ax in the late 60's. Less is known about pseudofinite groups. (The compactness theorem of first-order logic yields at once that there are infinite such groups.) It is surprisingly little known that there is a complete description of pseudofinite abelian groups due to Basarab in the 70's. Similar "pseudo-notions" arise when finiteness is replaced by other concept like torsion etc. I will discuss all this together with related concepts and results from joint work with Ivo Herzog. (Received March 28, 2010)

1060-20-149 **Andrzej Zuk*** (zuk@math.jussieu.fr), Institut de Mathematiques de Jussieu, University of Paris 7, 175, rue du Chevaleret, 75013 Paris, France. *L^2 Betti numbers.*

We present computations of spectra of random walk operators. This leads to new results concerning L^2 Betti numbers of closed manifolds. (Received March 29, 2010)

1060-20-164 **Robert H. Gilman*** (rgilman@stevens.edu), Department of Mathematical Sciences, Stevens Institute of Technology, Hoboken, NJ 07030. *Complexity of computations on compressed words.* Preliminary report.

Computations with compressed words have recently become more common in group theory. For example Saul Schleimer has used this technique to show that the word problem for the automorphism group of a free group is decidable in polynomial time. Usually one is interested in showing that a computation with compressed words is feasible. We will consider instead how to use compression to make solvable problems more difficult. We are motivated by cryptological concerns. (Received March 29, 2010)

1060-20-165 **Paul E. Schupp*** (schupp@math.uiuc.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801. *Cellular Automata on Cayley Graphs and Amenability for Finitely Generated Groups.*

The concept of amenability for groups has been intensively studied since its introduction by von Neumann in 1929 and there is a vast literature on the subject. In the early 1950's von Neumann introduced cellular automa in the "classic case" on the grid of integer lattice points in the plane, that is, the Cayley graph of $\mathbb{Z}^2$, in order to study the question of whether or not a machine could reproduce itself.

All the relevant definitions are well-defined on the Cayley graph of any finitely generated group. A major question about celluar automata is whether or not the global transition function is surjective. Two important theorems in the classical case are the theorems of Moore and of Myhill relating "Garden of Eden" patterns and "Mutually Erasable" patterns. Dave Muller pointed out that both these theorems are false on the Cayley graph of the free group of rank 2. In a series of papers Antonio Machi and colleagues proved that both theorems hold for celluar automata on the graphs of amenable groups. Laurent Bartholdi recently proved the converse! Thus amenability is completely characteized by cellular automata properties. We will also discuss decidabilty of surjectivty on classes of groups. (Received March 29, 2010)

1060-20-167 **Robert H. Gilman*** (rgilman@stevens.edu), Department of Mathematical Sciences, Stevens Institute of Technology, Hoboken, NJ 07030. *The generic word problem.* Preliminary report.

One of the fundamental problems for finitely presented groups is to decide if a given word in the generators represents the identity in the group. There are groups for which this decision problem is recursively unsolvable, but in the known examples the question seems to be easily answered for most words. Is this necessarily the case? We will discuss this possibility and the related problem of how to find difficult words. (Received March 29, 2010)

1060-20-171 **Susan Hermiller*** (smh@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Rewriting systems and geometry of groups.* Preliminary report.

In addition to solving the word problem, a finite complete rewriting system for a group implies certain geometric properties of the Cayley complex for the group. This can be used to show that the geometry of the group restricts the potential orderings to consider when searching for a rewriting system. (Received March 29, 2010)

1060-20-174 **Dmytro M Savchuk*** (dmytro.savchuk@gmail.com), Department of Mathematical Sciences, Binghamton University, Binghamton, NY 13902. *Schreier graphs of the action of Thompson's group F on the Cantor set.* Preliminary report.

Perhaps, the most intriguing currently open question about Thompson's group F is whether or not it is amenable. We try to approach this question by constructing the Schreier graphs of F.

Thompson's group F acts naturally on the Cantor set C. One can describe orbits of the elements of C under this action by corresponding Schreier graphs that show how generators of F act on these elements. We explicitly construct all these Schreier graphs with respect to the standard generating set $\{x_0, x_1\}$, and show that these graphs are amenable.

Unfortunately, this approach does not give the answer to the question about the amenability of F, but it sheds some light on the structure of the group itself. (Received March 29, 2010)

1060-20-179 **Olga Kharlampovich*** (olga@math.mcgill.ca), 805 Sherbrooke St. W., Montreal, QC H3C4J4, Canada. *Equations in groups, actions on trees, algorithmic topology and dynamical systems.*

I am going to talk about a formal rewriting process which has different names: Makanin-Razborov process, Rips machine, Rauzy-Veech induction, Elimination process. Solution of different problems from group theory, logic, topology, ergodic theory and dynamical systems was independently reduced to the study of the properties of this process. These exciting connections can be further developed to obtain new results and formulate new problems. (Received March 29, 2010)

1060-20-184 **Alex D Myasnikov***, Department of Mathematical Sciences, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ. *A computational approach to the Andrews-Curtis Conjecture.*

The famous Andrews-Curtis conjecture is one of the outstanding open problems in low-dimensional topology and group theory. Informally, it states that every finite balanced presentation of the trivial group can be reduced to the standard presentation by a finite sequence of so-called elementary Andrews-Curtis transformations.

There was a noticeable research activity in this area in recent years, including efforts to resolve problems using computational methods. Despite significant attention the progress in resolving questions about Andrews-Curtis equivalence classes has been very limited.

We propose a new computational approach based on recent results about Andrews-Curtis graphs in finite groups. (Received March 29, 2010)

1060-20-195 **Jane Gilman*** (gilman@rutgers.edu), Mathematics Department, Smith Hall, Rutgers University, Newark, NJ 07102. *Rank two free groups and the non-Euclidean Euclidean algorithm.*

Let $G = \langle A, B\rangle$ be a two generator group free group and let $\rho : G \to PSL(2, \mathbb{R})$ be a non-elementary representation. The *discreteness algorithm* determines whether or not $\rho(G)$ is a discrete group. It has both a geometric and an algebraic formulation. It finds a geometrically unique pair of primitive generators when the image is discrete and by work of Gilman and Keen can be used to give an enumeration scheme for all primitive pairs of generators in any rank two free group. In this talk we re-interpret the geometric algorithm as an algorithm in the hyperbolic plane that uses non-Euclidean distance. That is, we interpret this algorithm as a type of *Euclidean Algorithm* using the non-Euclidean distances that $\rho(A)$ and $\rho(B)$ have as their translation lengths when the images are hyperbolic. The *geometric discreteness algorithm* becomes a *non-Euclidean Euclidean algorithm*. We show how this formulation of the algorithm simplifies the Gilman-Jiang proof of polynomial time complexity. (Received March 30, 2010)

1060-20-200 **Stephen A. Linton*** (sal@cs.st-andrews.ac.uk), School of Computer Sciebnce, University of St Andrews, North Haugh, St Andrews, Fife KY10 3SA, Scotland. *Frameworks for Parallel and Distributed Computational Algebra.* Preliminary report.

The huge success of computational methods in algebra, combinatorics and representation theory over the last thirty years has been driven by both the development of increasingly sophisticated algorithms (backed by some

very lovely mathematics) and the steady increase in the speed of the computers available to mathematicians. In recent years, this increase has almost stopped, being replaced by an increase in the *number* of computers, or at least cores, available. Our current software base (primarily GAP and Magma, and associated packages and applications) is not well placed to take advantage of this. In this talk, I will explain a variety of developments in GAP, some already available, some in train, which aim to tackle this problem, and make it as easy and natural as possible to use multiple processors and multiple computers to solve bigger mathematical problems faster. I will also be seeking input from the audience into the types of large computation they might wish to do and the parallel programming constructs that might be of value. (Received March 30, 2010)

1060-20-205 **Alexei Miasnikov*** (amiasnikov@gmail.com), Department of Mathematics, Stevens Institute of Technology, Hoboken, NJ 07030. *Infinitely presented groups: constructions and algorithmic problems.*

In this talk I am going to touch on two problems: how to construct infinitely presented groups with required properties and how to compute efficiently with infinite presentations. (Received March 30, 2010)

1060-20-208 **Gillian Z. Elston** (Gillian.Z.Elston@hofstra.edu), Department of Mathematics, Hofstra University, Hempstead, NY 11549, and **Gretchen Ostheimer*** (Gretchen.Ostheimer@hofstra.edu), Department of Computer Science, Hofstra University, Hempstead, NY 11549. *Groups with logspace normal forms.*

When a group is given by a finite set generators, we can choose a so-called "language of normal forms", that is, a set of unique representatives (words in the generators) for the elements of the group. Attempts to classify groups according to whether they admit a language of normal forms with a given complexity have proved fruitful and interesting – such work includes the study of automatic groups, combable groups, groups with normal forms of geodesics which are regular, context-free or counter, and groups with finite confluent rewriting systems. In this talk we describe some work in progress investigating the question of which groups have languages of normal forms which are computable in logspace. In other words, we attempt to describe those groups with normal forms that can be calculated using a Turing machine in which the size of the work space is logarithmic in the size of the input word. Despite this powerful restriction on the power of the Turing machine, a rich and interesting class of groups appears to emerge. (Received March 30, 2010)

1060-20-223 **Nelly Fazio** (fazio@cs.ccny.cuny.edu), Department of Computer Science, 160 Convent Avenue, Shepard Hall 279, New York, NY 10031, and **William Skeith*** (wes@cs.ccny.cuny.edu), Department of Computer Science, 160 Convent Ave, NAC Room 8 206, New York, NY 10031. *Group-Theoretic Cryptography: Respice, Adspice, Prospice.*

This talk outlines an ongoing research effort towards a probabilistic framework for the application of infinite groups to cryptography.

We start by analyzing a classical group-theoretic construction for public-key cryptosystems from a complexity-theoretic perspective. We then suggest a way of casting some of the standard computational problems from group theory in terms of probabilistic cryptographic assumptions—an essential ingredient for a formal security analysis. Next, we outline a new approach for finding cryptographically-suitable group-theoretic assumptions, inspired by recent advances in lattice-based cryptography. The framework relies on a new problem that we term "Learning Homomorphisms from Images with Errors" (LHIE), which can be viewed as a generalization of the "Learning With Errors" (LWE) problem from the setting of vector spaces and linear transformations to the setting of groups and homomorphisms. We conclude by discussing how this assumption yields group-theoretic public-key cryptosystems, and describe some of the remaining challenges in this effort. (Received March 30, 2010)

1060-20-228 **Olga Kharlampovich*** (olga@math.mcgill.ca), 805 Sherbrooke St. West, Montreal, QC H3A2K6, Canada. *Equations in torsion feee hyperbolic groups.* Preliminary report.

Razborov described an algorithm whose output gives a parametrization of the entire solution set to a system of equations over a free group, Myasnikov and I refined this algorithm to obtain a description in terms of Hom-diagrams. Rips and Sela proved that it is possible to decide if a system of equations over a torsion-free hyperbolic group G has a solution. Many algorithms for equations over G were constructed by Dahmani, Groves, Wilton. Sela proved that for the entire solution set of a system over G there exists a description similar to the description for a free group. We will describe an algorithm to obtain a Hom-diagram for G. (Received March 30, 2010)

1060-20-230 **Alexander Ushakov*** (sasha.ushakov@gmail.com), Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ 07030, and **Natalia Mosina**. *Averaging Group Elements.*

I will discuss several measures of central tendency for group elements and present the strong law of large numbers for distributions on finitely generated groups. Finally, I will discuss Chebyshev's and Chernoff's type inequalities for random group elements. Based on a joint work with N. Mosina. (Received March 30, 2010)

22 ► Topological groups, Lie groups

1060-22-56 **Kiumars Kaveh*** (kavehk@math.mcmaster.ca), Hamilton Hall, Dept. of Math and Stat, McMaster University, Hamilton, Ontario L8S 1K4, Canada, and **Askold Khovanskii**, Dept. of Mathematics, University of Toronto, Toronto, Ontario M5S 2E4, Canada. *Moment polytopes and semigroup of representations with tensor product.*

We say that two representations of a reductive group G are spectrally equivalent if the same irreducible representations appear in both of them. The semigroup of finite dimensional representations of G with tensor product and up to spectral equivalence is a rather complicated object. We show that the Grothendieck group of this semigroup is more tractable and give a description of it in terms of moment polytopes of representations. As a corollary, we get a proof of the Kazarnovskii theorem on the number of solutions in G of a system of equations consisting of matrix elements of representations. We also describe the asymptotic of highest weights appearing in tensor powers of a representation of G. The main tool used is the PRV theorem. These results are in the spirit of theory of semigroups of integral points and Newton-Okounkov bodies. For the most part this is a joint work with A. G. Khovanskii. (Received March 15, 2010)

1060-22-77 **Manish M. Patnaik*** (mpatnaik@math.harvard.edu), Department of Mathematics, One Oxford Street, Cambridge, MA 02138. *Hecke Algebras for p-adic Loop Groups.* Preliminary report.

We describe a construction which allows one to make sense of convolution algebras of double cosets on p-adic loop groups. Using this construction, we can construct analogues of spherical and Iwahori Hecke algebras for these groups. In the spherical case, one obtains, by means of a Satake isomorphism, a polynomial algebra of theta functions considered previously by Looijenga. In the Iwahori case, one obtains a variant of Cherednik's double affine Hecke algebras. We will also explain how to obtain an explicit formula for spherical functions in this context and sketch some applications of this work. This is joint with Alexander Braverman and David Kazhdan. (Received March 21, 2010)

1060-22-79 **Donald R King*** (d.king@neu.edu), 567 Lake Hall, Northeastern University, Boston, MA, MA 02115. *Spherical nilpotent orbits and asymptotics of K-types of Harish Chandra modules.*

Let G be the adjoint group of a semisimple Lie algebra $\mathfrak{g}$ and K be a maximal compact subgroup. Let $\mathfrak{p}_{\mathbb{C}}$ be the complexification of the complement of $\mathfrak{k}$ in $\mathfrak{g}$. $K_{\mathbb{C}}$, the complexification of K, acts on $\mathfrak{p}_{\mathbb{C}}$. $\mathfrak{g}_{\mathbb{C}}$ is the complexification of $\mathfrak{g}$. Let $e \in \mathfrak{p}_{\mathbb{C}}$ be nilpotent, and set $\mathcal{O} = K_{\mathbb{C}} \cdot e$, the corresponding $K_{\mathbb{C}}$-orbit. $\overline{\mathcal{O}}$ denotes the Zariski closure of $\mathcal{O}$. $R[\overline{\mathcal{O}}]$ denotes the ring of regular functions on $\overline{\mathcal{O}}$. Assume that e has height 2. Then $\mathcal{O}$ is a spherical $K_{\mathbb{C}}$ variety and the subring of highest weight vectors in $R[\overline{\mathcal{O}}]$ is a polynomial ring. Let $f_1, \ldots, f_r$ be a set of generators with highest weights $\mu_1, \ldots, \mu_r$. Suppose that $\mathbf{X}$ is an irreducible $(\mathfrak{g}_{\mathbb{C}}, K)$ module whose associated variety is $\overline{\mathcal{O}}$. We show that the asymptotic directions of the K-types of $\mathbf{X}$ are determined by the weights μ_i. (Received March 21, 2010)

1060-22-88 **Benjamin Harris*** (blharris@math.mit.edu). *Fourier Transforms of Nilpotent, Coadjoint Orbits for $GL(n, \mathbb{R})$.*

In the 80s, Barbasch and Vogan proved that the first order approximation to an irreducible character of a reductive Lie group is a sum of Fourier transforms of invariant measures on nilpotent, coadjoint orbits for the group. In the 90s, Schmid and Vilonen showed that the coefficients in the sum are non-negative integers if the invariant measures are chosen to be the canonical measures on the coadjoint orbits, and they related this integral sum of orbits to the associated cycle and characteristic cycle, invariants of irreducible representations coming from algebraic geometry. In this talk, I will write down explicit formulas for the Fourier transforms of (the canonical measures on) coadjoint, nilpotent orbits for $\mathrm{GL}(n, \mathbb{R})$. (Received March 23, 2010)

1060-22-126 **Dmitry Gourevitch*** (dimagur@ias.edu), School of Mathematics, Institute for Advanced Study, Princeton, NJ 08540. *Gelfand pairs and invariant distributions.*

First I will introduce the notion of Gelfand pair and its connection to invariant functions and distributions on the group, and give some examples. We will start from finite groups and compact groups and then go on to reductive groups over local fields. Then we will list some recent results on Gelfand pairs. (Received March 26, 2010)

28 ► Measure and integration

1060-28-132 **Carmen Vlad*** (cvlad@pace.edu), New York, NY 10038. *Topological Aspects of Products of Lattices.*

Let X be an arbitrary set and L(X) a lattice of subset of X. The paper is analyzing the product lattices and their associated Wallman spaces and investigates certain lattice properties that carry over to the product of lattices. We proceed from a measure theoretic point of view which makes use of the support of a zero- one valued, finitely additive measure m, defined on the algebra generated by the lattice L(X). (Received March 27, 2010)

30 ► Functions of a complex variable

1060-30-108 **Yunping Jiang*** (yunping.jiang@qc.cuny.edu), Department of Mathematics, Queens College of CUNY, 65-30 Kissena Blvd, Flushing, NY 11367. *Function Model of the Teichmuller space of a closed hyperbolic Riemann Surface.*

In this talk, I will introduce a function model for the Teichmuller space of a closed hyperbolic Riemann surface. On this model of a Teichmuller space, we have a new metric by using the maximum norm on the function space. The identity map from the Teichmuller space equipped with the usual Teichmuller metric to the Teichmuller space equipped with this new metric is uniformly continuous. Furthermore, the inverse of the identity, that is, the identity map from the Teichm"uller space equipped with this new metric to the Teichmuller space equipped with the usual Teichmuller metric, is continuous. Therefore, the topology induced by the new metric is just the same as the topology induced by the usual Teichmuller metric on the Teichmuller space. I will give a remark about the new metric, the pressure metric, and the Weil-Petersson metric. (Received March 24, 2010)

1060-30-189 **Jun Hu***, Department of Mathematics, Brooklyn College of CUNY, Brooklyn,, NY 11210, and **Oleg Muzician**, Ph.D. Program in Mathematics, Graduate Center of CUNY, New York, NY 10036. *Cross-ratio distortion and Douady-Earle extension: A new upper bound on quasiconformality.*

In this paper, we develop a new method to explore the direct dependence of quasiconformality of the Douady-Earle extension Φ of a circle homeomorphism f on the cross-ratio distortion of f. Two outcomes arise: (1) we provide a new proof of that Φ is quasiconformal if f is quasisymmetric; (2) we provide a new upper bound for the complex dilatation $K(\Phi)$ in terms of the cross-ratio distortion norm $||f||_{cr}$ of f. (Received March 30, 2010)

1060-30-190 **Jun Hu**, Department of Mathematics, Brooklyn College of CUNY, Brooklyn, NY 11210, and **Oleg Muzician***, Ph.D. Program in Mathematics, Graduate Center of CUNY, New York, NY 10036. *Cross-ratio distortion and Douady-Earle extension: An numerical experiment.*

The Douady-Earle extension of a circle homeomorphism is equivariant under precomposition or postcomposition by Möbius transformations preserving the circle. With the help of MAY iterators (due to Milnor) developed by Abikoff and Ye, we study the Douady-Earle extensions Φ of the circle homeomorphisms f that are the restrictions to the unit circle of simple earthquakes with one leaf. We investigate numerically how the complex dilatation $K(\Phi)$ depends on the weight on the leaf of the earthquake map. This enables us to see a lower bound for $K(\Phi)$ in terms of the cross-ratio distortion $||f||_{cr}$ of f. It is shown in the talk given by the other author in this same conference that $\ln(\Phi)$ has an upper bound having a linear growth on $||f||_{cr}$. The numerical result in this talk implies that that upper bound of $\ln K(\Phi)$ is sharp in the sense that $\ln K(\Phi)$ has at least a linear growth on $||f||_{cr}$ in this particular family of maps. (Received March 30, 2010)

1060-30-240 **Zhe Wang*** (wangzhecuny@gmail.com), 92-17 52 Avenue, Elmhurst, NY 11373. *Holomorphic Motions and Holomorphic Maps into Teichmuller Spaces.*

I will talk about liftings of holomorphic maps from the unit disk into Teichmuller spaces and Slodkowski's extension theorem of holomorphic motions. (Received March 30, 2010)

31 ► Potential theory

1060-31-62 **Darren G Crowdy*** (d.crowdy@imperial.ac.uk), Dept of Mathematics, Imperial College London, 180 Queen's Gate, London, SW7 2AZ, England. *A new calculus for two dimensional vortex dynamics.*

In classical fluid dynamics, an important problem arising in a variety of applications is to understand how vorticity interacts with solid objects (e.g. aerofoils, obstacles or stirrers). For planar flows, a variety of powerful mathematical results exist (complex variable methods, conformal mapping, Kirchhoff-Routh theory) that have been used to study such problems but the constructions are usually restricted to problems with just one, or perhaps two, objects. Expressed another way, most studies deal only with fluid regions that are simply or doubly connected. There has been a general and longstanding perception that problems involving fluid regions of higher connectivity are too challenging to be tackled analytically.

The talk will show that there is a way to formulate the theory so that the relevant fluid dynamical formulae are exactly the same irrespective of the connectivity of the domain. This provides a flexible and unified tool for modelling the fluid dynamical interaction of multiple objects/aerofoils/obstacles/stirrers in ideal flow and their interaction with free vortices. (Received March 17, 2010)

32 ► Several complex variables and analytic spaces

1060-32-130 **Sudeb Mitra*** (sudeb.mitra@qc.cuny.edu), Department of Mathematics, Queens College, CUNY, 65-30 Kissena Blvd., Flushing, NY 11367. *Holomorphic maps from the unit disk into generalized Teichmüller spaces.*

We will discuss some metric properties of the Teichmüller space of a closed set in the Riemann sphere. In particular, we extend Earle's form of Teichmüller contraction for such spaces. The main goal is to study isometries of holomorphic maps from the open unit disk into these generalized Teichmüller spaces. (Received March 27, 2010)

1060-32-181 **Dragomir Saric*** (dragomir.saric@qc.cuny.edu), Queens College, Department of Mathematics, Kiely 237, Flushing, NY 11367. *Shear parametrization of the universal Teichmuller space.*

We give a parametrization of the universal Teichmuller space by shear coordinates on Farey tesselation of the hyperbolic plane and discuss some applications of the obtained parametrization. (Received March 29, 2010)

1060-32-234 **Anne Pichon*** (pichon@iml.univ-mrs.fr), Institut de Mathématiques de Luminy, Case 907, Campus de Luminy, 13009 Marseille, France. *analytic link theory in a complex surface singularity link.*

This is a joint work with Andràs Neméthi and W. D Neumann.

Let M be the link of a complex normal surface singularity (X, p), i.e. the boundary of a small regular neighbourhood of p in X. In particular, M is a closed 3-manifold which can be given by a negative definite plumbing. An "analytic link" in M is defined as the intersection $f^{-1}(0) \cap M$, where $f : (X, p) \to (\mathbb{C}, 0)$ is a germ of holomorphic function on (X, p).

There may exist many different complex analytic structures on the cone $C(M)$, i.e., many analytically different normal surface singularities $(X, 0)$ whose links L_X are homeomorphic to M. The aim of this talk is to show how one can understand these different analytic structures from the point of view of the "analytic link theory" on M.

For the link M of a normal complex surface singularity $(X, 0)$ we ask when a knot $K \subset M$ exists for which the answer to whether K is the link of the zero set of some analytic germ $f : (X, 0) \to (\mathbb{C}, 0)$ affects the analytic structure on $(X, 0)$. We show that if M is an integral homology sphere then such a knot exists, outward three exceptional manifolds M. (Received March 30, 2010)

33 ► Special functions

1060-33-55 **Alexander Rozenblyum*** (ARozenblyum@CityTech.cuny.edu), 300 Jay Street, Brooklyn, NY 11201. *Overlap coefficients in representations of the q-deformed algebra $U_q(so_4)$.*

Irreducible finite-dimensional representations of the classical type of the algebra $U_q(so_4)$ are considered. The main goal of the talk is to present explicit formulas for the elements of the matrix (overlap coefficients) that

connect the Gel'fand-Tsetlin basis to the weight basis. The main method is based on the diagonalization of the infinitesimal operator (generator) $I_{3,4}$ of a representation in a space of functions of a discrete variable. Operator $I_{3,4}$ corresponds to rotations in the plane (e_3, e_4) in the 4-dimensional Euclidian space. The overlap coefficients are described in terms of orthogonal polynomials in a discrete variable that can be considered as q-analogs of dual Hahn polynomials. (Received March 15, 2010)

1060-33-71 **Siddhartha Sahi*** (sahi@math.rutgers.edu), Department of Mathematics, Rutgers University, Hill Center for the Mathematical Sciences, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019. *Eigenvalues of generalized Capelli operators and binomial coefficients.*

Let $\mathbb{F}$ be a real division algebra of dimension d; thus $\mathbb{F} = \mathbb{R}, \mathbb{C}, \mathbb{H}$ and $d = 1, 2, 4$. The group $G = GL(n, \mathbb{F})$ acts naturally on the space V of $n \times n$ Hermitian $\mathbb{F}$-matrices. The associated representation of G on the polynomial algebra $P = P(V)$ is multiplicity-free with irreducible submodules P_λ indexed by partitions of length $\leq n$.

On the other hand, the space of G-invariant polynomial differential operators on V has a natural basis consisting of the *generalized* Capelli operators D_μ, which are also indexed by such partitions. By Schur's Lemma, D_μ acts on P_λ by a scalar, which we write as $c_{\lambda\mu}(d)$ to denote its dependence on the division algebra $\mathbb{F}$.

By an earlier result of the speaker, there is an element $\binom{\lambda}{\mu}_r$ in $\mathbb{Q}(r)$, called the generalized binomial coefficient, such that $c_{\lambda\mu}(d)$ is obtained from it by specializing $r = d$. We describe a new formula for these coefficients, which shows that they are quotients of two positive integral polynomials in r. (Received March 19, 2010)

1060-33-124 **Juri M. Rappoport*** (jmrap@landau.ac.ru), Vlasov Street Building 27 Apt.8, Moscow, 117335, Russia. *Approximation algorithms for some modified* Bessel *functions.*

The approximation and computation of kernels of Kontorovitch–Lebedev integral transforms–modified Bessel functions of the second kind with pure imaginary order $K_{i\beta}(x)$ and with complex order $K_{1/2+i\beta}(x)$ are elaborated on the basis of several approaches [1,2]. The hypergeometric type differential equations of the second order with polynomial coefficients are considered. The computational scheme of Tau method is extended for the systems of hypergeometric type differential equations [3]. The effective applications of the modified Bessel functions are given.

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(Received March 26, 2010)

34 ► Ordinary differential equations

1060-34-106 **J.B. van den Berg**, **J.D. Mireles James**, **J.-P. Lessard*** (lessard@math.rutgers.edu) and **K. Mischaikow**. *Rigorous Computations of Connecting Orbits for Flows. Part II: Contraction mapping, Radii polynomials and the Gray-Scott equation.*

We discuss a numerical scheme which leads to computer assisted proof of existence of connecting orbits for ordinary differential equations. The problem is formulated as a finite time boundary value problem by exploiting a high-order parameterization of the invariant manifolds at the equilibria. The boundary value problem is solved numerically via piecewise linear approximations and a Newton Scheme. We construct an operator on a function space whose unique fixed point corresponds to the desired connecting orbit, and rigorously establish that the operator is a contraction mapping in some neighborhood of the numerical solution. The verification of the contraction is done with the use of the so-called radii polynomials. In part II, we focus on the contraction mapping, the radii polynomials and we apply the method to prove existence of even homoclinics for the Gray-Scott equation. (Received March 24, 2010)

35 ► Partial differential equations

1060-35-50 **Jeremy Louis Marzuola*** (jm3058@columbia.edu), Department of Applied Mathematics, Columbia U, 200 S.W. Mudd Building, MC 4701, 500 W. 120th St., New York City, NY 10027, and **Michaeil I Weinstein**. *Long time dynamics near the symmetry breaking bifurcation for Nonlinear Schrödinger/Gross-Pitaevskii Equations.*

We consider a class nonlinear Schrödinger / Gross-Pitaevskii equations (NLS/GP) with a focusing (attractive) nonlinear potential and symmetric double well linear potential. NLS/GP plays a central role in the modeling of nonlinear optical and mean-field quantum many-body phenomena. It is known that there is a critical L^2 norm (optical power / particle number) at which there is a symmetry breaking bifurcation of the ground state. We study the rich dynamical behavior near the symmetry breaking point. The source of this behavior in the full Hamiltonian PDE is related to the dynamics of a finite-dimensional Hamiltonian reduction. We derive this reduction, analyze a part of its phase space and prove a *shadowing theorem* on the persistence of solutions, with oscillating mass-transport between wells, on very long, but finite, time scales within the full NLS/GP. The infinite time dynamics for NLS/GP are expected to depart, from the finite dimensional reduction, due to resonant coupling of discrete and continuum / radiation modes. (Received March 10, 2010)

1060-35-52 **Panos Kevrekidis*** (kevrekid@math.umass.edu), University of Massachusetts Amherst, 710 N. Pleasant Street, Lederle Graduate Research Tower, Amherst, MA. *Dynamics of Dark Soliton and Vortex Matter Waves.*

In this talk, we will present some recent results on the dynamics of dark soliton and multi-soliton solitary waves, as well as of vortex and multi-vortex states that arise in Bose-Einstein condensates. We will start with a brief overview of the initial attempts to identify such states in BECs and subsequently turn to recent experimental efforts and the theoretical challenges that they pose. In attempting to address these challenges, we will formulate an ODE-based particle picture for the soliton and vortex dynamics and will attempt to compare equilibrium, near-equilibrium and far from equilibrium features of such reduced descriptions with their corresponding PDE counterparts. Finally, time permitting, we will speculate on some interesting directions for future exploration, discussing, in particular, some recent results on multi-component variants of the above structures. (Received March 12, 2010)

1060-35-53 **Gerardo Hernandez-del-Valle*** (gerardo@stat.columbia.edu), 1255 Amsterdam Ave. Room 1005, New York, NY. *Heat Polynomials, boundary crossing probabilities and applications in finance.*

In this talk we will derive sharp bounds to the first crossing probabilities of diffusions, which in turn will be used the pricing of boundary options. We will discuss the relationship between these solutions and the so-called heat polynomials. (Received March 13, 2010)

1060-35-57 **M Cristina Caputo*** (caputo@math.utexas.edu), Dept of Mathematics, Univ of Texas, Austin, Austin, TX 78712, and **Nestor Guillen**, Dept of Mathematics, Univ of Texas, Austin, Austin, TX 78712. *Regularity for non-local almost minimal boundaries.*

We introduce a notion of non-local almost minimal boundaries similar to that introduced by Almgren in geometric measure theory. Extending methods developed recently for non-local minimal surfaces 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 non-local mean curvature in L^p and regularity of solutions to non-local obstacle problems. This is a joint work with N. Guillen. (Received March 15, 2010)

1060-35-142 **Barbara Prinari***, Department of Mathematics, University of Colorado at Colorado Springs, 1420 Austin Bluffs Pkwy, Colorado Springs, CO 80918. *Inverse Scattering Transform (IST) for the Multicomponent Nonlinear Schrodinger (NLS) Equation Under Non-Vanishing Boundary Conditions.* Preliminary report.

This talk reports on the development of the IST for vector NLS under nonvanishing boundary conditions (NBCs) for an arbitrary number N of components.

For the scalar NLS equation ($N = 1$) with NBCs, the scattering parameter k "lives" on a two-sheeted Riemann surface. When $N > 1$, a complication arises: $2(N - 1)$ out of the $2(N + 1)$ eigenfunctions are not analytic on either sheet of the Riemann surface, and one has to suitably complete the basis. The $N = 2$ case (Manakov system) is somehow special. The IST for this system under NBCs was developed in 2006 by Ablowitz et al and the basic idea was to use the adjoint scattering problem to construct two additional analytic eigenfunctions. This technique, however, does not admit an obvious generalization to arbitrary N.

In order to complete the basis of analytic eigenfunctions for the general N-component scattering problem, we generalize the approach suggested by Beals, Deift and Tomei [1988] for general scattering and inverse scattering on the line but developed under the assumption of vanishing BCs. The key step is the introduction of a fundamental tensor family as solutions of a suitable scattering problem associated to the given one, with each tensor analytic on either one or the other sheet of the Riemann surface. (Received March 28, 2010)

1060-35-153 **Szu-yu Sophie Chen*** (sophie@math.ias.edu), Einstein Drive, Princeton, NJ 08540. *Optimal curvature decays on asymptotically locally Euclidean manifolds.*

We present a method in nonlinear elliptic systems to study curvature decays on asymptotically locally Euclidean (ALE) manifolds. In particular, we obtain that scalar flat Kahler ALE metrics of real dimension n are of order $n-2$. This decay is optimal and is realized on complex line bundles over $CP^{\frac{n}{2}-1}$. (Received March 29, 2010)

1060-35-155 **Eduard-Wilhelm Kirr*** (ekirr@uiuc.edu), U. of Illinois, Department of Mathematics, 273 Altgeld Hall, MC-382, 1409 W. Green Street, Urbana, IL 61801. *Bifurcations of large bound states in nonlinear Schroedinger equation.*

I will present recent necessary and sufficient conditions for the existence of bifurcation points along ground state and excited state branches in nonlinear Schroedinger equations. The possible types of bifurcations and their effect on the dynamical stability of the bound states will also be discussed. This is joint work with D. Pelinovsky (McMaster), P. Kevrekidis (U. Mass.) and V. Natarajan (U. of Illinois). (Received March 29, 2010)

1060-35-191 **Patrick W. Dondl*** (pwd@hcm.uni-bonn.de), Hausdorff Center for Mathematics, University of Bonn, Endenicher Allee 60, 53119 Bonn, Germany, and **Luca Mugnai** and **Matthias Roeger**. *A phase field model for elastic confined structures.*

We consider the problem of minimizing Euler's elastica energy for simple closed curves confined to the unit disk. To this end, we propose a phase field approximation making use of the fact that one can approximate a simple closed curve by the zero level set of a smooth field with values $+1$ on the inside and -1 on the outside of the curve. The outer container now becomes just the domain of the phase field. The approximation of the elastica energy by an interfacial energy functional of the form $\frac{1}{c_0}\int_{B_1(0)}\frac{1}{\varepsilon}\left(-\varepsilon\Delta u+\frac{1}{\varepsilon}W(u)\right)^2$ is well known, the length of the curve can be evaluated using a Modica-Mortola functional. Implementing the topological constraint thus becomes the main difficulty here. We propose a solution based on a diffuse approximation of the winding number, present a proof that one can approximate a given sharp interface using a sequence of phase fields, and show some numerical results using finite elements based on subdivision surfaces. (Received March 30, 2010)

1060-35-206 **Levent Kurt*** (e108007@yahoo.com), 365 Fifth Ave, New York, NY 10016, and **Tobias Schaefer** (tobias@math.csi.cuny.edu), 2800 Victory Blvd 1S-215, Staten Island, NY 10314. *Impact of stochastic perturbations on ultra-short solitons.*

We study the propagation of ultra-short short solitons in a cubic nonlinear medium modelled by nonlinear Maxwell's equations with stochastic variations of the susceptibility. Using a modified multi-scale expansion for stochastic systems, we derive a new stochastic generalization of the short pulse equation that approximates the solutions of nonlinear Maxwell's equations. Numerical simulations show that soliton solutions of the short-pulse equation propagate stably in both deterministic and stochastic nonlinear Maxwell's equations. (Received March 30, 2010)

1060-35-221 **A. David Trubatch*** (david.trubatch@montclair.edu), Department of Mathematical Sciences, Montclair State University, Montclair, NJ 07043, and **Jose Barrios**, Department of Mathematical Sciences, Motnclair State University, Montclair, NJ 07043. *Pulse interaction in the Short-Pulse Equation: progress report.*

The short-pulse equation (SPE) describes the propagation of light pulses of ultra-short duration in nonlinear optical media. Breather soliton solutions of SPE have been constructed previously by a transformation from the Sine-Gordon equation. In simulations, pulse interaction is observed to vary qualitatively as a function of a parameter that measures the "shortness" of the pulse envelope relative to the internal oscillations. These changes are intermittent as the parameter varies. Moreover, for some parameter values, soliton interaction generates persistent, highly oscillatory coherent states. (Received March 30, 2010)

1060-35-227 **Russell K. Jackson*** (rkjackso@usna.edu), Department of Mathematics, 572C Holloway Road, United States Naval Academy, Annapolis, MD 21402-5002. *Bifurcations of standing waves in the cubic-quintic Schrödinger equation with a multi-well potential.* Preliminary report.

In this talk, we consider a cubic-quintic Schrödinger equation with an external potential

$$i\phi_t = \phi_{xx} + 2|\phi|^2\phi - |\phi|^4\phi + V(x)\phi.$$

Models like this one appear in a number of applications, recently in both nonlinear optics and Bose-Einstein condensation. In optics, the potential $V(x)$ might represent the varying refractive index in channels or waveguides; in Bose-Einstein condensates, it can be an optical or magnetic trap. The competing cubic-quintic nonlinearity suggests attraction (or self-focusing) at low intensities and repulsion (or defocusing) at higher intensities.

The interplay between the dispersion, nonlinearity and potential sews the seeds for an incredible variety of standing wave solutions. Even for a simple square-well potential, observers have noted the coexistence of a short and a tall standing wave – both stable! We describe these waves geometrically, pinpointing the mechanism for this bistability. Geometric techniques are also used to characterize the many standing waves in the presence of an N-well potential. We monitor the changing properties of these solutions as the space between adjacent wells increases. Finally, we fit our results where the well-spacing is large into a more general theoretical framework. (Received March 30, 2010)

1060-35-241 **Yi A Li*** (Yi.Li@stevens.edu), Castle Point on Hudson, Hoboken, NJ 07030. *Nonlinear Dispersive Evolution Equations, and Stability of their Solitary Waves.*

We investigate evolution equations as mathematical models for propagation of free surface waves. They include both weakly nonlinear and higher nonlinear model equations. The presence of nonlinearity and dispersion in these equations result in solitary waves which propagate with permanent form and interact elastically. One part of the talk will be concerned with stability of solitary waves. The other issue is the numerical computation to compare approximate physical models with the full water wave problem as a mean to justify the validity of the model equations. (Received March 30, 2010)

1060-35-243 **Natasa Sesum*** (natasa.sesum@gmail.com), 209 South 33rd street, Philadelphia, PA 19103. *Curvature conditions for extending the mean curvature flow and the Ricci flow.*

We will discuss various curvature conditions that appear to be sufficient for having a smooth solution of the mean curvature flow and the Ricci flow. These can be viewed as the improvement of Hamilton's and Huisken's result for extending the Ricci flow and the mean curvature flow, respectively past some finite time T. (Received March 30, 2010)

37 ► Dynamical systems and ergodic theory

1060-37-2 **Konstantin Mischaikow*** (mischaik@math.rutgers.edu), Department of Mathematics, Rutgers, The State University of New Jersey, 110 Frelinghusen Rd, Piscataway, NJ 08854. *Computational Topology Applied to the Global Dynamics of Nonlinear Systems.*

I will discuss new computational tools based on topological methods that extracts coarse, but rigorous, combinatorial descriptions of global dynamics of multiparameter nonlinear systems. These techniques are motivated by several observations which we claim can be addressed at least in part.

1. In many applications there are models for the dynamics, but specific parameters are unknown or not directly computable. To identify the parameters one needs to be able to match dynamics produced by the model against that which is observed experimentally.

2. It is well established that nonlinear dynamical systems can produce extremely complicated dynamics, e.g. chaos, that is not structurally stable. However experimental measurements are often too crude to identify such fine structure in the dynamics or to establish the parameter values to sufficient precision even at points that are structurally stable.

3. Often the models themselves are based on heuristics as opposed to being derived from first principles and thus the fine structure of the dynamics produced by the models may be of little interest for the applications in mind.

To make the above mentioned comments concrete I will describe the techniques in the context of a simple model arising in population biology. (Received March 25, 2010)

1060-37-14 **J D Mireles James*** (jjames@math.rutgers.edu), **J P Lessard**, **K M Mischaikow** and **J B van den Berg**. *Rigorous Computation of Connecting Orbits for Flows I: Problem Description and Parameterization of Invariant Manifolds.*

We discuss a numerical scheme which leads to computer assisted proof of the existence of connecting orbits for ordinary differential equations. The problem is formulated as a finite time boundary value problem by exploiting a high-order parameterization of the invariant manifolds at the equilibria. The boundary value problem is solved numerically via piecewise linear finite element approximations and a Newton Scheme. We construct an operator on a function space whose unique fixed point corresponds to the desired connecting orbit, and rigorously establish that the operator is a contraction mapping in some neighborhood of the numerical solution. In part I we focus on the problem set up, and discuss the parameterization of the invariant manifolds. (Received January 11, 2010)

1060-37-17 **Jan Bouwe van den Berg*** (janbouwe@few.vu.nl), Department of Mathematics, de Boelelaan 1081, 1081HV Amsterdam, Netherlands, and **Jean-Philippe Lessard**. *Chaotic braided solutions via forcing and rigorous numerics.*

The Swift-Hohenberg equation is a fourth order parabolic PDE that models aspects of pattern formation, such as the finite wavelength instability in Rayleigh-Benard convection. We focus on stationary solutions of the equation in one dimension, and interpret solutions of this ODE as braided strands. Using a variational principle this leads to topological forcing results. On the other hand, recent advances in rigorous numerics allow us to prove the existence of a periodic solution with the right geometric properties. Via the forcing results, this periodic solution implies chaotic dynamics for the Swift-Hohenberg ODE for a large range of parameter values. (Received January 18, 2010)

1060-37-19 **Sarah Day*** (sday@math.wm.edu), College of William and Mary, Department of Mathematics, P.O. Box 8795, Williamsburg, VA 23188, and **Benjamin Holman** (brholman@wm.edu) and **Sebastian Schreiber** (sschreiber@ucdavis.edu), Department of Evolution and Ecology, One Shields Ave, University of California, Davis, CA 95616. *Quantifying Patterns in a Coupled-Patch Population Model.* Preliminary report.

Coupled patch models of population dynamics combine local dynamics on patches with rules for dispersal of the population between patches. When an appropriate threshold is applied, population values give rise to patterns (in space) and may evolve in a complicated manner in time. I will discuss joint work with Benjamin Holman and Sebastian Schreiber in which we study coupled Ricker maps and the complicated patterns they produce. We use computational homology, and in particular the computation of Betti numbers, to measure the patterns and their evolution in time. (Received January 20, 2010)

1060-37-32 **Mohamed I Jamaloodeen*** (mjamaloo@ggc.usg.edu), Georgia Gwinnet College, School of Science and Technology, 1000 University Center Lan, Lawrenceville, GA 30043. *On the motion of point vortices on the sphere and hyperbolic sphere.* Preliminary report.

We present results for integrable point vortex motion on the sphere and hyperbolic sphere. We show that the only collapsing configurations of the three-vortex problem on the sphere are self-similar. We study the simplest four-vortex problem on the sphere, one analogous to the plane, and for which self-similar four-vortex collapsing configurations are admissible, and show that on the sphere these do not admit collapse. We study numerically the four-vortex relative equations and report that we are unable to find four-vortex self-similar collapse. We present explicit solutions of the three-vortex problem using quadrature and provide local bifurcation properties of these. We comment on the integrable four-vortex porblem proving the integrability of "collinear" four-vortex problems as well as present, informally, special relative equilibrium (vortex crystals) solutions of these configurations we found previously using other methods. We present some preliminary results on similar work with vortices on the hyperbolic sphere. Our results include the complete integration of the three-vortex collapse problem on the hyperbolic sphere, and draw parallels with the similar collapse of three vortices on the sphere and plane using asymptotics.[Joint work with Paul K. Newton] (Received February 24, 2010)

1060-37-37 **Siddhanta Athreya Jayadev*** (jathreya@gmail.com), Department of Mathematics, Yale University, P. O. Box 20823, New Haven, CT 06520-8283. *Discrete sets and dynamics on parameter spaces.* Preliminary report.

We prove quantitative results for dynamics of Lie group actions on parameter spaces by studying associated discrete sets in Euclidean spaces. We give applications to counting problems, equidistribution, and diophantine approximation. (Received March 06, 2010)

1060-37-59 **Annalisa Crannell*** (annalisa.crannell@fandm.edu), Department of Mathematics, Box 3003, Franklin & Marshall College, Lancaster, 17604-3003, and **Sohaib Alam** (malam@physics.utexas.edu). *Iterates of Quasicontinuous Functions.*

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 16, 2010)

1060-37-92 **Eva Kanso*** (kanso@usc.edu), University of Southern California, Aerospace and Mechanical Engineering, 854 Downey Way, RRB 214, Los Angeles, CA 90089. *Viscous evolution of a point vortex equilibrium.*

When point vortex equilibria of the (inviscid) 2D Euler equations are used as initial conditions for the (viscous) Navier-Stokes equations, typically an interesting dynamical process unfolds at short and intermediate time scales before the long time single peaked Oseen vortex state dominates. The details of this 'viscosity induced' dynamics depends crucially on the initial configuration. Here we use an analytical model to describe the viscous evolution of a three-vortex collinear structure that corresponds to a fixed equilibrium of the inviscid point vortex model. We observe rotation of the structure due to viscosity. Based on velocity field calculated in a rotating frame, we find instantaneous stagnation points and separatrices in the flow field. Bifurcation times are found from the topological change of the separatrices. This is joint work with my graduate student Fangxu Jing and Professor Paul K Newton of USC. (Received March 23, 2010)

1060-37-177 **Georgi S. Medvedev*** (medvedev@drexel.edu), 3141 Chestnut Street Philadelphia, Philadelphia, PA 10104. *Synchronization of coupled limit cycles.*

We consider coupled nonlinear dynamical systems with exponentially stable limit cycles. Under general assumptions on the local oscillatory dynamics, we prove exponential stability of the limit cycle of the coupled system provided that the linear coupling is dissipative and sufficiently strong. We also study robustness of synchrony to noise. To this end, we analytically estimate the degree of coherence of the network oscillations in the presence of noise. The analytical results are illustrated by several applications in computational neuroscience. (Received March 29, 2010)

1060-37-209 **Vadim Zharnitsky*** (vzh@illinois.edu), Department of Mathematics, University of Illinois, Urbana, IL 61801, and **Yuliy M. Baryshnikov**, Bell Labs, Alcatel-Lucent. *Nonlinear dynamics in the linear search problem.*

Consider an object that is hidden on the real line with a fixed (say Gaussian) probability distribution. To find the object one has to search to the right, then to the left, and then again to the right and so forth until the object is found. What is the best way to conduct this search? How to minimize the time of the search? This (and other natural variations) is one of the basic search problems in the field of operations research. The search problems have already received considerable attention in the engineering literature and many important results have been obtained. We attempt to introduce new tools based on the classical objects from nonlinear dynamics such as invariant manifolds to give qualitative explanation of specific optimal search strategies. This is a preliminary report with conclusions relying on numerical simulations and heuristic arguments. (Received March 30, 2010)

1060-37-238 **Bill Kalies*** (wkalies@fau.edu), Department of Mathematical Sciences, Florida Atlantic University, 777 Glades RD, Boca Raton, FL 33431. *Computing Global Dynamics of Multiparameter Systems.*

A generally applicable method for the computation of a database of global dynamics of a multiparameter dynamical system is introduced. An outer approximation of the dynamics for each subset of the parameter range is computed using rigorous numerical methods and is represented by means of a directed graph. The dynamics is then decomposed into the recurrent and gradient-like parts by fast combinatorial algorithms and is classified via Morse decompositions. These Morse decompositions are compared at adjacent parameter sets via continuation to detect possible changes in the dynamics. The method is illustrated with an application to the two-dimensional, density-dependent, Leslie population model. If time permits we will describe ongoing work to extend these ideas to time series analysis and infinite-dimensional systems. (Received March 30, 2010)

1060-37-244 **Subhojoy Gupta*** (subhojoy.gupta@yale.edu), 433 Dunham Lab, 10 Hillhouse Avenue, New Haven, CT 06511. *Quasiconformal maps for grafted surfaces.*

Grafting of hyperbolic surfaces induces a self-map of Teichmüller space which leads to some interesting dynamics, and questions of how it relates to the Teichmüller metric. In particular, I will address the question of understanding finer properties of the asymptotic behaviour of grafting rays and their projection to moduli space. (Received March 30, 2010)

46 ► Functional analysis

1060-46-232 **Alexander A. Katz*** (katza@stjohns.edu), Dep. of Math&CS, St. John's College of LAS, St. John's University, 300 Howard Ave., DaSilva AC 314, Staten Island, NY 10301. *A note on real non-commutative locally JB-algebras.*

In the note real non-commutative locally JB-algebras are introduced as topological Jordan algebras which are topologically Jordan isomorphic to the projective limits of projective families of real non-commutative JB-algebras. It has been shown that all these algebras are automatically commutative. (Received March 30, 2010)

1060-46-235 **Alexander A. Katz** (katza@stjohns.edu), Dep. of Math&CS, St. John's College of LAS, St. John's University, 300 Howard Ave., DaSilva AC 314, Staten Island, NY 10301, and **Oleg Friedman*** (friedman001@yahoo.com), Department of Mathematical Sciences, University of South Africa, P O Box 392, Pretoria, 0003, South Africa. *On continuity of derivations on real locally C*-algebras.*

In the paper we consider derivations everywhere defined on real locally C*-algebra (real topological algebras which are real topologically *-isomorphic to a projective limit of projective families of real C*-algebras), and establish that such derivations are automatically continuous. It has been as well shown that each derivation on an Abelean real locally C*-algebra is identically zero. (Received March 30, 2010)

47 ► Operator theory

1060-47-51 **Yong-Zhuo Chen*** (yong@pitt.edu), Department of Mathematics, University of Pittsburgh at Bradford, Bradford, PA 16701. *Some contractive type mappings and their applications to difference equations.*

We discuss a class of discrete dynamic systems in a complete metric space (M, d) defined by mappings which satisfy various types of contractive type conditions. Their variants in ordered Banach space are investigated and applied to solve the global asymptotic stability of the equilibriums of some discrete dynamic systems. (Received March 11, 2010)

49 ► Calculus of variations and optimal control; optimization

1060-49-34 **Andreas H Hamel*** (ahamel@princeton.edu), Department of Operations Research, and Financial Engineering, Sherrerd Hall, Charlton Street, Princeton, NJ 08544. *The set-valued approach for conical markets models: risk measures and utility functions.*

A main source for incompleteness of a financial market is the presence of transaction costs or bid-ask price spreads. If the set of portfolios which can be exchanged into a portfolio with non-negative positions for all assets in the market is a convex cone at every time point, the market is called conical.

Over the last years, it became apparent that major constructions for such markets, namely super-hedging prices (Schachermayer 2004, Pennanen, Penner 2010) and risk measures (Jouini et al. 2004, Hamel, Heyde 2010) are best understood as set-valued functions. Next to nothing has been published yet about the question how to minimize risk, if the risk is evaluated by a set-valued function.

We present an approach to set-valued optimization problems involving risk minimization and utility maximization in conical markets: A solution concept is defined, and optimality conditions and the construction of dual problems are discussed.

Our approach to utility functions for multivariate random variables is entirely new and different from known constructions (e.g. Campi, Owen 2008). It is based on a transformation of vector-valued utility functions to

set-valued ones. The corresponding utility maximization problem turns out to be an optimization problem with a set-valued objective. (Received March 01, 2010)

51 ► Geometry

1060-51-4 **Richard E Schwartz*** (res@math.brown.edu), Dept of Mathematics, Brown University, 161 Thayer St, Providence, RI 02912. *Polygonal Outer Billiards.*

Outer billiards is a geometrically inspired dynamical system based on a convex shape in the plane. When the shape is a polygon, the system produces rich dynamics with a combinatorial flabor, as well as intricate and poorly understood tilings of the plane. In my talk I will explain outer billiards and highlight some of its beautiful features. I will also sketch the proof of my solution to one of the main questions in the subject, the Moser-Neumann problem: Do there exist outer billiards systems with unbounded orbits. My main result is that outer billiards has unbounded orbits relative to any irrational kite. (A kite is a convex quadrilateral with bilateral symmetry.) I will illustrate my talk with computer demos, using my program Billiard King, a graphical user interface I created to explore the problem. (Received March 24, 2010)

1060-51-39 **William P. Cavendish*** (wcavendi@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544. *Growth of the Weil-Petersson Diameter of Moduli Space.*

The Weil-Petersson metric is a non-complete Kähler metric on the moduli space of Riemann surfaces $\mathcal{M}_{g,n}$ whose completion is the Deligne-Mumford compactification $\overline{\mathcal{M}}_{g,n}$. I will give a brief overview of the geometric properties of this space and describe how the Riemannian geometry at a point $X \in \mathcal{M}_{g,n}$ depends on the hyperbolic geometry of the uniformization of X. I will then present joint work with Hugo Parlier that determines the growth of the diameter of $\overline{\mathcal{M}}_{g,n}$ as g or n goes to infinity. (Received March 07, 2010)

1060-51-89 **Emanuel A Lazar*** (lazar@princeton.edu), PACM, Fine Hall, Princeton University, Princeton, NJ 08544. *The topological and geometrical evolution of cellular structures.*

Cellular structures are ubiquitous throughout nature, forming the backbone of biological tissue, crystalline materials, as well as geographical partitions of land and the the large-scale structure of the universe. In many of these systems, boundaries migrate over time to minimize some energy latent in the system. While these migrations occur locally to minimize local energies, and depend greatly on the geometry of the system, they work to create global changes. Acute topological events, such as cell disappearance, are induced by gradual geometrical change.

In mean curvature flow, the velocity of every point on a surface is determined by the plane tangent to the surface at that point and by the magnitude of its mean curvature there. This geometry imposes structure on the topology of the system as much as it is shaped by it. In this paper we investigate how the geometrical and topological dynamics of these systems interact, and show how investigation of one can shed light on the other. (Received March 23, 2010)

1060-51-114 **Lee Michelle***, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Dynamics on the $PSL(2,\mathbb{C})$-character variety of a twisted I-bundle.* Preliminary report.

The deformation space of a compact hyperbolizable 3-manifold M, $AH(M)$, is the space of marked hyperbolic 3-manifolds homotopy equivalent to M. $AH(M)$ sits inside $\mathcal{X}(M)$, the $PSL(2,\mathbb{C})$ character variety of $\pi_1(M)$. $Out(\pi_1(M))$ acts on both of these spaces and in particular acts properly discontinuously on the interior of $AH(M)$. Minsky recently defined a notion of primitive-stable representations in $\mathcal{X}(H_g)$ where H_g is a handlebody of genus g. He showed that the set of such representations forms an $Out(F_g)$-invariant open set strictly larger than the interior of $AH(H_g)$ on which the action of $Out(F_g)$ is properly discontinuous. We will discuss an analogous notion of primitive-stable representations in $\mathcal{X}(M)$ when M is a hyperbolizable twisted I-bundle to obtain an analogous result. (Received March 25, 2010)

53 ► Differential geometry

1060-53-1 **Simon Brendle*** (brendle@math.stanford.edu), Stanford University, 450 Serra Mall, Bldg 380, Stanford, CA 94305. *Curvature, sphere theorems, and the Ricci flow.*

In 1926, Hopf proved that any compact, simply connected Riemannian manifold with constant curvature 1 is isometric to the standard sphere. Motivated by this result, Hopf posed the question of whether a compact, simply connected manifold with suitably pinched curvature is topologically a sphere. This question has been

studied by many authors over the past six decades, a milestone being the Topological Sphere Theorem proved by Berger and Klingenberg in 1960.

In this lecture, I will discuss the history of this problem, and describe the proof (joint with R. Schoen) of the Differentiable Sphere Theorem. This theorem classifies all manifolds with 1/4-pinched curvature up to diffeomorphism. The distinction between homeomorphism and diffeomorphism is significant in light of the exotic spheres constructed by Milnor; the proof uses the Ricci flow technique introduced by Hamilton. (Received March 13, 2010)

1060-53-36 **Valentino Tosatti*** (tosatti@math.columbia.edu), Columbia University, Department of Mathematics, 2990 Broadway, New York, NY 10027, and **Ben Weinkove**. *Complex Monge-Ampere equations on compact manifolds.*

We will discuss the complex Monge-Ampere equation on compact hermitian manifolds. We will explain to which extent the classical theory of Calabi-Yau for Kahler manifolds extends to this case, and give some applications. (Received March 05, 2010)

1060-53-73 **Mao-Pei Tsui***, 2801 W. Bancroft St, Toledo, OH 43606, and **Yng-Ig Lee** and **Mu-Tao Wang**. *Stability of the Minimal Surface System and Convexity of Area Functional.* Preliminary report.

In this paper, we show that the solution to the Dirichlet problem for the minimal surface system in any codimension is stable in the space where the area functional is convex. This is joint work with Yng-Ing Lee and Mu-Tao Wang. (Received March 20, 2010)

1060-53-90 **Jacob Bernstein***, Stanford University, Dept. of Math., Bldg. 380, Stanford, CA 94305, and **Christine Breiner**, MIT, Dept. of Math., Bldg. 2, Cambridge, MA 02139. *The Asymptotic Geometry of Genus-g Helicoids.*

We discuss the problem of classifying the asymptotic geometry of complete, properly embedded minimal surfaces in R^3 with finite topology. We will focus on the case of surfaces with one end and sketch the tools needed to address this question – namely the theory of Colding and Minicozzi. (Received March 23, 2010)

1060-53-102 **Jeffrey L. Jauregui*** (jeff@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708. *The harmonic conformal class and the Penrose inequality.*

I will introduce some invariants of the harmonic conformal class of an asymptotically flat manifold and their relationship with the Penrose inequality in general relativity. The invariants are not numbers, but real-valued functions. (Received March 24, 2010)

1060-53-233 **Evelyn J Lamb*** (ejlamb@rice.edu), Mathematics, MS 136, Rice University, P.O. Box 1892, Houston, TX 77251. *The Hopf differential and harmonic maps on branched hyperbolic surfaces.* Preliminary report.

The Hopf differential is a useful tool in the study of harmonic maps. Here, we use the Hopf differential to give a parametrization of the space of branched hyperbolic surfaces. (Received March 30, 2010)

54 ► General topology

1060-54-83 **Christopher R Cornwell***, 2721 Trappers Cove Trail, Apt. 2C, Lansing, MI 48910. *Polynomial and contact invariants of links in lens spaces.*

Using grid diagrams we construct a new polynomial invariant for links in lens spaces. We then find an inequality that relates this polynomial to the contact invariants of Legendrian and transverse links in lens spaces having a certain tight contact structure. Our result is a generalization of the Franks-Williams- Morton inequality. Along the way we will point out applications of our work to questions about lens space surgeries. (Received March 22, 2010)

55 ► Algebraic topology

1060-55-201 **Maxim Zyskin***, Department of mathematics, UTB, 80 Fort Brown, Brownsville, TX 78520. *Liquid crystals in polyhedral domains: topological problems.*

Configuration of liquid crystal in polyhedral domain is described by a map from polyhedron to a space (sphere), which on faces of polyhedron is restricted to be a map to subspaces (great circles of the sphere parallel to corresponding face).

Stable configurations of liquid crystal are those minimising energy functional.

We give homotopy classification of configurations of liquid crystal.

If domain is a cone, or rectangular prism, we give bounds on minimal Dirichlet energy in homotopy classes. Such bound involve spelling length problem for words in fundamental group of n-punctured sphere.

This work has applications to bi-stable liquid crystal displays. (Received March 30, 2010)

57 ► Manifolds and cell complexes

1060-57-25 **Robert Todd*** (rtodd@unomaha.edu), Department of Mathematics, University of Nebraska at Omaha, Omaha, NE 68182-0243. *The W-Polynomial and the Mahler Measure of the Kauffman Bracket.*

The W-polynomial is a many variable graph polynomial. To a graph we associate a family of links whose Kauffman Bracket is an evaluation of the W-polynomial of the graph. We show that the Twist Polynomial defined by Champanerkar and Kofman is an evaluation of the W-polynomial. This leads to slight improvement on the understanding of the geometry of a families of links with bounded Mahler measure. We also use the W-polynomial to find a technique to investigate the construction of families of links for which we can prove the Mahler measure diverges. (Received February 09, 2010)

1060-57-30 **Ilesanmi Adeboye*** (adeboye@math.ucsb.edu), Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 93106. *On volumes of hyperbolic orbifolds.*

One notable aspect of the study of covolumes of Kleinian groups is the variety in the techniques that have been brought to bear. In this talk, we show how revisiting H. C. Wang's results on discrete subgroups of Lie groups, plus a little differential geometry, leads to an explicit lower bound for the volume of a hyperbolic orbifold in any given dimension. This is joint work with Guofang Wei. (Received February 22, 2010)

1060-57-31 **Johanna Mangahas*** (mangahas@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *A Recipe for Short-word Pseudo-Anosovs.*

Suppose some subset of the mapping class group of a surface generates a subgroup containing a pseudo-Anosov. One can find a particular pseudo-Anosov with bounded length in the word metric induced by this subset, where the bound depends only on the surface. We describe how one goes about this. (Received February 22, 2010)

1060-57-38 **Joseph Maher*** (joseph.maher@csi.cuny.edu), Department of Mathematics 1S-215, 2800 Victory Boulevard, Staten Island, NY 11201. *Asymptotics for pseudo-Anosov's in Teichmuller lattices.*

A Teichmüller lattice is the orbit of a point in Teichmüller space under the action of the mapping class group. We use work of Athreya, Bufetov, Eskin and Mirzakhani to show that the asymptotic growth rates of lattice points corresponding to pseudo-Anosov elements, is the same as the growth rate of the total number of lattice points. (Received March 06, 2010)

1060-57-60 **Charles D Frohman*** (frohman@math.uiowa.edu), The Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Continuous Quandles and Knot Homology theories.* Preliminary report.

Following ideas of Ryshard Rubensztein and Magnus Jacobsson we are exploring the homology of the representation spaces of a knot quandle into CP(n) viewed as a continuous quandle. We will explain some basic examples and explore their relationship with the colored Jones polynomial (Received March 16, 2010)

1060-57-61 **Joseph Maher*** (joseph.maher@csi.cuny.edu), CUNY College of Staten Island, Department of Mathematics 1S-215, Staten Island, NY 11201. *Random Heegaard splittings.*

We show that generic Heegaard splittings give rise to hyperbolic manifolds, in the follow sense. If you take a random walk on the mapping class group, and use this as the gluing map between the two handlebodies, then the probability you obtain a hyperbolic manifold tends to one as the length of the random walk tends to infinity. (Received March 17, 2010)

1060-57-86 **Cody Armond***, 303 Lockett Hall, Department of Math, Louisiana State University, Baton Rouge, LA 70803. *Walks Along Braids and the Colored Jones Polynomial.* Preliminary report.

We investigate the coefficients of the colored Jones Polynomial for alternating braids and positive braids. The method used is a reinterpretation of the quantum determinant description introduced by Vu Huynh and Thang Lê in terms of walks along the braid. (Received March 22, 2010)

1060-57-94 **David Gabai*** (gabai@princeton.edu), Department of Mathematics, Princeton University, Princeton, NJ 08540-5410. *Do norm minimizing surfaces remain norm minimizing after filling?* Preliminary report.

Suppose that S is a Thurston norm minimizing surface in $S^3 \setminus \text{int}(N(L))$, where L is an n-component link. Consider the manifold N obtained by filling several components of $\partial N(L)$ along slopes determined by S. Let T denote the natural extension of S to N. Is T norm minimizing if S is norm minimizing? We present positive and negative results and an interesting conjecture. (Received March 23, 2010)

1060-57-96 **Oliver T Dasbach*** (kasten@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918, and **Adam M Lowrance** (alowrance@math.uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242-1419. *Turaev genus, knot signature, and the knot homology concordance invariants: Part 1.*

The Turaev surface of a knot diagram is a certain Heegaard surface on which the knot has an alternating projection. The minimum genus of any Turaev surface of a diagram is the Turaev genus of the knot. In this talk, I will give the construction of the Turaev surface and explain a connection to the Khovanov and knot Floer homology of the knot. (Received March 24, 2010)

1060-57-97 **Oliver T Dasbach** (kasten@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803-4918, and **Adam M Lowrance*** (alowrance@math.uiowa.edu), Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242-1419. *Turaev genus, knot signature, and the knot homology concordance invariants: Part 2.*

In this talk, I will give a relationship between the Ozsvath-Szabo tau invariant, the Rasmussen s invariant, knot signature, and the Turaev surface of a knot. This leads to new lower bounds for the Turaev genus of a knot. (Received March 24, 2010)

1060-57-115 **Joan Birman***, Columbia University, Department of Mathematics, New York, NY 10027, and **Peter Brinkmann** and **Keiko Kawamuro**. *On the monodromy maps of certain fibered twisted torus knots.*

We will describe how to compute the monodromy maps for certain fibered twisted torus knots, and discuss what we learned from the computation. This is joint work with Peter Brinkmann and Keiko Kawamuro. (Received March 25, 2010)

1060-57-117 **Razvan Gelca*** (rgelca@gmail.com), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79410, and **Alejandro Uribe**, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *The theory of classical theta functions from a topological perspective.*

We will show how the skein modules of the linking number can be used to model the theory of classical theta functions in the representation theoretic point of view of A. Weil. These skein modules were introduced by J. Przytycki as one parameter deformations of group algebras of the first homology groups of 3-manifolds. According to Witten's quantum field theoretic constructs, these skein modules arise in abelian Chern-Simons theory, and they should therefore be linked to classical theta function. The aim of this talk is to show that one can arrive at these skein modules, and at the Reshetikhin-Turaev formula for invariants of 3-manifolds, by looking closely at the classical theory of theta functions, without the insights of quantum field theory. (Received March 25, 2010)

1060-57-119 **Hao Wu*** (haowu@gwu.edu), Department of Mathematics, GWU, Monroe Hall, Room 240, 2115 G Street, NW, Washington, DC 20052. *Generic deformations of the colored sl(N)-homology for links.*

I will generalize the construction by Lee and Gornik to give an invariant basis for each generic deformation of the colored sl(N)-homology. I will also discuss some of its applications. (Received March 25, 2010)

1060-57-122 **Tian Yang*** (tianyang@math.rutgers.edu), 23855 BPO Way, Piscataway, NJ 08854. *On the Hyperbolic Gluing Equations and Representations of Fundamental Groups of Closed 3-Manifolds.*

We show that for a representation of the fundamental group of a triangulated closed 3-manifold (not necessarily hyperbolic) into $\mathbf{PSL}(2;\mathbb{C})$ so that any edge loop has non-trivial image under the representation, there exist uncountably many solutions to the hyperbolic gluing equation whose associated representations are the given representation, and whose volumes are equal to the volume of the given representation. As a consequence, the hyperbolic structure on a closed, orientable, hyperbolic 3-manifold can be constructed from a solution to the hyperbolic gluing equations using any triangulation with essential edges. (Received March 26, 2010)

1060-57-125 **Aaron D Magid*** (magid@math.udm.edu), University of Maryland, Department of Mathematics, 1301 Mathematics Building, College Park, MD 20742. *The Topology of Deformation Spaces of Kleinian Groups.*

For any 3-manifold M, let $AH(M)$ denote the space of all marked hyperbolic 3-manifolds homotopy equivalent to M. This deformation space of hyperbolic manifolds is naturally a subset of the $PSL(2,\mathbb{C})$ character variety of $\pi_1(M)$. After reviewing some of the classical results that describe topology of the interior of $AH(M)$, we will show that in many cases there are points on the boundary where $AH(M)$ fails to be locally connected. This is a generalization of Ken Bromberg's result that the space of Kleinian punctured torus groups is not locally connected. (Received March 26, 2010)

1060-57-134 **Carmen L Caprau*** (ccaprau@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue, M/S PB 108, Fresno, CA 93740. *Link cohomology and extended TQFTs.*

We will describe a Khovanov type cohomology theory for oriented links using foams and a 2-dimensional extended Topological Quantum Field Theory. (Received March 28, 2010)

1060-57-147 **Ronald van Luijk** and **Melissa Macasieb***, Department of Mathematics, Mathematics Building, College Park, MD 20742, and **Kathleen Petersen**. *Character varieties of a family of 2-bridge knot complements.*

To every hyperbolic finite volume 3-manifold M, one can associate a pair of related algebraic varieties $X(M)$ and $Y(M)$, the $SL_2(\mathbb{C})$- and $PSL_2(\mathbb{C})$-character varieties of M. These varieties carry much topological information about M, but are in general difficult to compute. If M has one cusp, then both these varieties have dimension one. In this talk, I will also show how to obtain explicit equations for the character varieties associated to a family of hyperbolic two-bridge knots $K(m,n)$ and discuss some interesting consequences of these results. This is joint work with Kate Petersen and Ronald van Luijk. (Received March 28, 2010)

1060-57-150 **Neal W. Stoltzfus*** (stoltz@math.lsu.edu), Dept. of Maths, Louisiana State University, Baton Rouge, LA 70803. *Toward an Arithmetic theory of Chekhov-Fock Algebras.* Preliminary report.

This is a preliminary report on an arithmetic theory of Chekhov-Fock Algebras over the ring of integral Laurent polynomials in the quantum parameter. A relationship to the Kauffman Bracket skein module of a cylinder over a surface is proposed and comparisons made between these two quantizations of the coordinate ring of the character variety. (Received March 29, 2010)

1060-57-151 **Shaun R Harker*** (sharker@math.rutgers.edu). *Discrete Morse Theory for Homology Computation.*

Discrete Morse Theory for Homology Computation

Morse theory was developed in a discrete setting by Robin Forman, who defined discrete Morse functions on cell complexes and showed one could construct a smaller complex – the *Morse complex* – built only out of the so-called *critical cells* of the complex. Moreover, this smaller complex is guaranteed to have the same homology as the original complex. We have developed algorithms to find such discrete Morse functions and also algorithms to quickly evaluate the boundaries of chains in the Morse complex. This gives us another method of computing homology. (Received March 29, 2010)

1060-57-156 **Daryl Cooper** (cooper@math.ucsb.edu) and **David Futer*** (dfuter@temple.edu), Philadelphia, PA 19122, and **Jessica S Purcell** (jpurcell@math.byu.edu). *Knots with long unknotting tunnels.*

Given a knot K in S^3, an unknotting tunnel for K is an arc τ, such that the complement of K and τ is a handlebody. Unknotting tunnels provide an important insight into the topology of both K and its complement. But how do they look geometrically? Is τ a geodesic in the hyperbolic metric, and how long is it? I will describe

an explicit construction that gives knots in S^3 whose unknotting tunnels are arbitrarily long. This is joint work with Jessica Purcell and Daryl Cooper. (Received March 29, 2010)

1060-57-158 **Colin Adams*** (cadams@wiliams.edu), Bronfman Science Center, Williams College, Williamstown, MA 01267, and **Dan Collins**, **Katherine Hawkins**, **Charmaine Sia**, **Robert Silversmith** and **Bena Tshishiku**. *Indicatrices and Superinvariants of Knots.*

The first superinvariant, superbridge number, was introduced by Kuiper in 1985. It has proved to be instrumental in determining stick numbers of knots. We consider this and other superinvariants and how they are related to certain labelings of the unit sphere associated to a conformation of a knot. These in turn are seen to be related to the tangent, normal and binormal indicatrices of the conformation. We examine duality that occurs between the various indicatrices and choices of labelings of the sphere. (Received March 29, 2010)

1060-57-169 **Mikhail Khovanov*** (khovanov@math.columbia.edu), Department of Mathematics, Columbia University, New York, NY 10027. *Adventures in categorification.*

We'll consider several examples of categorification and clarify the importance of suitable bilinear forms and their graphical interpretations for categorification of quantum groups and Hecke algebras. (Received March 29, 2010)

1060-57-172 **Keiko Kawamuro*** (kawamuro@math.uiowa.edu), 14 McLean Hall, Iowa City, IA 52240. *Invariants of psedo-Anosov maps.*

Associated to a pseudo-Anosov mapping class, the Bestvina-Handel algorithm produces a train track map. Given a train track map, we can compute the dilatation number, a will known invariant of pseudo-Anosov maps. I will discuss that we can obtain more informations of the pseudo-Anoso mapping class from a train track map. (Received March 29, 2010)

1060-57-183 **Genevieve S. Walsh*** (genevieve.walsh@gmail.com), 503 Boston Ave, Medford, MA 02155. *The combinatorics of the domain of discontinuity.*

We will discuss the combinatorics of the domain of discontinuity for a geometrically finite Kleinian group. In particular, this can be used to obtain basic topological information about the quotient 3-manifold. (Received March 29, 2010)

1060-57-185 **Daniel S Silver*** (silver@jaguar1.usouthal.edu), Dept of Mathematics and Statistics, ILB 325, University of South Alabama, Mobile, AL 36608, and **Susan G Williams** (swilliam@jaguar1.usouthal.edu), Dept of Mathematics and Statistics, ILB 325, University of South Alabama, Mobile, AL 36688. *Twisted Alexander Polynomials and Representation Shifts.* Preliminary report.

Twisted Alexander knot polynomials generalize the classical Alexander polynomial by incorporating information form the linear representations of the knot group. We explain how one can use a larger class of representations, representations of the commutator subgroup that are periodic in a natural sense. Of particular interest are finite-image permutation representations. We present results and conjectures about the zeros of the polynomials that arise. (Received March 29, 2010)

1060-57-186 **Christian Krogager Zickert*** (zickert@math.berkeley.edu), CA. *On the volume and Chern-Simons invariant.*

A hyperbolic 3-manifold defines an element in the extended Bloch group, an object introduced by Walter Neumann. Evaluating a version of Rogers dilogarithm on this element gives the volume and Chern-Simons invariant of the manifold. We describe a new way of constructing the extended Bloch group element, giving rise to a very fast algorithm for computing the volume and Chern-Simons invariant. The method generalizes to a formula for the volume and Chern-Simons invariant of representations of 3-manifold groups. (Received March 29, 2010)

1060-57-188 **Jennifer Hom***, jenhom@math.upenn.edu. *Bordered Heegaard Floer homology and the τ-invariant of cable knots.* Preliminary report.

We will use bordered Heegaard Floer homology to give a formula for the Ozsváth-Szabó concordance invariant τ of the (p, q)-cable of a knot K, in terms of p, q, and two invariants, $\tau(K)$ and $\delta(K)$, associated to the knot Floer complex of K. As a consequence, we will show that for any integer n, there exist knots K and K' with $\tau(K) = \tau(K') = n$, such that $\tau(K_{p,q}) \neq \tau(K'_{p,q})$, for all pairs of relatively prime integers p and q. (Received March 30, 2010)

1060-57-192 **Rumen Zarev*** (rzarev@math.columbia.edu), 509 Mathematics, MC 4406, 2990 Broadway, New York, NY 10027. *Link Floer homology via bordered sutured Floer homology.*

Link Floer homology, *HFL* is a powerful invariant of links in 3–manifolds, and can be considered a special case of the more genral sutured Floer homology *SFH*. The theory of bordered sutured Floer homology gives new ways of computing *HFL*, and investigating its properties. Given a link L in a 3–manifold Y, we can cut the link complement into pieces $Y_1, \dots, Y_n$. To these pieces we can associate bordered sutured invariants $BSD(Y_i)$, and use them to compute $HFL^-(Y, L)$ and $\widehat{HFL}(Y, L)$. This allows us to investigate how *HFL* behaves under small, local changes to the link. (Received March 30, 2010)

1060-57-196 **Daniel S. Silver** (silver@jaguar1.usouthal.edu), Department of Mathematics and Statistics, Mobile, AL 36688, and **Susan G. Williams*** (swilliam@jaguar1.usouthal.edu), Dept. of Mathematics and Statistics, Mobile, AL 36688. *Alexander-Lin Twisted Polynomials.*

We extend Xiao-Song Lin's original definition of twisted Alexander polynomial, given in terms of regular Seifert surfaces, to a "pointed invariant" of a finitely presented group and conjugacy class of elements. We give an algebraic generalization of a knot fibering obstruction of J. Cha, and a bound on the degree of the twisted polynomial. (Received March 30, 2010)

1060-57-197 **Peter D Horn*** (pdhorn@math.columbia.edu), Department of Mathematics, Columbia University - MC 4403, 2990 Broadway, New York, NY 10027, and **Tim D Cochran** and **Shelly L Harvey**. *Higher-order signature cocycles for subgroups of the mapping class group.*

This is joint work with Tim Cochran and Shelly Harvey. We define families of invariants for elements of the mapping class group of Σ, a compact, orientable surface. For a characteristic subgroup $H \triangleleft \pi_1\Sigma$, let $J(H)$ denote the subgroup of mapping classes that induce the identity map on $\pi_1\Sigma/H$. To a unitary representation ψ of $\pi_1\Sigma/H$, we associate a higher-order ρ-invariant, ρ_ψ, and a signature 2-cocycle σ_ψ, a generalization of the Meyer cocycle. We show that each ρ_ψ is a quasimorphism from $J(H) \to \mathbb{R}$, and that the σ_ψ span an infinite rank subgroup of $H^2_{bounded}(J(H); \mathbb{R})$ (Received March 30, 2010)

1060-57-203 **Heather M. Russell*** (hrussell@math.lsu.edu). *The topology of two-row Springer varieties.* Preliminary report.

Springer varieties appear in the study of both knot homologies and geometric representation theory. Classically, Springer varieties are defined as subvarieties of the variety of full flags in $\mathbb{C}^N$. For each partition λ of N there is an associated Springer variety X_λ. For N even Khovanov gives a combinatorial and geometric construction of $X_{(N/2,N/2)}$ which is motivated by knot theory. We extend Khovanov's construction to all two-row Springer varieties and give a new geometric and diagrammatic description of the Springer representation on the homology of this class of Springer varieties. Some of this work is joint with Julianna S. Tymoczko at The University of Iowa. (Received March 30, 2010)

1060-57-212 **Daniel Krasner***, 17 Gauss Way, Berkeley, CA 94720, and **Ben Elias**, 2990 Broadway Ave, New York, NY 10027. *Graphical calculus of Soergel bimodules in Khovanov-Rozansky link homology.*

I will outline a graphical calculus of Soergel bimodules, developed by B. Elias and M. Khovanov, and describe how it can be used to construct an integral version of sl(n) and HOMLFYPT link homology, as well as prove functoriality of the latter. (Received March 30, 2010)

1060-57-220 **Scott Baldridge*** (sbaldrid@math.lsu.edu), 224 Lockett Hall, Baton Rouge, LA 70803, and **Adam Lowrance**. *Cube Diagrams: The Topology and Geometry of Knots in Three Dimensions.* Preliminary report.

In this talk we will introduce the notion of a cube diagram—a three dimensional representation of a knot in R^3 whose three planar knot projections are grid diagrams. The main goal in defining cube diagrams was to develop a data structure that describes an embedding of a knot in R^3 such that (1) every link is represented by a cube diagram, (2) the data structure is rigid enough to easily define invariants, yet (3) a limited number of 5 inherently 3-dimensional moves are all that are necessary to transform one cube diagram of a link into any other cube diagram of the same link.

As an example of the usefulness of cube diagrams we will present a homology theory constructed from cube diagrams and show that it is equivalent to knot Floer homology, one of the most powerful known knot invariants. (Received March 30, 2010)

1060-57-222 **Marc Culler*** (culler@math.uic.edu), MSCS Department M/C 249, University of Illinois at Chicago, 851 S. Morgan St., Chicago, IL 60607-7045, and **Peter B. Shalen**, MSCS Department M/C 249, University of Illinois at Chicago, 851 S. Morgan St., Chicago, IL 60607-7045. *Margulis numbers for Haken manifolds.* Preliminary report.

A positive number μ is said to be a Margulis number for a given closed hyperbolic 3-manifold M if each component of the $\mu/2$-thin set in M is a tube about a geodesic of length less than μ. The Margulis Lemma says that there exists a positive number which is a Margulis number for every closed hyperbolic 3-manifold. Thus we can define the Margulis constant for a class of closed hyperbolic 3-manifolds to be the supremum of the set of numbers which serve as Margulis numbers for every manifold in the class. In this paper we determine a lower bound for the Margulis constant of the class of Haken hyperbolic 3-manifolds. This bound is significantly larger than the largest known lower bound for the Margulis constant of the class of all hyperbolic 3-manifolds. (Received March 30, 2010)

1060-57-237 **Alexander N. Shumakovitch*** (Shurik@gwu.edu), The George Washington University, Department of Mathematics, Monroe Hall, room 240, Washington, DC 20052. *Homologically $\mathbb{Z}_2$-thin knots have no 4-torsion in Khovanov homology.* Preliminary report.

We will demonstrate how to use the Bockstein spectral sequence to prove that homologically $\mathbb{Z}_2$-thin knots have no 4-torsion in Khovanov homology. This completes the proof of the fact that the integer Khovanov homology of alternating knots is completely determined by their Jones polynomial and signature. (Received March 30, 2010)

1060-57-242 **Ben McCarty*** (benm@math.lsu.edu), Lockett Hall, Baton Rouge, LA 70803. *On the cube number of a knot.* Preliminary report.

We will highlight some of the differences between cube diagrams and grid diagrams, and explore the relationship between the arc index and the cube number of a knot. Furthermore, we'll introduce a possible link between cube number and link orientation. (Received March 30, 2010)

1060-57-248 **Stephan M. Wehrli*** (smwehrli@msri.org), Mathematical Sciences Research Institute, 17 Gauss Way, Office 304, Berkeley, CA 94720-5070, and **J. Elisenda Grigsby**. *On the relationship between sutured Khovanov homology and sutured Floer homology.*

In this talk, I will discuss a spectral sequence converging from a sutured version of Khovanov homology to the sutured Floer homology of a branched double-cover. I will show that certain algebraic structures on the Khovanov side (such as a weight space decomposition) correspond naturally to geometric structures on the sutured Floer side (e.g., an Alexander grading). I will also describe a relationship between the sutured Khovanov homology of a braid closure in a thickened annulus and bimodules over certain quiver algebras defined by Khovanov and Seidel. (Received March 30, 2010)

1060-57-252 **Krzysztof Putyra*** (putyra@math.columbia.edu). *A 2-category of dotted cobordisms and odd link homologies with parameters.* Preliminary report.

A chronology on a cobordism is a Morse function $f\colon M \to I$ which separates critical points. $(1+1)$-cobordisms with chronologies form a category which has a natural structure of a 2-category, where 2-morphisms are given by homotopies (changes) of chronologies. I showed two years ago that for a given tangle diagram we can build a complex in the additive closure of this 2-category from which we can recover both even and odd homology groups. This time I will describe how to introduce dots to chronological cobordisms and a neck-cutting relation. This gives us a natural Abelian framework for the odd construction and may result in fast algorithms to compute odd homologies. Further applications include:

- non-existence of an odd version of the Lie construction
- no analogues of the t and h parameters

(Received March 30, 2010)

1060-57-253 **Maciej Niebrzydowski** and **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, George Washington, Monroe Hall, Room 240 2115 G Street NW, Washington, DC 20052. *The second quandle homology of the Takasaki quandle of an odd abelian group is an exterior square of the group.*

M.Takasaki introduced the notion of kei (involutive quandle) in 1942. His main example was the quandle of an abelian group $T(G)$ with $a * b = 2b - a$, which we call a Takasaki quandle. We prove that if G is an abelian group of odd order then the second quandle homology $H_2^Q(T(G))$ is isomorphic to $G \wedge G$ where $\wedge$ is the exterior product. In particular, for $G = Z_k^n$, k odd we have $H_2^Q(T(Z_k^n)) = Z_k^{n(n-1/2}$. We start our

proof by constructing Cayley graph and Cayley 2-complex of $T(G)$ in such a way that the first homology of the complex is the second homology of $T(G)$. We choose a spanning tree for the Cayley graph and contract it. The homological result is the group $Z(G \times G)$ divided by relations $[x, x] = 0$ (this corresponds to the fact that in quandle homology we nullify degenerate elements), $[0, x] = 0$ (elements of a chosen spanning tree are equal to zero) and $[x, z] + [z, y] = [x, z - y + x] + [z - y + x, y]$. Then we prove that for G generated by 2 elements the main result holds, in particular that $[x, y] = -[y, x]$. After some algebraic manipulations we obtain generally $G \wedge G$. Our result can be directly applied to classical links as 2-(co)cycles give link invariants. They also can be used to produce new nontrivial quandles. (Received March 31, 2010)

60 ► Probability theory and stochastic processes

1060-60-28 **Hongzhong Zhang** (union4v@yahoo.com), 365 5th ave, New York, NY 10016, and **Olympia Hadjiliadis*** (ohadjiliadis@brooklyn.cuny.edu), 365 5th ave, New York, NY 10016. *Drawdowns, drawups and risk management.*

In this work we study drawdowns and drawups of general diffusion processes. The drawdown process is defined as the current drop of the process from its running maximum, while the drawup process is defined as the current increase over its running minimum. The drawdown and the drawup stopping times are the first hitting times of the drawdown and the drawup processes respectively. We derive a closed-form formula for the Laplace transform of the probability density of the drawdown of a units when it precedes the drawup of b units. We then discuss an application of these results in financial risk management. In particular, consider a digital with a unit payoff on the event that a drawdown precedes a drawup. Such an instrument would provide insurance against adverse movements in the market and could thus be of interest to an investor. Using model-free relationships derived in this work, we are able to provide a robust replication of this instrument using One-touch knockouts. Under extra assumptions on the underlying process we show that it is also possible to derive semi-static replication using single-barrier and plain digital options. (Received February 18, 2010)

1060-60-82 **Tim S.T. Leung*** (leung@jhu.edu), **Ronnie Sircar** and **Thaleia Zariphopoulou**. *Forward Indifference Valuation of American Options in Incomplete Markets.*

We discuss the forward indifference valuation of American options in general incomplete diffusion markets. Under a general forward performance criterion, we formulate the option holder's valuation problem as a combined stochastic control and optimal stopping problem. This leads to the analytic and numerical studies of the associated variational inequality. We examine two specific financial applications: the valuation of American options under stochastic volatility, and the modeling of early exercises of American-style employee stock options. We also show that the marginal forward indifference price is independent of the investor's wealth and risk preferences, and is represented as the claim's risk-neutral price under the minimal martingale measure. (Received March 21, 2010)

1060-60-95 **Hasanjan Sayit*** (hs7@wpi.edu), 100 Institute Road, Worcester, MA 01609, and **Frederi Viens** (viens@stat.purdue.edu), Purdue University, West Lafayette, IN 47907. *Arbitrage-Free Models In Markets With Transaction Costs.*

In this note, we study no-arbitrage conditions in a market with multiple risky assets and proportional transaction costs. We present a condition which is sufficient for the market to be arbitrage-free and investigate its properties. In particular, we provide examples of price processes that are not semimartingales but are consistent with absense of arbitrage. (Received March 23, 2010)

1060-60-161 **Libor Pospisil*** (lp2185@columbia.edu), 1255 Amsterdam Avenue, New York, NY 10027, and **Jan Vecer**, 1255 Amsterdam Avenue, New York, NY 10027. *Maximum Drawdown of a Jump-Diffusion Process and the Corresponding Partial Integro-Differential Equations.*

In this talk, we introduce the maximum drawdown as a tool for measuring market crashes – drops in the price of an asset. Moreover, contracts with payoffs depending on the realized maximum drawdown can serve as insurance against market crashes. Our main goal is to develop a method for pricing these types of contracts under the assumption that the price of the asset is a diffusion process plus a compound Poisson process. Given the complexity of the underlying model, the most suitable method is derivation of the pricing partial integro-differential equation and solving it numerically. The special feature of the equations is the presence of the running maximum and the running maximum drawdown, which may be discontinuous due to the jumps in the asset price. We will also discuss properties of the numerical solution. (Received March 29, 2010)

1060-60-166 **Birgit Rudloff*** (brudloff@princeton.edu), Sherrerd Hall 203, Princeton University, Princeton, NJ 08544, and **Andreas Hamel**. *Risk measures for multivariate variables in markets with random solvency cones.*

We consider a conical market model (generated, for example, by proportional transaction costs or bid-ask price spreads) and extend the notion of set-valued risk measures (Jouini, Meddeb, Touzi 2004, Hamel, Heyde 2010) to the case of random solvency cones at terminal time. Several new features such as market compatibility will be discussed which do not appear (or are trivial) if the solvency cones are constant.

Dual representations are given in terms of vector probability measures. This admits an interpretation very close to the scalar case. Examples include the set-valued versions of the worst case risk measure and the average value at risk.

Related results will be discussed. For example, it can be shown that in analogy to the frictionless case the superhedging price in a conical market (see e.g. Schachermayer 2004, Pennanen, Penner 2009) is a set-valued coherent risk measure, where the supremum in the dual representation is taken w.r.t. the set of equivalent martingale measures.

Moreover, we will show that the case of multiple eligible assets perfectly fits into the set-valued framework: The scalar risk measures introduced in Artzner, Delbaen, Koch-Medina 2009 turn out to be scalarizations of set-valued risk measures. (Received March 29, 2010)

1060-60-194 **Patricia Giurgescu***, ., Danbury, CT 06810. *On convergence and convexity properties of probabilistic metric spaces.* Preliminary report.

An overview of Menger, Wald and finite expectation probabilistic metric spaces: convergence and convexity properties, existence of fixed points for contractive mappings; application of T-intersection norms and T-union conorms for fuzzy sets with respect to additive generators for contractive T-norms (Received March 30, 2010)

1060-60-207 **Michael Coulon*** (mcoulon@princeton.edu), Princeton University - ORFE Department, 117 Sherrerd Hall, Princeton, NJ 08544. *Energy price correlations: Understanding the links between coal, gas, electricity and carbon prices.*

Energy price modeling is a growing area of financial mathematics in which many interesting problems exist and many different approaches are used. In this talk, I shall focus on the question of how to capture the complex dependence structure between different energy spot prices which is of key importance to energy companies, as well as many financial institutions. In particular, the structure of the electricity market is a natural starting point for this task, as it brings together generators of different types with production costs tied to different fuels and emissions costs. Evidence from the PJM and New England electricity markets illustrates the benefit of using observed auction data to better understand the strong relationships between fundamental supply and demand factors and power prices. We exploit these observations to create a structural model for both electricity and (if necessary) CO2 emissions prices, which embeds the correlation with fuel prices through important features such as merit order changes and fuel switching by generators, helping us to better understand the complicated behavior of energy prices. (Received March 30, 2010)

65 ► Numerical analysis

1060-65-3 **Ricardo H. Nochetto*** (rhn@math.umd,edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Curvature Driven Flows in Deformable Domains.*

We discuss modeling, analysis, and computation of three challenging curvature driven flows in deformable domains: surface diffusion (materials science), electrowetting on dielectric (microelectromechanical systems MEMS), and fluid biomembranes (biophysics). They all involve the Laplace-Beltrami operator, which, being variational, allows for finite element methods of any polynomial degree on surfaces. We also discuss geometrically consistent accuracy preserving mesh modifications (refinement, coarsening, and mesh smoothing) of piecewise polynomial surfaces with incomplete information about their underlying geometry. This is crucial for large domain deformations and a new paradigm in adaptivity. (Received March 30, 2010)

1060-65-118 **Anita T Layton*** (alayton@math.duke.edu), Department of Mathematics, Duke University, Durham, NC 27708. *Solving the immersed interface problem using the decomposition with boundary integral approach.*

We present a second-order accurate method for computing the coupled motion of a viscous fluid, described by the Navier-Stokes equations with Dirichlet boundary conditions, and with a singular force arising from the deformation of the moving interface. We decompose the velocity into three parts: "Stokes", "regular", and

"boundary correction." The "Stokes" part is determined by the Stokes equations and the singular interfacial force. The Stokes solution is computed from the solution of three Poisson problems, with the right side replaced by a discrete Laplacian, formed by pressure or velocity values given by boundary integrals, on irregular grid points. The "regular" velocity is given by the Navier-Stokes equations with a body force resulting from the Stokes part, and with periodic boundary conditions. The boundary correction solution is described by the unforced Navier-Stokes equations, with Dirichet boundary conditions given by the deviation of the overall Navier-Stokes solution, and the boundary values of the Stokes and regular velocities. Because the regular and boundary correction solution are sufficiently smooth, jump conditions are not necessary. (Received March 25, 2010)

1060-65-129 **Sören Bartels*** (bartels@ins.uni-bonn.de), Institute for Numerical Simulation, University of Bonn, 53115 Bonn, Germany. *Modeling and Simulation of Director Fields on Flexible Surfaces.*

We discuss the numerical minimization of an energy functional that couples the curvature of a surface with a director field defined on the surface. The functional is a combination of a Frank energy and a Willmore functional including a spontaneous curvature that is proportional to the surface divergence of the director field. Defects in the director field thus induce strong local curvature. Such functionals occur in the mathematical modeling of surfactants and may serve as simple descriptions for the interplay of shapes and orientations of lipid molecules of biomembranes. For surfaces that can be described by graphs, we propose and analyze a combined mixed finite element and projection scheme. Numerical experiments are presented and generalizations to closed surfaces are discussed. This is joint work with Georg Dolzmann (U Regensburg, Germany) and Ricardo H. Nochetto (U Maryland, USA). (Received March 27, 2010)

1060-65-154 **Xiaolin Li*** (linli@ams.sunysb.edu), Department of Applied Math and Stat, SUNY at Stony Brook, Stony Brook, NY 11794, and **Wurigen Bo**, **Brian Fix**, **JoungDong Kim** and **James Glimm**. *Front tracking and its coupling with convection dominated problems.*

The renovated FronTier library, equipped with high order surface algorithms, is coupled with a set of new PDE solvers. This includes the AMR-enabling compressible solver, the incompressible Navier-Stokes solver and the precipitation solver. We apply these new solvers to simulations of fluid mixing, bubbling, jet, fluid-structure interaction and convection driven precipitation of subsurface flow. We will present some interesting verification and validation on these problems. (Received March 29, 2010)

1060-65-170 **M. Sebastian Pauletti*** (pauletti@math.tamu.edu). *A Parametric FEM for Biomembrane.*

Joint with: Andrea Bonito and Ricardo H. Nochetto.

When lipid molecules are immersed in aqueous environment they spontaneously aggregate into a membrane made up up two mono-molecular layers. The membrane forms an encapsulating bag called vesicle. This happens because lipids consist of a hydrophilic head group and a hydrophobic tail, which isolate itself in the interior of the membrane.

As a first approach, we have studied a model based on geometry assuming that the equilibrium shapes are the minimizers of the Willmore energy under area and volume constraints. Then, the effect of the inside (bulk) fluid is taken into account leading to a more physical dynamics.

A parametric approach is employed, which leads to forth order highly nonlinear PDEs on surfaces and involves large domain deformations. An adaptive finite element method (AFEM), with either piecewise linear or quadratic polynomials, is used for both the geometric and coupled problems. Several computational challenges needed to be addressed and solved. (Received March 29, 2010)

68 ► Computer science

1060-68-198 **Parisa Babaali*** (pbabaali@york.cuny.edu), Dept. of Mathematics and Computer Sciences, 94-20 Guy R. Brewer Blvd, Jamaica, NY 11415. *A Lower Bound on the Asymptotic Density of Minimal Automata.*

There are existing methods to generate a complete deterministic automaton at random, however it is not known what percentage of these automata are minimal. In this talk we give a lower bound on the asymptotic density of minimal automata of size n in the super set of all deterministic complete automata of size n generated by the existing methods by constructing a family of non-minimal automata. (Received March 30, 2010)

70 ► Mechanics of particles and systems

1060-70-12 **Timothy D Andersen*** (andert@alum.rpi.edu), Hampton, VA 23666, and **Chjan C Lim**, Tory, NY 12180. *Anomalous expansion and negative specific heat in quasi-2D plasmas.*

The electron magnetohydrodynamic (EMH) model for plasma vorticity allows for a one-component Coulomb ensemble to describe a confined plasma's statistics of electron columns. These columns, often studied in strict two-dimensions, can have significant 3D effects, causing deviations from 2D statistics. Two deviation results can be obtained from the statistics: (1) an anomalous expansion of the size of the ensemble at a specific "temperature" in the canonical (heat bath) case and (2) negative specific heat in the microcanonical (isolated ensemble) case. Both of these results can be derived in a mean-field limit of the interaction potential and are applicable to magnetic nuclear fusion experiments. (Received January 05, 2010)

1060-70-24 **Lou Kondic*** (kondic@njit.edu), Department of Mathematical Sciences, NJIT, University Heights, Newark, NJ 07102, and **Miroslav Kramar**, **Konstantin Mischaikow** and **Robert P. Behringer**. *Granular materials: from discrete to continuum description.*

One property of granular materials is the lack of spatial scale separation between the one characterizing the particle size and the one characterizing system as a whole. This property requires careful understanding of the features which exist on particle scale, such as force chains, with the hope that this understanding will help us produce appropriate continuum level models. In this talk, we will discuss our initial attempts to characterize force chains. These attempts are based on algebraic topology techniques that will be used to analyze and quantify force chain structures. In particular, we will discuss how these properties differ for the systems exposed to shear versus compression, and correlate the topological measures to the phenomena such as jamming. Furthermore, we will discuss the possibility of using topological techniques to come up with a quantitative way of comparing experiments and simulations. (Received January 25, 2010)

74 ► Mechanics of deformable solids

1060-74-107 **Kai-Bin Fu*** (kafu@pvamu.edu), Department of Mathematics, Prairie View A&M University, Prairie View, TX 77446. *A new constitutive framework for biological materials with elastic behavior.* Preliminary report.

To fully understand mechanisms of any biological material, we need to understand its mechanics. Although there are numerous attempts to model the constitutive relation from the nanoscale , it is extremely difficult to verify the results due to the complexity of biological tissues. Their mathematical foundations are rather weak. Ultimately the ultra-structural mechanisms for tissue behavior are most important, yet phenomenological relations are crucial toward understanding the material as a whole. We start with continuum mechanics framework for materials with elastic mechanical behavior, which has rigorous mathematical support.

Existing constitutive theories for high-strain materials, such as those of Rivlin and Fung, are not suitable for the determination of constitutive relation via bi-axial experiments because of the choice of kinematical variables. It is no wonder little work has been done to analyze the mathematical features of those models. A new constitutive framework has been proposed. When we gain more confidence from its applications and mathematical features, we can apply it to the study of biomembrane. (Received March 24, 2010)

76 ► Fluid mechanics

1060-76-6 **Anatoliy K. Prykarpatsky*** (pryk.anat@ua.fm), 21-D Rozdroze Str. Apt. 1, 30-361 Krakow, Poland, and **Ziemowit Popowicz** (ziemek@ift.uni.wroc.pl), University of Wroclaw, 9 Max Born, 50-204 Wroclaw, Poland. *THE NON-POLYNOMIAL CONSERVATION LAWS AND INTEGRABILITY ANALYSIS OF A GENERALIZED RIEMANN TYPE HYDRODYNAMICAL EQUATION.* Preliminary report.

Based on the gradient-holonomic algorithm we analyze the integrability property of the generalized hydrodynamical Riemann type equation $D_t^N u = 0$ for arbitrary $N \in \mathbb{Z}_+$. The infinite hierarchies of polynomial and non-polynomial conservation laws, both dispersive and dispersionless are constructed. Special attention is paid to the cases $N = 2, 3$ and $N = 4$, for which the conservation laws, Lax type representations and bi-Hamiltonian structures are analyzed in detail. We also show that the case $N = 2$ is equivalent to a generalized Hunter-Saxton dynamical system, whose integrability follows from the results obtained. As a byproduct of our analysis we

demonstrate a new set of non-polynomial conservation laws for the related Hunter-Saxton equation. (Received December 30, 2009)

1060-76-7 **Lennaert van Veen*** (lennaert.vanveen@uoit.ca), 2000 Simcoe Street North, Oshawa, Ontario L1H 7K4, Canada, and **Genta Kawahara** (kawahara@me.es.osaka-u.ac.jp) and **Atsushi Matsumura** (atsushi324@mbox.me.es.osaka-u.ac.jp). *The tangled edge of turbulence in bursting Couette flow.* Preliminary report.

In recent years, the scale of dynamical systems-type computations in turbulence research has increased spectacularly. Equilibrium and periodic solutions have been computed for Couette flow, pipe flow and many other geometries. One of the goals of these computations is to explain the process of turbulent bursting in shear flows. Bursting occurs in the presence of an asymptotically stable laminar flow, so that ordinary bifurcation scenarios do not offer an explanation. Instead, the current focus is on "edge states," i.e. saddle-type equilibria or periodic solutions that live on a boundary between turbulent and laminar behaviour. We should be able to clarify the bursting process if we know the geometry of the (un)stable manifolds of such states. However, the systematic computation of these manifolds is a hard task. We present a recently developed algorithm for the computation of unstable manifolds and its application to turbulent Couette flow. This algorithm uses matrix-free linear solving and comes with a strong convergence result. Initial computations indicate that the (un)stable manifolds of an edge state in turbulent Couette flow form a homoclinic tangle, an observation with far-reaching implications for our understanding of the transition to turbulence. (Received December 31, 2009)

1060-76-20 **John F. Gibson*** (johnfgibson@gmail.com), School of Physics, 837 State St, Georgia Institute of Technology, Atlanta, GA 30332-0430, and **Predrag Cvitanović** (predrag.cvitanovic@physics.gatech.edu), School of Physics, 837 State St, Georgia Institute of Technology, Atlanta, GA 30332-0430. *Invariant solutions and state-space dynamics of low-Reynolds turbulence.*

It has recently become possible to compute precise 3D, nonlinear solutions of Navier-Stokes equations at Reynolds numbers above the onset of turbulence, for simple geometries such as pipes and channels. These solutions capture the form and dynamics of "coherent structures" and provide a starting point for understanding low-Reynolds turbulence as a dynamical system. In this talk I will present a number of equilibrium, traveling wave, and periodic orbit solutions of plane Couette flow, emphasizing visualizations of their physical structure and state-space dynamics, and comparisons to turbulent flow. Certain spatially localized solutions exhibit homoclinic snaking remarkably similar to that observed in simpler 1D PDE systems such as the Swift-Hohenberg equation. What emerges is a picture of low-Reynolds turbulence as a walk among a set of weakly unstable invariant solutions. (Received January 21, 2010)

1060-76-49 **Shawn W Walker*** (walker@cims.nyu.edu), 251 Mercer Street, Warren Weaver Hall, New York, NY 10012-1185, and **Michael J Shelley**. *Shape Optimization of Peristaltic Pumping.*

We present a variational method for optimizing peristaltic pumping in a two dimensional periodic channel with moving walls to pump fluid (peristalsis is common in biology). No a priori assumption is made on the wall motion, except that the shape is static in a moving wave frame. Thus, we pose an infinite dimensional optimization problem and solve it with finite elements. Additional physical effects are also investigated (i.e. elastic walls, variable viscosity). (Received March 10, 2010)

1060-76-137 **David Saintillan*** (dstn@illinois.edu), 1206 West Green Street, 126 Mechanical Engineering Building, Urbana, IL 61801. *Modeling and simulation of biologically active suspensions.*

Biologically active suspensions, of which a bath of swimming bacteria is a paradigmatic example, are fluid systems whose microstructure is motile, and constitute a fundamental example of nonequilibrium pattern-forming systems. In this work, we apply a kinetic theory previously developed by Saintillan and Shelley (*Physics of Fluids*, **20** 123304, 2008) to study the nonlinear dynamics and pattern formation in active suspensions in a variety of situations. We first consider the case of a uniform isotropic suspension, where we show using a linear stability analysis that long-wavelength fluctuations are unstable as a result of hydrodynamic interactions. The long-time dynamics and pattern formation are studied using large-scale three-dimensional numerical simulations, where we report results on the coherent structures that are seen to emerge and their relation to the disturbance flows driven by the particles. Second, we extend this study to investigate the effects of an external shear flow: in this case, it is found using a stability analysis that the external flow is stabilizing at high shear rates, and nonlinear simulations demonstrate the existence of several regimes of instability at low and moderate shear rates. (Received March 28, 2010)

1060-76-175 **Petia M Vlahovska*** (petia.vlahovska@dartmouth.edu), 8000 Cummings Hall, Hanover, NH 03755. *Microhydrodynamics of soft particles.*

The dynamics of deformable particles such as drops and cells in flow or electric fields represents a long standing problem of interest in many branches of science and engineering, for instance because of its relevance to the rheology of emulsions and biological suspensions such as blood. The problem is challenging because the shape of these "soft" particles is not given a priori but is governed by the balance between interfacial forces, e.g. due to stretching and/or bending of the interface, fluid, and electric stresses. In this talk I will present theoretical analyses of the behavior of drops and vesicles (closed lipid bilayer membranes) in various flows. Analytical solutions by perturbation expansions and numerical solutions using Boundary Integral Method will be presented. (Received March 29, 2010)

1060-76-211 **John A Pelesko*** (pelesko@math.udel.edu), University of Delaware, Department of Mathematical Sciences, Newark, DE 19716. *Current Results on the Interaction of Electric Fields with Soap Films.*

G.I. Taylor began the field of electrohydrodynamics with a study of the interaction of electric fields and soap films. In particular, he examined the deflection of circular films in a highly symmetric situation under the application of a D.C. field. This work has found application in the area of microelectromechanical systems (MEMS), which also uses this simple concept as a motive force. This has led to extensive developments in the theory of such deflections. However experimental work now lags behind theory. In this talk, we outline recent efforts to rectify this situation and indicate areas where new mathematical efforts are needed. (Received March 30, 2010)

1060-76-229 **David Salac*** (d-salac@northwestern.edu), 2145 Sheridan Rd, Evanston, IL 60208, and **Michael Miksis**, 2145 Sheridan Rd, Evanston, IL 60208. *Dynamic Behavior of Lipid Vesicles in Viscous Flows.*

The behavior of lipid bilayer vesicles has been of great interest due to their possible use in novel technologies such as drug delivery and as a model system for biological cells such as red blood cells. The dynamic response of these vesicles to an external viscous flow field is governed by the balance of interfacial forces such as bending and stretching and fluid stresses. This results in a rich and complex set of behavior that can not be determined a priori.

Here a model of lipid bilayer motion in viscous flow is presented. The model takes into account the bending rigidity of the interface and enforces the constant surface area constraint by way of a time-varying surface tension. Unlike previous investigations of lipid bilayer vesicles a restriction to Stokes flow is not made. Implementation of this model using the level set method and a multiphase Navier-Stokes solver allows for the response of vesicle systems to be determined for a variety of flow conditions. Results for the dynamic behavior of lipid bilayer vesicles under a number of flow conditions will be presented. The behavior obtained shows excellent agreement with previous experimental and analytical results. (Received March 30, 2010)

1060-76-251 **Scott David Kelly*** (scott@kellyfish.net), Dept of Mechanical Engr and Engr Science, University of North Carolina at Charlotte, 9201 University City Boulevard, Charlotte, NC 28223-0001. *Wake Structure and Energy Efficiency in Idealized Fishlike Locomotion.*

The planar mechanical system comprising a free Joukowski foil interacting with a collection of point vortices in a perfect fluid admits a Hamiltonian structure. Augmenting this system with a mechanism whereby vorticity can be shed from the trailing edge of the foil in a momentum-conserving way, we realize an idealized model for fishlike swimming. We use this model to explore two related issues pertaining to energy-efficient locomotion: (1) the characterization of efficient gaits for an isolated swimmer in terms of wake geometry and (2) the passive or controlled harvesting of propulsive energy by such a swimmer from the wakes of nearby swimmers. (Received March 30, 2010)

78 ► Optics, electromagnetic theory

1060-78-199 **Edward D. Farnum*** (efarnum@kean.edu), Kean University, NJCSTM, Room T-117F, Union, NJ 07083, and **J. Nathan Kutz**. *A Master Mode-locking Equation for Ultra-short Laser Pulses.*

We propose a new model for pulse formation and propagation in a mode-locked laser cavity, which is valid in the few-femtosecond regime. The standard model for a mode-locked laser is based on a dissipative perturbation to the Nonlinear Schrodinger Equation, to allow nonlinear gain and loss terms. However, the slow envelope approximation of the NLS breaks down for very short time scales, making an NLS-based model suspect. Instead,

we perturb the Short Pulse Equation, with dissipative gain and loss terms. This model is valid beyond breakdown of NLS-based models, and successfully produces stable ultra-short pulses from initial white-noise. This provides an initial theoretical framework for quantifying dynamics and stability as pulses approach the attosecond regime. (Received March 30, 2010)

81 ► Quantum theory

1060-81-11 **Craig Jackson*** (chjackso@owu.edu), 90 S. Henry St, Delaware, OH 43015, and **Thomas Kerler**. *The Lawrence-Krammer-Bigelow Representations of the Braid Groups via Quantum* $\mathfrak{sl}_2$.

We construct representations of the braid groups B_n on n strands on free $\mathbb{Z}[q^{\pm 1}, s^{\pm 1}]$-modules $W_{n,l}$ using generic Verma modules for an integral version of the quantum enveloping algebra $U_q(\mathfrak{sl}_2)$. We prove that the $W_{n,2}$ are isomorphic to the faithful Lawrence-Krammer-Bigelow representations of B_n after appropriate identification of parameters of Laurent polynomial rings by constructing explicit integral bases and isomorphism. We also prove that the B_n-representations $W_{n,l}$ are irreducible over the fractional field $\mathbb{Q}(q, s)$. (Received January 04, 2010)

82 ► Statistical mechanics, structure of matter

1060-82-13 **Corey S OHern*** (corey.ohern@yale.edu), Department of Mechanical Engineering, P. O. Box 208286, New Haven, CT 06520-8268. *What Do We Know about Static Packings: From Hard Spheres to Ellipsoidal Particles and from Collapsed Polymers to Folded Proteins?*

I will survey my recent computational and theoretical studies of particle packings with different particle shapes and interactions, dimensionality, boundary conditions, and constraints. In particular, I will highlight four interesting results: 1. The probability with which particular packings occur is highly nonuniform, 2. Continuous geometrical parameterizations of states are necessary to characterize frictional packings and those over a range of boundary conditions, 3. Static packings of ellipsoidal particles have very different structural and mechanical properties compared to packings of spherical particles, and 4. Structural properties of model collapsed polymers are highly sensitive to the preparation history. (Received January 11, 2010)

83 ► Relativity and gravitational theory

1060-83-141 **Dan A Lee*** (dlee2@qc.cuny.edu), 237 Kiely Hall, 65-30 Kissena Blvd, Flushing, NY 11367. *Static uniqueness and the Penrose inequality.* Preliminary report.

We consider the problem of classifying static spacetimes with black hole boundaries. We prove an unusual case of the Penrose inequality which implies a static uniqueness theorem in the negative curvature setting. This is a report on joint work-in-progress with A. Neves. (Received March 28, 2010)

91 ► Game theory, economics, social and behavioral sciences

1060-91-23 **Suneal K. Chaudhary*** (schaudha@monmouth.edu), Mathematics Department, 400 Cedar Av, West Long Branch, NJ 07764. *A Boom Model: Trader Herding and Autocorrelation from Communication.*

In this paper we study noise traders that communicate and trade with each other in a market. We begin by computing a statistic which identifies a boom, and use it on the NASDAQ-100 dot-com "bubble." We next generalize the classical geometric Brownian motion stock model accordingly. We represent individual traders that observe each others' past n daily returns using a nonlinear vector autoregressive NLVAR(n) process. We model traders endogenously creating a market price. We measure autocorrelation and herding as functions of traders' communication level (α) and number of past daily returns (n) that the traders rely on. We find that autocorrelation and herding increase with communication level α, and they decrease with n. Under this model, we can specify α and n leading to traders forming spontaneous herds without specific leaders and thus to price booms. Finally we see that our model replicates the statistical property we examined of the NASDAQ-100 boom. (Received January 25, 2010)

1060-91-48 **Kasper Larsen***, Dept of math sciences, 5000 Forbers Ave, Pittsburgh, PA 15213, and **Hang Yu**. *Horizon dependency of utility optimizers in incomplete models.*

This paper studies the utility maximization problem with changing time horizons in the incomplete Brownian setting. We show that the dual and primal value functions as well as the optimal terminal wealth are left-continuous with respective to the time horizon $T > 0$. We exemplify that the expected utility stemming from applying the T-horizon optimizer on a shorter time horizon S with $S < T$ may not converge as $S \uparrow T$ to the T-horizon value. In other words, exiting an optimal strategy before maturity can have severe costs for the investor. Finally, we provide necessary and sufficient conditions preventing the existence of this phenomenon. (Received March 09, 2010)

1060-91-163 **Peter Friz**, **Stefan Gerhold**, **Archil Gulisashvili** and **Stephan Sturm*** (ssturm@princeton.edu), 116 Sherrerd Hall, Princeton University, Princeton, NJ 08544. *On refined volatility smile expansion in the Heston model.*

It is known that Heston's stochastic volatility model exhibits moment explosion, and that the critical moment s^* can be obtained by solving (numerically) a simple equation. This yields a leading order expansion for the implied volatility at large strikes: $\sigma_{BS}(k,T)^2 T \sim \Psi(s^* - 1) \times k$ (Roger Lee's moment formula). Motivated by recent "tail-wing" refinements of this moment formula, we first derive a novel tail expansion for the Heston density, and then show the validity of a refined expansion of the type $\sigma_{BS}(k,T)^2 T = (\beta_1 k^{1/2} + \beta_2 + \dots)^2$, where all constants are explicitly known as functions of s^*, the Heston model parameters, spot vol and maturity T. In the case of the "zero-correlation" Heston model such an expansion was derived by Gulisashvili and Stein. Our methods and results may prove useful beyond the Heston model: the entire quantitative analysis is based on affine principles; at no point do we need knowledge of the closed form expression of the Fourier transform of $\log S_T$.Secondly, our analysis reveals a new parameter ("*critical slope*"), defined in a model free manner, which drives the second and higher order terms in tail- and implied volatility expansions. (Received March 29, 2010)

92 ► Biology and other natural sciences

1060-92-103 **Qiang Du*** (qdu@math.psu.edu). *Phase field modeling and simulations of vesicle membranes.*

We discuss diffuse interface (phase field) models of both single-component and multi-component vesicle membranes. We also consider models for the interactions of vesicles with an adhesive substrate, and those with a background fluid as well as those involving fluctuation effects. We present the mathematical derivations and compare results of numerical simulations with experimental findings. (Received March 24, 2010)

1060-92-112 **Horacio G. Rotstein*** (horacio@njit.edu), Department of Mathematical Sciences, New Jersey Institute of Technology, University Heights, Newark, NJ 07102, and **Tilman Kispersky** (tilman@bu.edu) and **John A. White**. *Canard dynamic structures and their roles in generating abrupt transitions between firing frequency regimes in neural models: The stellate cell case.*

Recent experimental studies have shown that SCs become hyper-excitable in animal models of temporal lobe epilepsy. These studies have also demonstrated the existence of recurrent connections among SCs (excitatory),reduced levels of recurrent inhibition in epileptic networks as compared to control ones, and comparable levels of recurrent excitation among SCs in both network types. In this work, we show that minimal, recurrently connected networks of SCs and interneurons (inhibitory cells) exhibit an abrupt, threshold-like transition between the theta (4- 10 Hz) and hyper-excitable spiking (about 60 Hz) frequency regimes as the result of small increases in the amount of recurrent excitation. These abrupt transitions are observed in the absence of inhibition and in single, self-coupled SCs, which represent a network of coupled synchronous SCs, but not in synaptically isolated SCs. Experimental results confirm our theoretical predictions. We use dynamical systems tools to explain how synaptic excitation interacts with the nonlinearities and time-scale separation present in the SC model to generate these abrupt transitions between firing frequency regimes. (Received March 25, 2010)

1060-92-204 **Benjamin B Machta*** (ben.machta@gmail.com), **Stefanos Papanikolaou**, **James P Sethna** and **Sarah L Veatch**. *Implications of Ising Criticality in Live Cell Membranes.* Preliminary report.

Recent work demonstrates that plasma membrane vesicles that are isolated from the cortical cytoskeleton contain two liquid phases at low temperatures and exhibit critical behavior that is strongly manifest near their transition temperature. Here we present a minimal model of plasma membrane heterogeneity that combines criticality

with connectivity to cortical cytoskeleton. We incorporate criticality using a conserved order parameter Ising model coupled to a simple actin cytoskeleton interacting through point-like pinning sites. Using this model, we recapitulate several experimental observations of membrane raft heterogeneity. Small (r 20nm) and dynamic fluctuations at physiological temperatures arise from criticality. Including connectivity to cortical actin disrupts large fluctuations and macroscopic phase separation at low temperatures (T<23C) and provides a template for long lived fluctuations at physiological temperature (T=37C). In addition we consider more abstractly the benefit cells derive by tuning near to criticality. We use conformal field theory to bound the entropic forces between membrane components and information theory to quantify bandwidth of critical fluctuations for inter-protein communication. (Received March 30, 2010)

1060-92-231 **Benjamin R Capraro***, Department of Chemistry, University of Pennsylvania, 231 S 34th St, Philadelphia, PA 19104, and **Aiwei Tian**, **Michael C Heinrich** and **Tobias Baumgart**. *Coupling of membrane shape and local protein and lipid composition and its relevance to intracellular trafficking.*

The sorting of lipids and proteins in cellular membrane sorting centers, such as the trans-Golgi network and the endocytic recycling compartment, lies at the heart of fundamental biological phenomena such as organelle homeostasis and membrane signaling. We study biophysical contributions to the sorting of membrane components, using experimental lipid model membranes, and analytical thermodynamic and membrane elasticity theory. We will present measurements of thermodynamically reversible membrane curvature sensing for peripherally binding membrane proteins, e.g., showing cholera toxin subunit B to partition away from regions of high positive membrane curvature, and the Epsin N-terminal homology domain to enrich in such regions. While we find that ideally diluted lipids are not significantly sorted in curvature gradients, consistent with theory and simulation, in ternary mixture lipid vesicles, lipid sorting is observed to be amplified by cooperative interactions. Two regimes of amplified curvature demixing are distinguished: the weak segregation limit in compositions near a demixing phase boundary, and the strong segregation limit, deep in the coexistence region. We will describe both regimes by means of thermodynamic models and also discuss dynamic aspects of curvature sorting. (Received March 30, 2010)

1060-92-239 **Daniel Martí***, 4 Washington Pl, New York, NY 10003, and **Heather Dean**, **John Rinzel** and **Bijan Pesaran**. *A model of two interacting accumulators for reach and saccade reaction time behavior.* Preliminary report.

During coordinated eye-hand movements, saccade and reach reaction times (RTs) are correlated. We have explored the relationship between RTs and coordination in a dual RT task with monkeys where the responses made with eye and hand movements were separated by a random interval (stimulus onset asynchrony, SOA). The study shows that correlations of saccade and reach RT are high and positive at short SOAs, and drop quickly as the SOA increases to a few hundred milliseconds. Also, mean saccade RT decrease for short SOAs, suggesting a facilitation of saccades by reaches when they are cued nearly simultaneously. We propose a phenomenological model of RT based on two mutually coupled accumulators, each of which is associated with a particular movement. Each accumulator triggers a response when it hits a prescribed threshold and is ultimately thought to be encoded in the firing activity of a neuronal population involved in the planning of the associated movement. We consider several biologically plausible mechanisms of interaction between neuronal populations and analyze their behavioral outcomes. The analysis shows that a model with mutual excitation and asymmetric coupling accounts best for the dependencies on SOA of the low-order moments of the RT distributions. (Received March 30, 2010)

1060-92-249 **Nadarajah Kirupaharan*** (nkirupaharan@bmcc.cuny.edu), 199 Chambers Street, Room N-520, New York, NY 10007, and **Channa Navaratna** (channa@iup.edu), 210 South 10th Street, Indiana, PA 15705. *Compartmental SIS/SIR models with Multiple Strains.*

Compartmental models of types Susceptible-Infected- Susceptible (SIR) and Susceptible -Infected- Recovered (SIR) will be analyzed for the dynamics of disease spread among multiple colonies. The dynamics of multiple strains have been treated for single patch and two patches are investigated. Numerical simulations have been carried out to study the effects of recurrence of a disease between two patches. Analytical results have been compared with the numerical results that complement the characteristics of the existence of multiple strains. (Received March 30, 2010)

94 ► Information and communication, circuits

1060-94-16 **Yasuaki Hiraoka*** (hiraok@hiroshima-u.ac.jp), 33rd & Walnut street, DRL, Philadelphia, PA. *Rational Maps and Maximum Likelihood Decoding: Duality in Algebraic Geometry Codes.*

A new approach to coding theory via dynamical systems is presented in this talk. A key idea is to deal with a bit-wise maximum likelihood decoding as a rational map. The main theorem shows that this rational map can be approximated with low computational complexity and high accuracy by controlling the minimum distance of its dual code. One of the contribution of this result is to give a new application of algebraic geometry codes, which enables us to design a good code in both the senses of long minimum distance and low computational complexity for decodings. A simple example to this direction is shown by studying the Hermitian curve for a code design. (Received January 15, 2010)

1060-94-109 **Vladimir Shpilrain*** (shpil@groups.sci.ccny.cuny.edu). *Fuzzy authentication.* Preliminary report.

I am going to discuss private-key authentication with "noise" that is supposed to make it more difficult (or even impossible) for the adversary to recover the secret key. (Received March 25, 2010)

05 ► Combinatorics

1061-05-53 **César Hernández Cruz*** (cesar@matem.unam.mx), Segovia #94, Col. Alamos, 03400 México, Mexico, and **Hortensia Galeana Sánchez**. *k-kernels in k-transitive and k-quasi-transitive digraphs.*

Let D be a digraph with set of vertices V and set of arcs A.

A (k,l)-kernel N of D is a k-independent (if $u,v \in N$ then $d(u,v), d(v,u) \geq k$) and l-absorbent (if $u \in V(D) - N$ then there exists $v \in N$ such that $d(u,v) \leq l$) set of vertices. A k-kernel is a $(k, k-1)$-kernel. A digraph D is transitive if $(u,v),(v,w) \in A$ implies that $(u,w) \in A$. A digraph D is quasi-transitive if $(u,v),(v,w) \in A$ implies (u,w) or $(w,u) \in A$. It has been proved that every transitive digraph has a k-kernel for every $k \geq 2$ and that every quasi-transitive digraph has a k-kernel for every $k \geq 3$.

A digraph D is k-transitive if whenever $(x_0, \ldots, x_k)$ is a directed path in D, then $(x_0, x_k) \in A$; k-quasi-transitive digraphs are analogously defined, so (quasi-)transitive digraphs are 2-(quasi-)transitive digraphs. We prove structural results that imply that a k-transitive digraph has an n-kernel for every $n \geq k$; that for even $k \geq 2$, every k-quasi-transitive digraph has a n-kernel for every $n \geq k+2$; and that every 3-quasi-transitive digraph has k-kernel for every $k \geq 4$. Also, we prove that a k-quasi-transitive digraph has a $(k+1)$-king if and only if it has an unique initial strong component. (Received March 26, 2010)

1061-05-67 **Hortensia Galeana-Sánchez*** (hgaleana@matem.unam.mx), Área de la Investigación Científica, Circuito Exterior, Ciudad Universitaria, 04510 México D.F, Mexico, and **Martín Manrique**, Área de la Investigación Científica, Circuito Exterior, Ciudad Universitaria, 04510 México D.F, Mexico. *The Level Hypergraph.* Preliminary report.

In this talk, I introduce the concept of Level Hypergraph. I show several properties of the Level Hypergraph which allow us to obtain important generalizations on classical results in Hypergraph Theory. (Received April 02, 2010)

1061-05-72 **Andrew Vince*** (avince@ufl.edu), University of Florida, Department of Mathematics, 358 Little Hall, PO Box 118105, Gainesville, FL 32611-8105, **Meera Sitharam** (sitharam@cise.ufl.edu), University of Florida, CISE, Gainesville, FL 32611, and **Miklos Bona** (bona@ufl.edu), University of Florida, Department of Mathematics, Gainesville, FL 32611. *Enumerating Tree Orbits - Application to Viral Capsid Assembly.*

Combinatorial methods (permutations, trees, Mobius inversion, generating functions) are used to answer a question about the assembly of icosahedral viral shells. Although the geometric structure of the capsid (shell) is fairly well understood in terms of its constituent subunits (monomers), the assembly process is not. The capsid is modeled by a polyhedron that is a subdivision of the icosahedron and whose facets represent the monomers. The assembly process is modeled by a rooted tree, the leaves representing the facets of the polyhedron, the root representing the assembled polyhedron, and the internal vertices representing intermediate stages of assembly (subsets of facets). To help clarify the effect of symmetry on the probability of the occurrence of a given assembly process a purely combinatorial problem concerning the enumeration of trees is solved. (Received April 04, 2010)

1061-05-113 **M. Gabriela Araujo-Pardo*** (garaujo@math.unam.mx), Instituto de Matemáticas, Circuito Exterior s/n, Ciudad Universitaria, 04510 México D.F., Mexico, and **Camino Balbuena**, **Luis Montejano** and **Juan Carlos Valenzuela**. *Partial linear spaces and identifying codes.*

Let $(\mathcal{P}, \mathcal{L}, I)$ be a partial linear space and $X \subseteq \mathcal{P} \cup \mathcal{L}$. Let us denote by $(X)_I = \bigcup_{x \in X} \{y : yIx\}$ and by $[X] = (X)_I \cup X$.

With this terminology a *partial linear space* $(\mathcal{P}, \mathcal{L}, I)$ *is said to admit a* $(1, \leq k)$*-identifying code* if and only if the sets $[X]$ are mutually different for all $X \subseteq \mathcal{P} \cup \mathcal{L}$ with $|X| \leq k$.

In this talk, we give a characterization of k-regular partial linear spaces admitting a $(1, \leq k)$-identifying code. Equivalently, we give a characterization of k-regular bipartite graphs of girth at least six admitting a $(1, \leq k)$-identifying code. That is, k-regular bipartite graphs of girth at least six admitting a set C of vertices such that the sets $N[x] \cap C$ are nonempty and pairwise distinct for all vertex $x \in X$ where X is a subset of vertices of $|X| \leq k$. Moreover, we present a family of k-regular partial linear spaces on $2(k-1)^2 + k$ points and $2(k-1)^2 + k$

lines whose incidence graphs do not admit a $(1, \leq k)$-identifying code. Finally, we show that the smallest $(k; 6)$-graphs known up to now for $k - 1$ not a prime power admit a $(1, \leq k)$-identifying code. (Received April 09, 2010)

1061-05-118 **Jesus A. De Loera*** (deloera@math.ucdavis.edu), Dept of Mathematics, University of California, Davis, CA 95616. *Algebraic-Geometric Methods in Algorithmic Graph Theory.*

Many hard combinatorial problems can be modeled by a system of polynomial equations. Noga Alon coined the term *polynomial method* to describe the use of nonlinear polynomials when solving combinatorial problems. We report on recent progress on the polynomial method and show how the algorithmic theory of polynomial ideals can be used to detect k-colorability, unique Hamiltonicity, and automorphism rigidity of graphs. In some particular cases offering polynomial complexity bounds.

Our techniques involve Nullstellensatz certificates,, Gröbner bases, toric geometry, and real algebraic geometry, but interestingly computations reduce to fast linear algebra over finite fields and convex programming which are known to perform well.

This reports on results joint work with various subsets of the following people. Chris Hillar (MSRI), Jon Lee (IBM), Peter Malkin (UC Davis), Susan Margulies (Rice), Pablo Parrilo (MIT) and Mohamed Omar (UC Davis). (Received April 10, 2010)

1061-05-128 **Federico Ardila*** (federico@math.sfsu.edu), Department of Mathematics, San Francisco State University, 1600 Holloway Ave., San Francisco, CA 94132. *The combinatorics of CAT(0) cubical complexes.* Preliminary report.

A CAT(0) cube complex is a connected, non-positively curved space which is built by gluing cubes along their faces. These complexes play an important role in geometric group theory and in numerous applications in biology and robotics, among others. Gromov showed the remarkable fact that CAT(0) cube complexes can be characterized by their local combinatorial structure at each vertex. Sageev later gave a global version of this result, and we propose another one: a correspondence between CAT(0) cube complexes and certain combinatorial objects which we call "posets with incompatible pairs". The talk will explain this correspondence and discuss some applications. (Received April 12, 2010)

1061-05-151 **Goran Konjevod*** (goran@asu.edu). *Some combinatorial and algorithmic results on origami.*

We review some recent combinatorial and algorithmic results on origami. One of these is a new construction for folding an n by n checkerboard from an uncut square or rectangular sheet. The two sides of the sheet have different colors and this is used to create a grid of squares alternating in color. The construction is asymptotically the best known and, in particular, beats a long-conjectured lower bound.

Results presented include joint work with Erik and Martin Demaine and Robert Lang. (Received April 12, 2010)

1061-05-156 **Maria Axenovich** and **Joan P. Hutchinson*** (hutchinson@macalester.edu), Macalester College, 1600 Grand Ave., Saint Paul, MN 55105, and **Michelle Lastrina**. *Precoloring extension to 5-list-coloring of planar graphs.* Preliminary report.

M. O. Albertson asked whether, given a planar graph, there is a distance d such that if a set of vertices, pairwise at distance at least d, is precolored arbitrarily and all other vertices have a 5-list, then the precoloring extends to a list-coloring of the rest of the graph. Zs. Tuza and M. Voigt showed that d must be at least 5. We answer Albertson's question in the affirmative in a variety of cases, including the case when the graph contains a "wide" Steiner tree containing all precolored vertices and contains no 3- or 4-cycle separating precolored vertices. (Received April 12, 2010)

1061-05-158 **Diane L. Souvaine*** (dls@cs.tufts.edu), Tufts University, Department of Computer Science, 161 College Avenue, Medford, MA 02155. *Combinatorial Bounds for Geometric Connectivity Augmentation.*

The k-connectivity augmentation problem asks for the minimum number of edges needed to augment a graph to make it k-connected; k-edge-connectivity augmentation is defined analogously. In abstract graphs, the connectivity augmentation problem can be solved in linear time for $k = 2$, and in polynomial time for any fixed k. For a given planar straight-line graph, computing the minimum augmentation using noncrossing straight-line edges is NP-Hard for any $2 \leq k \leq 5$.

We focus on combinatorial bounds for geometric connectivity augmentation. First, we prove that if a geometric graph on n vertices in general position is 3-edge augmentable, then $2n-2$ new edges are sometimes necessary and always sufficient. Next, as a step towards finding tight bounds for 3-vertex-connectivity augmentation, we

prove combinatorial bounds on the minimum number of edges that are always sufficient and sometimes necessary to produce three vertex-disjoint paths from each of k interior-disjoint convex polygons to the vertices of a triangular container.

This talk reports on joint work conducted at Tufts University with various subsets of Marwan Al-Jubeh, Gill Barequet, Mashhood Ishaque, Kristóf Rédei, Csaba D. Tóth, and Andrew Winslow. (Received April 12, 2010)

1061-05-162 **Francisco Larrión** and **Miguel Pizaña*** (map@xanum.uam.mx), Moras 821 depto 201, Col Acacias, Del Benito Juárez., 03240 Mexico City, D.F., Mexico, and **Rafael Villarroel-Flores**. *On the Clique Behavior of Compact Surfaces.* Preliminary report.

A *clique* of a graph is a maximal complete subgraph. The clique graph $K(G)$ is the intersection graph of all the cliques of G. Iterated clique graphs are defined by $K^0(G) = G$ and $K^{n+1}(G) = K(K^n(G))$. We say that a graph is *clique-divergent* if the sequence of orders of its iterated clique graphs is unbounded, otherwise it is *clique-convergent*. Iterated clique graphs have been used in Loop Quantum Gravity (LQG) to explain the quantum space-time as an emergent property of the underlying discrete reality at the Planck scale and to tackle certain renormalization problems in LQG.

A *Whitney triangulation* of a topological space X is a graph G such that the geometric realization of its clique complex (simplexes = complete subgraphs) is homemorphic to X. We have then:

Theorem Almost every compact surface admits a clique-divergent Whitney triangulation; The only possible exception is the disk.

Theorem Almost every compact surface admits a clique-convergent Whitney triangulation; The only possible exceptions are: The sphere, the projective plane, the torus and the Klein bottle.

It is conjectured that all five unresolved cases are indeed exceptions. (Received April 12, 2010)

1061-05-184 **Juan Jose Montellano-Ballesteros*** (juancho@matem.unam.mx), **Hortensia Galeana-Sanchez** and **Ricardo Gomez Aiza**. *Transversals of longest paths in digraphs.*

In this talk we present some results concerning the Laborde-Payan-Xuang conjecture stating that in every digraph there exists an independent set of vertices intersecting every longest path. (Received April 13, 2010)

1061-05-200 **Isidoro Gitler*** (igitler@math.cinvestav.edu.mx), Avenida Instituto Politecnico Nacional # 2508, 07360 Mexico City, D.F., Mexico, and **Enrique Reyes**, CINVESTAV-IPN, Department of Mathematics, Apartado Postal 14-740, 0700 Mexico, D. F. Mexico. *Complete Intersection Toric Ideals of Oriented Graphs and Generalized Theta-Graphs.*

Let $G = (V, E)$ be a graph, for every orientation D of G, we associate the toric ideal P_D. In this paper we classify the graphs, with the property that P_D is a complete intersection, for every D orientation of G. We also introduce and study a family of simple graphs that we call ring graphs, some characterizations of this family are shown. A Let $G = (V, E)$ be a graph, for every orientation D of G, we associate the toric ideal P_D. In this paper we classify the graphs, with the property that P_D is a complete intersection, for every D orientation of G. We also introduce and study a family of simple graphs that we call ring graphs, some characterizations of this family are shown. A graph G has the *primitive cycle property* (PCP) if any two primitive cycles intersect in at most one edge. The following implications hold for any graph G: outerplanar $\Rightarrow$ ring graph $\Leftrightarrow$ PCP + contains no subdivision of $K_4 \Rightarrow$ planar.

If G is bipartite, then ring graph $\Leftrightarrow$ complete intersection $\Leftrightarrow$ PCP + planar. The toric ideal of the edge subring of a digraph will also be examined. This ideal is related to the acyclic orientations of digraphs. (Received April 14, 2010)

1061-05-206 **Ruy Fabila-Monroy*** (ruyfabila@math.cinvestav.edu.mx), Av. Instituto Politécnico Nacional 2508, Col San Pedro Zacatenco, 14740 Mexico D.F., Mexico, and **David Flores-Peñaloza**, **Clemens Huemer**, **Ferran Hurtado**, **Jorge Urruta** and **David Wood**. *Token Graphs.*

For a graph G and integer $k \leq 1$, we define the token graph $F_k(G)$ to be the graph with vertex set all k-subsets of $V(G)$, where two vertices are adjacent in $F_k(G)$ whenever their symmetric difference is a pair of adjacent vertices in G.

Token graphs have a nice intuitive interpretation by considering k indistinguishable tokens placed on the vertices of G (at most one token per vertex); constructing then a graph whose vertex set are all the possible token configurations and where two configurations are adjacent if one can be reached from the other by sliding a token along an edge from its current position to an unoccupied vertex.

In this talk we will introduce the token graphs proving various of its properties in terms of the same properties of the original graph. (Received April 14, 2010)

13 ► Commutative rings and algebras

1061-13-45 **Steven V Sam*** (ssam@math.mit.edu) and **Jerzy Weyman**. *Pieri resolutions for classical groups.*

The first construction of pure free resolutions in characteristic 0 was given by Eisenbud, Fløystad, and Weyman using the representation theory of the general linear group. These are the resolutions of a special case of what we call Pieri maps, and we generalize their construction to all Pieri maps. These Pieri resolutions have explicit combinatorial descriptions in terms of Young diagrams. I will give some background related to Boij–Söderberg cones which motivated the original construction and explain the explicit description of the Pieri resolutions. Time permitting, I will also discuss a conjectural equivariant analogue of Boij–Söderberg cones and some partial results. (Received March 21, 2010)

1061-13-96 **Luis C. Nuñez-Betancourt*** (luisnub@umich.edu), 3068 East Hall, 530 Church St., Ann Arbor, MI 48104-1043. *On the hyperhomology of the small Gobelin for codimension 2.* Preliminary report.

The Gobelin and the small Gobelin are quasi-isomorphic complexes constructed from a commutative square of matrices over a ring. Using the small gobelin we exhibit patterns between its homology groups. This is joint work with Xavier Gomez-Mont. (Received April 08, 2010)

1061-13-102 **M Gonzalez** and **C Renteria*** (renteri@esfm.ipn.mx), Escuela Superior de Fisica y Matematicas, Edif. 9, UPALM, 07734 Mexico City, Mexico, and **E Sarmiento**, **A Simis** and **R H Villarreal**. *Evaluation Codes of Parameterized Sets.* Preliminary report.

Let $K = \mathbb{F}_q$ be a finite field with q elements and let X be a subset of the projective space $\mathbb{P}^{s-1}$, over the field K, which is parameterized by monomials. We study the evaluation code $C_X(d)$ associated to X. We compute the dimension and the length of $C_X(d)$ using the standard K-algebra $S/I(X)$, where $S = K[t_1, \ldots, t_s]$ is a polynomial ring and $I(X)$ is the vanishing ideal of X. In some cases, we also compute the minimum distance. (Received April 09, 2010)

1061-13-123 **Sonja Mapes*** (smapes@math.duke.edu), Mathematics Department, 117 Physics Bldg, Box 90320, Durham, NC 27708. *LCM lattices and resolutions of monomial ideals.*

It is known that monomial ideals which have equivalent LCM lattices also have equivalent minimal free resolutions. It has also been shown that any finite atomic lattice L is an LCM lattice of a monomial ideal. The purpose of this talk is to discuss how to use this coordinate free approach to study the structure of minimal resolutions of monomial ideals. In particular, I will focus on how the parameter space of all such lattices is of use. (Received April 10, 2010)

1061-13-126 **Federico Ardila*** (federico@math.sfsu.edu), Department of Mathematics, San Francisco State University, 1600 Holloway Ave., San Francisco, CA 94110, and **Alexander Postnikov**, Department of Mathematics, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139. *Power ideals of hyperplane arrangements.*

We investigate ideals in a polynomial ring which are generated by powers of linear forms. We pay special attention to a family of power ideals that arises naturally from a hyperplane arrangement A. We prove that their Hilbert series are determined by the combinatorics of A. We also compute the Hilbert series of the resulting fat point ideals and zonotopal Cox rings. Our work unifies and generalizes results on power ideals obtained by Dahmen-Micchelli, de Boor-Ron, Holtz-Ron, Postnikov-Shapiro-Shapiro, and Sturmfels-Xu, among others. It also settles a conjecture of Holtz-Ron on the spline interpolation of functions on the lattice points of a zonotope. This is joint work with Alex Postnikov from MIT. (Received April 10, 2010)

1061-13-149 **José Martínez-Bernal*** (jmb@math.cinvestav.mx), **Edwin O'Shea** and **Rafael H. Villarreal**. *Ehrhart Clutters.*

We show that clutters that are both ideal and clique clutters of Meyniel graphs satisfy the max-flow min-cut property. We prove this combinatorial optimization result by studying Ehrhart rings of clutters and by showing that clique clutters of Meyniel graphs are Ehrhart; a property related to Hilbert basis. (Received April 12, 2010)

1061-13-152 **Ezra Miller*** (ezra@math.duke.edu), **Isabella Novik** and **Ed Swartz**. *Face rings of simplicial complexes with singularities.*

The face ring of a simplicial complex modulo m generic linear forms is shown to have finite local cohomology if and only if the link of every face of dimension m or more is *nonsingular*, i.e., has the homology of a wedge of spheres of the expected dimension. This is derived from an enumerative result for local cohomology of face rings modulo generic linear forms, as compared with local cohomology of the face ring itself. The enumerative result is generalized to squarefree modules. A concept of *Cohen–Macaulay in codimension c* is defined and characterized for arbitrary finitely generated modules and coherent sheaves. For the face ring of an r-dimensional complex Δ, it is equivalent to nonsingularity of Δ in dimension $r-c$; for a coherent sheaf on projective space, this condition is shown to be equivalent to the same condition on any single generic hyperplane section. The characterization of nonsingularity in dimension m via finite local cohomology thus generalizes from face rings to arbitrary graded modules. (Received April 12, 2010)

1061-13-153 **Lars Winther Christensen**, **David Jorgenson**, **Hamid Rahmati** and **Janet Striuli*** (jstriuli@fairfield.edu), North Benson rd, Fairfield, CT 06824, and **Roger Wiegand**. *Constructing infinite families of totally reflexive modules.* Preliminary report.

Let (R, m) be a local Noetherian ring which is not Gorenstein and such that it admits a non-free totally reflexive module. A theorem due to Christensen, Piepmeyer, Striuli and Takahashi guarantees the existence on an infinite family of non-isomorphic totally reflexive modules. In this talk we will present some constructions for such family under different assumptions. Particular attention will be given to the case where R admits a pair of exact divisors. (Received April 12, 2010)

1061-13-163 **Enrique Reyes*** (ereyes@math.cinvestav.mx), **Christos Tatakis** and **Apostolos Thoma**. *Generators of toric ideals of graphs.*

Let $G = (V, E)$ be a graph, where $V = \{x_1, \ldots, x_n\}$ and $E = \{y_1, \ldots, y_m\}$ are the vertex set and the edge set respectively. The toric ideal P_G associated to G is the kernel of the graded homomorphism of k-algebras

$$\phi\colon k[y_1, \ldots, y_m] \to k[x_1, \ldots, x_n],$$

induced by, $\phi(y_i) = x_k x_j$, where $y_i = \{x_k, x_j\}$.

We present a characterization of the primitive, the minimal, the indispensable and the fundamental binomials of the toric ideal P_G. (Received April 12, 2010)

1061-13-170 **Joseph Gubeladze*** (soso@math.sfsu.edu), Department of Mathematics, San Francisco State University, San Francisco, CA 94132. *Commutative algebra of lattice polytopes with long edges.*

By homogenization, a lattice polytope $P \subset \mathbb{R}^n$ gives rise to an affine submonoid $M(P) \subset \mathbb{Z}^{n+1}$. For a field k, the monoid ring $k[M(P)]$ is graded in a natural way. The homological properties of $k[M(P)]$, captured by the minimal graded free resolution of k over $k[M(P)]$, have been studied a lot in combinatorial commutative algebra. For instance, if one scales P by a factor $c \in \mathbb{N}$ with $c \geq \dim P$, the resulting ring $k[M(cP)]$ becomes Koszul. When, instead of homothetically blowing up the ground polytope, one considers lattice polytopes whose edges contain sufficiently many lattice points, depending on $\dim P$, similar results turn out to be surprisingly difficult to prove. Even the 0th homological slice of the Koszul property, the normality property, had been an open question for some time. It was answered in the positive only recently. In the talk I will also explain why one may expect that the analogous claim on the next homological level is true as well – that the toric ring $k[M(P)]$ is defined quadratics, assuming P has 'long' edges with respect to $\dim P$. This leads to an obvious general conjecture whose proof, unfortunately, seems well beyond the currently available technics. (Received April 12, 2010)

1061-13-176 **Sang Bum Lee*** (sblee@smu.ac.kr), Dept. of Mathematics, Sangmyung University, Seoul, 110-743, South Korea. *Weak-injectivity over commutative rings.* Preliminary report.

Weak-injective modules over integral domains were defined by Lee and were studied in many papers by several authors. We now consider them over arbitrary commutative rings. It turns out that they retain some of their features even if the underlying rings admit zero-divisors, but several useful properties are lost. (Received April 13, 2010)

1061-13-181 **Emily E Witt*** (emwitt@umich.edu), University of Michigan, Department of Mathematics, 530 Church St, Ann Arbor, MI 48109. *Local cohomology with support in ideals of maximal minors.*

Suppose k is a field, and $k[X]$ 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 April 13, 2010)

1061-13-182 **Liana Sega*** (segal@umkc.edu). *Self-tests for finite projective dimension over artinian rings.*

Let R is a commutative noetherian ring. The commutative version of the Auslander-Reiten conjecture states: For every finitely generated R-module M, if $\mathrm{Ext}^i_R(M, M \oplus R) = 0$ for all $i > 0$, then M has finite projective dimension. Counterexamples to a related conjecture of Auslander, which implies the Auslander-Reiten conjecture, are known, yet they fail to disprove the later. In this talk we will shed more light on this "failure" and show that certain classes of artinian rings satisfy the Auslander-Reiten conjecture. We also give evidence for a test for finite projective dimension involving vanishing of $\mathrm{Tor}^R_i(M, M)$. (Received April 13, 2010)

1061-13-188 **Christine Berkesch*** (cberkesc@math.purdue.edu), Purdue University, Department of Mathematics, 150 North University Street, West Lafayette, IN 47907, and **Daniel Erman** and **Manoj Kummini**. *The poset structures of Boij–Soederberg theory.*

The proof of the Boij–Soederberg conjectures by Eisenbud and Schreyer provides powerful structure theorems for the cones of Betti tables of standard graded minimal free resolutions over polynomial rings and cohomology tables of vector bundles on projective spaces. The extremal rays of these cones correspond to degree sequences of pure resolutions and root sequences of Hilbert polynomials of vector bundles, respectively. We provide an interpretation of the poset structure on the extremal rays in terms of the existence of nonzero homomorphisms. This suggests a method for generalizing this partial order to multigraded rings and toric varieties. (Received April 13, 2010)

1061-13-193 **Daniel Jesus Hernandez***, dhernan@umich.edu. *F-thresholds of polynomials.*

To a given polynomial over a field of prime characteristic, there is an associated invariant called the *F-threshold*. This invariant, defined using the Frobenius morphism, can be thought of as a prime characteristic analog of the well known log canonical threshold in characteristic zero. In the talk, we will present some formulas for F-thresholds, and use these formulas to provide examples of families of polynomials with the property that the F-threshold is equal to the log canonical threshold for infinitely many primes. We also point out how this is related to a longstanding open problem about the equivalence of F-pure and log canonical singularities. (Received April 13, 2010)

1061-13-198 **Ralf Youtz*** (ryoutz@sfsu.edu). *Toric ideals of small matroids are generated in degree 2.*

Neil White has conjectured that the toric ideal associated with a matroid is generated by quadratic binomials associated with double swaps. We prove this conjecture for matroids of rank 2. Also, we confirm the conjecture for matroids on ground sets of size nine and less. (Received April 13, 2010)

14 ► Algebraic geometry

1061-14-30 **Tolga Karayayla*** (tkarayay@math.upenn.edu), Department of Mathematics, 209 S. 33rd Street, Philadelphia, PW 19104. *Automorphisms of Rational Elliptic Surfaces with Section.* Preliminary report.

A rational elliptic surface with section is the blow up of $\mathbb{P}^2$ at the 9 base points of a pencil of cubics and the elliptic fibration is given by the induced map to $\mathbb{P}^1$ determined by this pencil. It is more useful to interpret it as a fibration over $\mathbb{P}^1$ with generic fiber an elliptic curve. Singular fibers of elliptic surfaces with section had been classified by Kodaira. For rational elliptic surfaces with section all possible configurations of singular fibers have been listed by Persson. The automorphism group of a rational elliptic surface with section is closely related

to the configuration of singular fibers on that surface. This configuration determines the Mordell-Weil group (group of sections) which can be seen as a subgroup of the automorphism group by translation in each smooth fiber, an elliptic curve. Another subgroup of automorphisms is the automorphisms which send the zero section to itself setwise. The configuration of singular fibers is again important to determine this second subgroup via the combinatorial information it gives. Finite groups of order up to 24 may arise as such subgroups. The whole automorphism group is then the semidirect product of these two subgroups. All elliptic surfaces are assumed relatively minimal. (Received February 16, 2010)

1061-14-60 **Nero Budur*** (nbudur@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Local zeta functions of hyperplane arrangements.*

We report on recent results on the local zeta function, Bernstein-Sato polynomials, and the monodromy conjecture for hyperplane arrangements. (Received March 31, 2010)

1061-14-65 **A. Libgober*** (libgober@math.uic.edu), Department of mathematics, UIC, 851 S.Morgan Str., Chicago, IL 60607. *Sequences of polytopes of log-canonical thresholds.*

Given a collection of r ideals on a germ of a smooth variety one can associate to it a rational polytope in $\mathbf{R}^r$ (called LCT-polytope) which for $r = 1$ is the log-canonical threshold of the ideal and for a collection of principal ideals is a special case of polytopes of quasi-adjunction. I will discuss a generalization of the ascending chain condition for log-canonical thresholds for such LCT-polytopes. This is a report on joint work with M.Mustata (arxive: 1002.4163). (Received April 02, 2010)

1061-14-71 **Santiago López de Medrano*** (santiago@matem.unam.mx), Recreo 95-505., Col. Actipan., 03100 Mexico, D.F., Mexico. *Intersections of Quadrics, Moment-Angle Manifolds and Connected Sums.*

Intersections of quadrics in R^m of the form

$$\Sigma_i \Lambda_i x_i^2 = 0$$
$$\Sigma_i x_i^2 = 1.$$

where $\Lambda_i \in R^k, i = 1, \ldots, m$, have been studied from the point of view of Geometric Topology since the 80's when they appeared in problems of Singularities of Functions, Dynamical Systems and Algebraic Geometry. They include the *moment-angle manifolds*, studied since the 90's from the point of view of Algebraic Topology in the framework of quasi-toric manifolds. In this version they have been the subject of successive generalizations, the last one being abstract and functorial. In all their forms, their study is closely related to group actions and convex polytopes.

We will give a short review of the origin of these manifolds and finish with some recent results describing the topological type of wide families of them. They have been found through a combination of the geometric ideas from the 80's with the more recent functorial approach, although the final proofs are purely geometric. Several new problems about these manifolds and questions of Geometric Topology and Convex Polytopes have been opened by this work (in collaboration with Samuel Gitler). (Received April 04, 2010)

1061-14-76 **E. Javier Elizondo*** (javier@javier.math.unam.mx), Ciundad Universitaria, 04510 Mexico, DF, Mexico, and **Paulo Lima-Filho**, **Frank Sottile** and **Zach Teitler**. *Arithmetic toric varieties.* Preliminary report.

We study toric varieties over a field k that split in a Galois extension K/k using Galois cohomology with coefficients in the toric automorphism group. This Galois cohomology fits into an exact sequence induced by the presentation of the class group of the toric variety. This perspective helps to compute the Galois cohomology, particularly for cyclic Galois groups. We use Galois cohomology to classify k-forms of projective spaces when K/k is cyclic, and we also classify k-forms of surfaces. (Received April 05, 2010)

1061-14-79 **Abel Castorena*** (abel@matmor.unam.mx), Instituto de Matematicas,UNAM Campus Morelia, Apdo. Postal 61-3(Xangari), 58089 Morelia, Michoacan, Mexico. *On the slope of relatively minimal fibrations on rational complex surfaces.*

Given a relatively minimal fibration $f : S \to \mathbb{P}^1$ with general fiber C of genus g, we investigate under what conditions the inequality $6(g-1) \leq K_f^2$ occurs, where K_f^2 is the canonical relative sheaf of f. We give conditions for having such inequality, depending of the genus and gonality of C and the number of certain exceptional curves on S. We apply our results for constructing examples of fibrations with the desired property. (Received April 06, 2010)

1061-14-83 **Jing Zhang*** (jzhang@albany.edu), 1400 Washington Avenue, ES110, Albany, NY 12222.
Hypersurface Sections of a Projective Variety.

Let X be a smooth irreducible projective variety of dimension at least 2 over an algebraically closed field k of characteristic 0 in the projective space $\mathbb{P}^n$. Bertini's Theorem states that a general hyperplane H intersects X with an irreducible smooth subvariety of X. However, the precise location of the smooth hyperplane section is not known. We consider the following question: Given q closed points on X and let V be the linear system of homogeneous polynomials of degree m vanishing at these points, then for what q, m and V, a general member of V as a hypersurface intersects X with an irreducible, smooth subvariety of codimension 1 on X? We will discuss this question in the talk and report our recent result. (Received April 07, 2010)

1061-14-94 **Alexis García Zamora*** (alexiszamora06@gmail.com), Unidad Académica de Matemáticas, UAZ, Camino a la Bufa y Calzada Solidaridad, 98000 Zacatecas, Zacatecas, Mexico. *Irreducible components of the singular locus of A_g.* Preliminary report.

The singular locus of the moduli space of principally polarized abelian varieties A_g is known to be the locus representing abelian varieties admitting non-trivial automorphism group (i.e. $\neq \{\pm 1\}$). In this talk we explain the local an global deformation theory associated to a pair (X, α) formed by an abelian variety and a non-trivial automorphism $\alpha \in Aut(X)$. We give several criteria to determine irreducible components of the singular locus of A_g and illustrate how to use it through examples. This is a joint work with J. M. Muñoz Porras (U. of Salamanca, Spain) and V. Gónzalez-Aguilera (U. F. Santa María, Chile). (Received April 08, 2010)

1061-14-129 **Lev Birbrair**, **Walter D Neumann*** (neumann@math.columbia.edu) and **Anne Pichon**. *Bilipschitz geometry of normal complex surface singularities.* Preliminary report.

Birbrair, Fernandez and Neumann have shown in a series of papers that the bilipschitz geometry of a complex singularity germ, although trivial for one-dimensional germs, is generally quite non-trivial in higher dimensions. The talk will describe phenomena that can arise (e.g., "fast cycles," "Cheeger cycles") and outline ongoing work of Birbriar, Neumann and Pichon towards a complete classification of possible bilipschitz geometries for normal surface singularities. (Received April 10, 2010)

1061-14-134 **Paolo Aluffi*** (aluffi@math.fsu.edu), Florida State University, Tallahassee, FL 32306. *Deletion-contraction and multiple edge formulas for graph hypersurfaces.*

Graph hypersurfaces arise naturally in the computation of Feynman amplitudes in scalar quantum field theory. We study the effect of basic combinatorial operations on their Grothendieck classes, and as an application we obtain information on their virtual Hodge polynomials. This is joint work with Matilde Marcolli. (Received April 11, 2010)

1061-14-137 **Claudiu Raicu*** (claudiu@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, 970 Evans Hall #3840, Berkeley, CA 94720-3840. *Affine Toric Equivalence Relations are Effective.*

Any map of schemes $X \to Y$ defines an equivalence relation $R = X \times_Y X \subset X \times X$, the relation of "being in the same fiber". Kollár asked whether all finite equivalence relations have this form (are effective). The answer to this question is in general negative, but is affirmative in the case of affine toric equivalence relations on affine toric varieties. I will explain the relationship between this result and the vanishing of the first cohomology group in the Amitsur complex associated to a toric map of toric algebras, and present some examples of noneffective equivalence relations. (Received April 12, 2010)

1061-14-154 **Xavier Gomez-Mont*** (gmont@cimat.mx), AP 402, 36000 Guanajuato, Mexico. *Bilinear Forms in Mixed Hodge Structure of a Real Isolated Hypersurface Singularity.*

The cohomology groups of an Isolated Hypersurface Singularity has a natural filtration coming from its mixed Hodge structure (Steenbrink, Scherk, Varchenko).

If the defining equation is real, then one may define a nondegenerate real valued bilinear form on the real Milnor Algebra (Eisenbud-Levine), whose signature contains the information of the Euler characteristic of the positive and negative real Milnor fibre (Arnold).

Using the filtration from the mixed Hodge structure one can introduce real valued bilinear forms on the graded module associated to the filtration, which receive a simple expression in terms of the Eisenbud-Levine form on the real Milnor Algebra using multiplication by powers of the defining equation (as a symmetric operator of the bilinear form): $< f^j *, * >$.

We will explain the connection of these bilinear forms with the GSV-index (or topological index a la Poincaré-Hopf) of a vector fields tangent to the Milnor fibre, with Teissier's polar curves and to invariants coming from multiplier ideals. (Received April 12, 2010)

1061-14-159 **Pedro Luis Del Angel R.*** (luis@cimat.mx), Jalisco s/n, Colonia Valenciana, 36240 Guanajuato, Guanajuato, Mexico, and **Isidro Nieto**. *On Variations of Hodge Structures arising from an equisingular family of Calabi-Yau 3-folds.* Preliminary report.

We will present an equisingular family of Calabi-Yau 3-folds and will consider the variations of Hodge Structures associated to the desingularization as well as the Picard-Fuchs equation associated to that Variation of HS. (Received April 12, 2010)

1061-14-161 **Herbert Kanarek*** (herbert@cimat.mx), Departamento de Matemáticas, UG, Jalisco S/N, Mineral de Valenciana c.p.36240, 36240 Guanajuato, Guanajuato, Mexico, and **Pedro Luis Del Angel** (luis@cimat.mx), Cimat, Jalisco S/N, Mineral de Valenciana c.p.36240, 36240 Guanajuato, Guanajuato, Mexico. *Infinitesimal Torelli theorem for cyclic coverings of compact hermitian symmetric spaces.*

We give an effective infinitesimal Torelli theorem for cyclic covers of compact hermitian symmetric spaces. In the case of Grassmannians the result is even sharp. (Received April 12, 2010)

1061-14-169 **Fuensanta Aroca*** (fuen@matcuer.unam.mx), Instituto de Matemáticas UNAM, Apartado Postal 273., Admon. de correos #3, 62251 Cuernavaca, Morelos, Mexico. *Tropical Geometry in arbitrary rank.* Preliminary report.

Valuations into the real numbers are just a particular type of valuations called classical. In 1932 W. Krull extended the classical definition considering valuations with values in an arbitrary ordered group. Krull's definition is the one currently used in most articles and reference texts. Replacing $\mathbb{R}$ by another totally ordered group Γ, the tropical semi-ring $G := \Gamma \cup \{\infty\}$ may be defined naturally. The same happens with the concept of tropical hypersurface and the tropicalization of a polynomial.

We will discuss kapranow's theorem and the balancing condition in this context. (Received April 12, 2010)

1061-14-177 **Kevin Tucker*** (kevtuck@umich.edu), Department of Mathematics, University of Michigan, 2704 East University Avenue, Ann Arbor, MI 48109-1109, and **Karl Schwede** (kschwede@umich.edu), Department of Mathematics, University of Michigan, 2704 East University Avenue, Ann Arbor, MI 48109-1109. *On Certain Pathological Behavior of Mulitplier Ideals in Positive Characterstic and Related Open Questions.*

The multiplier ideal of a $\mathbb{Q}$-divisor on a complex algebraic variety is a fundamental object in the study of higher dimensional birational geometry. However, the behavior of the multiplier ideals in positive characteristic can be quite enigmatic. We describe how the multiplier ideal transforms under certain kinds of finite separable morphisms in positive characteristic, and also demonstrate more general pathological behavior in specific examples. This leads to several open questions, including the general interest question of the surjectivity of the trace map. (Received April 13, 2010)

1061-14-194 **Yu-jong Tzeng*** (yjt@math.stanford.edu), Math Department, Stanford University, Stanford, CA 94305. *Universal Formulas for Counting Nodal Curves on Surfaces.*

The problem of counting nodal curves on algebraic surfaces has been studied since the nineteenth century. On the projective space $\mathbb{P}^2$, it asks how many curves defined by homogeneous degree d polynomials have only nodes as singularities and pass through points in general position. On K3 surfaces, the number of rational nodal curves was predicted by the Yau-Zaslow formula. Göttsche conjectured that for sufficiently ample line bundles L on algebraic surfaces, the numbers of nodal curves in $|L|$ are given by universal polynomials in four topological numbers. Furthermore, based on the Yau-Zaslow formula he gave a conjectural generating function in terms of quasi-modular forms. The formula is consistent with many existing results on $\mathbb{P}^2$, K3, and curves with at most 8 nodes on general surfaces. In this talk, I will discuss how degeneration methods can be applied to count nodal curves. (Received April 13, 2010)

1061-14-199 **Maria Angelica Cueto*** (macueto@math.berkeley.edu), 970 Evans Hall #3840, Berkeley, CA 94720-3840, and **Shaowei Lin**. *Tropical secant graphs of monomial curves.*

The first secant variety of a monomial curve is a threefold with an action by a one-dimensional torus. Its tropicalization is a three-dimensional fan with one-dimensional lineality space, so the tropical threefold is represented by a balanced graph. Our main result is an explicit construction of that graph. As a consequence we obtain algorithms to effectively compute the multidegree and Chow polytope of an arbitrary monomial curve. This generalizes an earlier degree formula due to Ranestad. The combinatorics underlying our construction is rather delicate, and it is based on a refinement of the theory of geometric tropicalization due to Hacking, Keel and Tevelev.

The key step in the construction of the balanced graph involves finding a suitable compactification (a "tropical compactification") of the complement of a binomial arrangement in the 2-torus $(\mathbb{C}^*)^2$, whose boundary divisor has no three components intersecting at a point. Such compactification can be obtained by resolving all multiple intersections in $\mathbb{P}^2$ by blowups, and realizes the wonderful compactification of De Concini and Procesi.

This is joint work with Shaowei Lin. (Received April 13, 2010)

1061-14-208 **Ricardo Uribe-Vargas*** (ricardo.uribe-vargas@u-bourgogne.fr) and **Peter Giblin** (pjgiblin@liverpool.ac.uk). *On the flecnodal and vertex curves of a smooth surface and the geometry of its plane sections.*

This is a joint work with Peter Giblin (University of Liverpool). The motivation of my talk comes from Computer Vision, which is concerned with the recognition, extraction and reconstruction of 3-dimensional objects from one or more 2-dimensional images, and with the classification of 2-dimensional and 3-dimensional shapes by means of geometrical or other properties. (Computer Graphics, on the other hand, is concerned more with taking 3-dimensional objects and rendering them in visually appealing ways as images: the inverse problem.)

Here, for each point p of a generic smooth surface S, we consider the sections of S by parallel planes near the tangent plane at p. We are mainly interested in the domain where the Gaussian curvature is negative (*hyperbolic domain*). When the parallel plane tends to the tangent one, the corresponding section becomes singular and undergoes a bifurcation.

In order to understand the so called *symmetry set* (and *medial axis*) of the sections near the singular one, it is very useful to know which vertices and inflections of the section are coming to p as the plane tends to the tangent one, and the configuration of those vertices and inflections on the curve. It happens that the hyperbolic domain is subdivided in several regions on which both the number of vertices and inflections and/or their configurations are different. These sub-domains are separated by two relevant curves of the surface: the flecnodal curve and the vertex curve. I will describe the configurations of vertices and inflections in all those domains and on the flecnodal and vertex curves. (Received April 15, 2010)

16 ► Associative rings and algebras

1061-16-59 **Birge Huisgen-Zimmermann*** (birge@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *Degenerations of finite dimensional representations.* Preliminary report.

Let Λ be a basic finite dimensional algebra over an algebraically closed field K, and let $\mathbf{d}$ be a dimension vector. We supplement existing investigations of the degenerations of the $\mathbf{d}$-dimensional representations of Λ (due to Riedtmann, Bongartz, Zwara, and many others) by slicing up the full class of degenerations of a Λ-module M into those that share a top T. After reviewing some prior structural results along this line, we present a theorem which was jointly obtained by H. Derksen, J. Weyman and the speaker. It implies that the $\mathbf{d}$-dimensional representations with fixed top T, which are devoid of proper degenerations with the same top, are classified by a fine moduli space. (Received March 30, 2010)

1061-16-157 **Alex S Dugas*** (adugas@richmond.edu), Dept. of Mathematics & Computer Science, University of Richmond, 28 Westhampton Way, Richmond, VA 23173. *Periodic modules and algebras.* Preliminary report.

It follows from Eisenbud's matrix factorization theorem that any maximal Cohen-Macaulay module over a hypersurface has a periodic free resolution of period 2. We will review work of Auslander, Reiten and Buchweitz that uses this periodicity to explain the existence of periodic projective resolutions over certain finite-dimensional algebras 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. We then consider generalizations that produce periodic algebras as endomorphism rings of d-cluster tilting objects in a triangulated category. In particular, this work applies to 1-cluster tilting objects in the category of CM-modules over a curve singularity as recently studied by Burban, Iyama, Keller and Reiten. (Received April 12, 2010)

18 ► Category theory; homological algebra

1061-18-1 **Peter W-K Li***, University of California, Department of Mathematics, Irvine, CA. *What do we know about open manifolds?.*

An open manifold being non-compact may have infinite topology. The first obstacle towards the understanding of the structure of a complete open manifold is to determine if it has finitely many ends (infinities). In this talk, I will describe an analytic method of detecting the number of ends. In particular, the effectiveness of this method will be demonstrated on various classes of manifolds. Moreover, rigidity type theorems can be obtained in some cases. (Received April 23, 2009)

20 ► Group theory and generalizations

1061-20-42 **John S. Maginnis*** (maginnis@math.ksu.edu), Dept. of Mathematics, Cardwell Hall, Kansas State University, Manhattan, KS 66506, and **Silvia E. Onofrei**, Dept. of Mathematics, The Ohio State University, Columbus, OH 43210. *Fixed Point Sets and Lefschetz Modules for Subgroup Complexes.*

The best known reduced Lefschetz module is the Steinberg module for a finite Chevalley group acting on its Tits building, an irreducible and projective module. The reduced Lefschetz module for a finite group G acting on its Brown complex (simplices are given by chains of p-subgroups) is always projective. We study another subgroup complex, using p-subgroups which contain in their centers an element lying in the center of a Sylow p-subgroup of G. We have theorems concerning fixed point sets of elements of order p acting on these simplicial complexes, and we apply results of Robinson and others to determine information about indecomposable summands of the reduced Lefschetz module (vertices and defect groups of their blocks). We have many specific computations for sporadic simple groups, some of them determined using the GAP package. (Received March 17, 2010)

26 ► Real functions

1061-26-21 **Aliasghar Alikhani-Koopaei*** (axa12@psu.edu), Tulpehocken Road, Reading, PA 19610. *On the Set of Periodic Points of Continuously Differentiable Functions.*

In recent years, researchers have studied the size of different sets related to the dynamics of self-maps of an interval. In this note we show that typically the set of periodic points of continuously differentiable selmaps of an interval have a countable set of periodic points. (Received January 25, 2010)

28 ► Measure and integration

1061-28-35 **Jorge Rivera-Noriega***, Av. Universidad 1001, Col. Chamilpa, 62209 Cuernavaca, Morelos, Mexico. *Notes on Uniform Rectifiability in the Parabolic Sense.*

We survey some recent progress related to a parabolic version of uniform rectifiability and its connection with L^2 boundedness of certain parabolic singular integrals. (Received March 10, 2010)

32 ► Several complex variables and analytic spaces

1061-32-46 **David B Massey*** (d.massey@neu.edu). *Zero vanishing cycles versus normal slicing.*

Suppose that K is a bounded, constructible complex of sheaves on a complex analytic space X, and f is a complex analytic function on X. Then, the condition that K has no vanishing cycles along f serves, in many ways, as a purely cohomological version of saying that the zero locus of f is normally nonsingular to a Whitney stratification with respect to which K is constructible.

However, a fundamental problem with this philosophy is that intersection cohomology (with constant or twisted coefficients) need not yield intersection cohomology (even after a shift) when one takes such a "cohomological normally nonsingular" slice.

We discuss how to "fix" this problem, and the interesting, deep, questions which surround the issue. (Received March 22, 2010)

1061-32-99 **Jose Luis Cisneros-Molina*** (jlcm@matcuer.unam.mx), Instituto de Matematicas, UNAM, Av. Universidad s/n, Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico. *Complex and Real Milnor Fibrations.*

In this talk we present a refinement of Milnor's Fibration Theorem for complex analytic maps and we use analogous ideas to generalize Milnor's Fibration Theorem for real analytic maps for some families of real analytic maps with isolated critical value.

Joint work with S. Seade y J. Snoussi (Received April 08, 2010)

1061-32-122 **Jing Zhang*** (jzhang@albany.edu), 1400 Washington Avenue, ES110, Albany, NY 12222. *Sections of a Holomorphic Line Bundle.*

Let X be a compact complex manifold with an effective divisor D. Then D gives a holomorphic line bundle L on X. We will discuss the following question: given some fixed points of X, whether there is a nonconstant element ϕ in the vector space $H^0(X, L)$ of global sections of L such that ϕ vanishes at these points and defines a submanifold of X. We will also investigate the singularity of the holomorphic map f from the open manifold $Y = X - D$ to a projective space determined by a basis of the vector space $H^0(X, L)$. (Received April 10, 2010)

1061-32-125 **Stephen Bruce Sontz*** (sontz@cimat.mx), CIMAT, Jalisco s/n, Mineral de Valenciana, 36024 Guanajauto, Gto., Mexico. *Recent results in Segal-Bargmann theory associated with a Coxeter group.*

We apply a technique of functional analysis (the polar decomposition) as a way to define the Segal-Bargmann transform (in four of its versions) in the Segal-Bargmann theory associated to a Coxeter group acting in a Euclidean space. This complements a talk that will be given in the special session on Toeplitz Operators and Discrete Quantum Models. (Received April 10, 2010)

1061-32-148 **Suzanne Lynch Hruska***, University of Wisconsin Milwaukee, PO Box 413, Milwaukee, WI 53211, and **Roland K. W. Roeder**. *Topology of Fatou Components for Endomorphisms of $\mathbb{CP}^2$: linking with the Green's Current.*

Little is known about the global topology of Fatou components for holomorphic endomorphisms $f : \mathbb{CP}^2 \to \mathbb{CP}^2$. We develop a type of linking number between closed loops in the Fatou set of f with the Green's current T, which forms the complement of the Fatou set. Using these linking numbers we establish that many classes of endomorphisms have Fatou components with infinitely generated first homology; for example, polynomial endomorphisms of $\mathbb{CP}^2$ for which the restriction to the line at infinity is hyperbolic and has disconnected Julia set, and polynomial skew products of $\mathbb{CP}^2$ such that the vertical Julia set in an appropriate slice is disconnected. We conclude with some concrete examples and questions for further study. (Received April 12, 2010)

35 ► Partial differential equations

1061-35-20 **Elena Kaikina*** (ekaikina@matmor.unam.mx), Instituto de Matematicas, UNAM Campus Morelia, AP 61-3 (Xangari), 58089 Morelia, Michoacan, Mexico, and **Martin Arciga Alejandre** (mparciga@matmor.unam.mx), Instituto de Fisica y Matematicas, UMSNH, Edificio C-3, Ciudad Universitaria, Morelia, Michoacan 58089. *Absolute value of a fractional derivative on a half-line.*

Consider the initial-boundary value problem on a half-line for the nonlinear evolution equations with a fractional derivative

$$\begin{cases} u_t + \lambda |u|^\sigma u + |\partial_x|^\alpha u = 0, \ t > 0, x > 0, \\ u(x, 0) = u_0(x), \ x > 0, \end{cases}$$

where the $|\partial_x|^\alpha$ operator on a half-line is defined as follows for $\alpha \in (1, 2)$

$$|\partial_x|^\alpha u = \theta(x) \int_{-i\infty}^{i\infty} e^{px} |p|^\alpha \left(\widehat{u}(p, t) - \frac{u(0, t)}{p} \right) dp.$$

Here the function θ is defined as

$$\theta(x) = \begin{cases} 1, x \geq 0 \\ 0, x < 0. \end{cases}$$

We study traditionally important problems of a theory of nonlinear partial differential equations, such as global in time existence of solutions to the initial-boundary value problem and the asymptotic behavior of solutions for large time. (Received January 25, 2010)

1061-35-34 **Gustavo Ponce*** (ponce@math.ucsb.edu), Department of Mathematics, University of California-Santa Barbara, Santa Barbara, CA 93106, and **German Fonseca** (gefonsecab@unal.edu.co), Departamento de Matematicas, Universidad Nacional de Colombia en Bogota, Bogota, Colombia. *Title : On the IVP for the Benjamin-Ono equation in weighted Sobolev spaces.*

We consider the initial value problem for the Benjamin-0no equation (and its generalized form) in weighted Sobolev spaces $Z_{s,b} = H^s(\mathbb{R}) \cap L^2(|x|^{2b}dx)$, $s \geq 1$ and $s \geq b \in [0, \infty)$. We deduce necessary and sufficient conditions for the persistence property of the solution flow to hold in this spaces $Z_{s,b}$. These results extend previous ones due to R. I . Iorio. (Received March 09, 2010)

1061-35-40 **Nils Ackermann*** (nils@ackermath.info), Instituto de Matematicas, Circuito Exterior, CU, 04510 Mexico, DF, Mexico, and **Norman Dancer**. *The impact of real analyticity of the nonlinearity on the structure of the solution set of semilinear elliptic problems.* Preliminary report.

If the nonlinearity of the semilinear stationary Schrödinger equation is real analytic on the positive half line, in general the Euler-Lagrange functional is not real analytic in any open subset of the natural Sobolev space. We use a new result on the exact decay at infinity of solutions of the stationary Schrödinger equation to show that the gradient of this functional is analytic in a neighborhood of the set of positive solutions, at least if one works in a carefully chosen weighted Banach space instead of the natural Sobolev space. Here the gradient retains its structure I-K, where K has compact derivative at every point.

To illustrate the usefulness of this result we apply it to an equation on the whole space with periodic potential and superlinear nonlinearity, real analytic on the positive half line. The set of positive solutions is then locally path connected by piecewise differentiable arcs. As a consequence, the set of critical levels of the functional is discrete at low values. This fact can be important in the application of variational principles. (Received March 17, 2010)

1061-35-44 **Ting Zhou*** (tzhou@math.washington.edu). *Reconstructing Electromagnetic obstacles by the Enclosure method.*

We show that one can determine Perfectly Magnetic Conductor obstacles, Perfectly Electric Conductor obstacles and obstacles satisfying impedance boundary condition, embedded in a known electromagnetic medium, by making electromagnetic measurements at the boundary of the medium. The boundary measurements are encoded in the impedance map that sends the tangential component of the electric field to the tangential component of the magnetic field. We do this by probing the medium with complex geometrical optics solutions to the corresponding Maxwell's equations and extend the enclosure method to this case. Moreover, using complex spherical waves, constructed by the inversion transformation with respect to a sphere, the enclosure method can recover some non-convex part of the obstacle. (Received March 19, 2010)

1061-35-68 **Sebastian Herr** and **Daniel Tataru*** (tataru@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, Berkeley, CA , and **Nikolay Tzvetkov**. *Energy critical nonlinear Schroedinger equations on a torus.*

I will describe new results concerning small data global well-posedness results for the energy critical nonlinear Schroedinger equation on a torus. (Received April 03, 2010)

1061-35-92 **Dean Baskin*** (dbaskin@math.stanford.edu), Stanford University, Department of Mathematics, Building 380, Sloan Hall, Stanford, CA 94305. *The Klein-Gordon equation on asymptotically de Sitter spaces.*

Asymptotically de Sitter spaces are Lorentzian manifolds that resemble the de Sitter space near infinity and are asymptotic solutions of the Einstein equations with positive cosmological constant. We construct the forward fundamental solution for the wave and Klein-Gordon equations on these manifolds and describe qualitative and quantitative properties of solutions. (Received April 08, 2010)

1061-35-100 **S Nonnenmacher**, **J Sjöstrand** and **M Zworski*** (zworski@math.berkeley.edu). *From open quantum systems to open quantum maps.*

We show that for a class of open quantum systems satisfying a natural dynamical assumption the study of the resolvent, and hence of scattering, and of resonances, can be reduced to the study of open quantum maps, that is of finite dimensional quantizations of canonical relations obtained by truncation of symplectomorphisms. (Received April 09, 2010)

1061-35-109 **Luz De Teresa*** (deteresa@matem.unam.mx), Circuito Exterior C.U., 04510 Mexico, D.F., Mexico. *Some results on the controllability of two parabolic equations with first order terms in the coupling.* Preliminary report.

We explain some new results on the controllability on two parabolic equations with first order terms in the coupling. First, we will review the existing result when the coupling is with zero order terms and secondly present the new results that include the obtention of a new Carleman inequality that requires the control set to be a neighborhood of part of the boundary. At the end we will present a controllability result for a system of three parabolic equations a present some open problems. (Received April 09, 2010)

1061-35-114 **Emilio Marmolejo-Olea*** (emili@matcuer.unam.mx), A:P: 273-3 Admon. 3, Cuernavaca, Morelos 62251, MEXICO, Cuernavaca, Mexico, and **Irina Mitrea**, **Marius Mitrea** and **Qiang Shi**. *Transmission Boundary Problems for Dirac operators on Lipschitz domains and Applications to Maxwell's and Helmholtz's Equations.*

The transmission boundary value problem for a perturbed Dirac operator on arbitrary bounded Lipschitz domains in R3 is formulated and solved in terms of layer potentials of Clifford- Cauchy type. As a byproduct of this analysis, an elliptization procedure for the Maxwell system is devised which allows us to show that the Maxwell and Helmholtz transmission boundary value problems are well-posed as a corollary of the unique solvability of this more general Dirac transmission problem. (Received April 09, 2010)

1061-35-116 **Steve Zelditch*** (zelditch@math.northwestern.edu), Department of Mathematics, Northwestern University, Evanston, IL 60208-2370, and **Hamid Hezari** (hezari@math.mit.edu). *C^{infty} spectral rigidigy of ellipses.* Preliminary report.

We prove that if

$$\Omega_t$$

is a smooth curve of isospectral Z_2xZ_2 symmetric C^∞ domains with Ω_0 an ellipse, then the deformation is trivial.

That is, a smooth deformation of the ellipse through smooth domains with the symmetry of the ellipse cannot be isospectral.

The best previous result was that the ellipse is spectrally rigid among analytic domains. The contribution of this talk is to remove the analyticity assumption. (Received April 10, 2010)

1061-35-150 **Richard B. Melrose** and **Andras Vasy***, Department of Mathematics, 450 Serra Mall, Stanford University, Stanford, CA 94305-2125, and **Jared Wunsch**. *On the gain of Sobolev regularity of diffracted waves.*

I will describe recent results in joint work with Richard Melrose and Jared Wunsch on wave propagation on manifolds with corners. These show that – under an appropriate non-focusing assumption – singularities diffracted from an edge, i.e., loosely speaking, singularities that are not propagated along limits of rays transversely reflected from adjacent boundary hypersurfaces, are smoother in a Sobolev sense than the main singularities of the solution. This, as well as natural generalizations, should have applications to inverse problems, allowing one to ignore diffracted waves from corners in certain cases. Some special, 2-dimensional, cases have been analyzed by Ivrii and Gerard-Lebeau. (Received April 12, 2010)

1061-35-165 **Hart F Smith*** (hart@math.washington.edu), **Valeriy Brytik**, **Maarten Van de Hoop** and **Gunther Uhlmann**. *The elastic wave equation in media of limited smoothness.*

I will discuss joint work on the wave equation of linear, isotropic elasticity, in the case that the elastic moduli are of limited differentiability. Our key result governs the decoupling of the P and S components of the elastic waves. (Received April 12, 2010)

1061-35-179 **Thierry Paul*** (paul@math.polytechnique.fr), CMLS, Ecole polytechnique, 91 128 Palaiseau, France. *Semiclassical methods and Töplitz quantization.*

In this talk will be presented a review of recent results concerning semiclassical methods involving Töplitz quantization methods, with emphasis on time dependence and regularity properties for operators and initial data. (Received April 13, 2010)

1061-35-190 **Antonio Capella*** (capella@matem.unam.mx). *Solutions of a pure critical exponent problem involving the half-laplacian in annular-shaped domains.*

We consider the nonlinear and nonlocal problem

$$A_{1/2}u = |u|^{2^\sharp - 2}u \quad \text{in } \Omega, \qquad u = 0 \quad \text{on } \partial\Omega$$

where $A_{1/2}$ represents the square root of the Laplacian in a bounded domain with zero Dirichlet boundary conditions, $\Omega \subset \mathbb{R}^n$, $n \geq 2$ and $2^\sharp = 2n/(n-1)$ is the critical trace-Sobolev exponent. We assume that Ω is annular-shaped (i.e. $\exists R_2 > R_1 > 0$ s.t. $\{x \in \mathbb{R}^n \text{ s.t. } R_1 < |x| < R_2\}$, $0 \notin \Omega$, and invariant under a group Γ of orthogonal transformations of $\mathbb{R}^n$. We show that: if R_1/R_2 is arbitrary and the minimal Γ-orbit of Ω is large enough, or if R_1/R_2 is small enough and Γ is arbitrary, then the above problem has a positive solution and multiple sign changing solutions.

The results presented here are similar to the ones of Clapp and Pacella [in Math. Z. 2008] for the analogous problem in the case of the Laplacian and the critical Sobolev exponent. (Received April 13, 2010)

1061-35-196 **Kiril Datchev*** (datchev@math.berkeley.edu). *Quantum decay rates for manifolds with hyperbolic ends.*

We study resonances at high energy for manifolds with hyperbolic funnel ends, and give interpretations of these as quantum rates of decay. We show how various assumptions on the classical trapped set of the manifold give information about resonance free regions and about the density of resonances. (Received April 13, 2010)

1061-35-201 **Michael Hitrik*** (hitrik@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095-1555. *Spectra and resolvent bounds for non-self-adjoint operators with double characteristics.*

In this talk, we would like to report on an ongoing work together with Karel Pravda-Starov. For a class of non-selfadjoint pseudodifferential operators with double characteristics, we study semiclassical resolvent bounds and asymptotics for the low lying eigenvalues. Specifically, assuming that the quadratic approximations along the characteristics enjoy a suitable dynamical averaging property, we establish semiclassical hypoelliptic and subelliptic estimates for the operators in question. We also obtain the more precise asymptotic description of the low lying eigenvalues in the semiclassical limit. (Received April 14, 2010)

1061-35-202 **Ricardo Salazar*** (rsalazar@math.ucla.edu), 520 Portola Plaza, Math Sciences Building 6363, Los Angeles, CA 90095. *Determination of time-dependent coefficients for a hyperbolic inverse problem.* Preliminary report.

We consider an inverse boundary value problem for the hyperbolic partial differential equation

$$(-i\partial_t + A_0(t,x))^2 u(t,x) - \sum_{j=1}^{n} \big(-i\partial_{x_j} + A_j(t,x)\big)^2 u(t,x) + V(t,x)u(t,x) = 0$$

with time dependent vector and scalar potentials $\big(\mathcal{A} = (A_0, \ldots, A_m)$ and $V(t,x)$ respectively$\big)$ on a bounded, smooth cylindric domain $(-\infty, \infty) \times \Omega$. Using a geometric optics construction we show that the boundary data allows us to recover integrals of the potentials along 'light rays' and we then establish the uniqueness of these potentials modulo a gauge transform. (Received April 14, 2010)

37 ► Dynamical systems and ergodic theory

1061-37-16 **Patricia Domínguez-Soto*** (pdsoto@fcfm.buap.mx), Universidad Autónoma de Puebla, Facultad de Ciencias Físico-Matemáticas, CU, Av. San Claudio y 18 Sur, Col. San Manuel, 72570 Puebla, Puebla, Mexico. *Connectivity of the Julia and Fatou sets for meromorphic functions.* Preliminary report.

We study conditions for which the Julia and Fatou sets have simply-connected components for different classes of meromorphic functions. (Received January 12, 2010)

1061-37-41 **John Banks**, **Dung Nguyen** and **Piotr Oprocha*** (oprocha@agh.edu.pl), Departamento de Matematicas, Universidad de Murcia, Campus de Espinardo, 30100 Murcia, Spain, and **Belinda Trotta**. *Dynamics of spacing shifts.*

Spacing shifts were introduced in 1973 by Lau and Zame to provide accessible examples of maps that are (topologically) weakly mixing but not mixing. Although they show a rich variety of dynamical characteristics, they have received little subsequent attention in the dynamical systems literature.

This talk will discuss the variety of topological dynamical behaviours they exhibit, and some conditions under which they are sofic. (Received March 17, 2010)

1061-37-43 **Renato Iturriaga*** (renato@cimat.mx), Cimat, Callejon Jalisco sn, Guanajuato, Mexico. *Selection of solutions of the Hamilton Jacobi equation.*

When there are several static classes, we can find several solutions of the Hamilton Jacobi solution. We preesent Different schemes of approximation that select different solutions. (Received March 19, 2010)

1061-37-47 **Carlos Cabrera*** (carlos@matcuer.unam.mx), Av. Universidad s/n. Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico, and **Peter Makienko** (makienko@matcuer.unam.mx), Av. Universidad s/n. Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico. *On dynamical Teichmuller spaces.*

Dynamical Teichmuller spaces.

Abstract: We discuss basic properties of the space of local qc deformations of a rational map R. In particular, we show that if R is a polynomial whose Julia set is homeomorphic to a Cantor set, then the space local qc deformations has a laminated structure. This is a Joint work with Petr Makienko. (Received March 22, 2010)

1061-37-48 **Peter Makienko*** (makienko@matcuer.unam.mx), Av. Universidad s/n. Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico, **Carlos Cabrera** (carloscabrerao@gmail.com), Av. Universidad s/n. Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico, and **Peter Plaumann** (peter.plauman@mi.uni-erlangen.de), Bismarckstrasse 1 1/2, D-91054 Erlangen, Germany. *Semigroups in holomorphic dynamics.* Preliminary report.

We investigate a new approach to holomorphic dynamics considering semigroups of maps together with constants. First we discuss a method to construct multiplicative characters, and then we describe the automorphism groups of different semigroups connected with holomorphic dynamics. We give examples showing that the representation theory of this kind of semigroups is relevant to holomorphic dynamics. (Received March 22, 2010)

1061-37-106 **Jose Ferran Valdez*** (ferran@matmor.unam.mx), Inst. de Matematicas UNAM, Campus Morelia, Apartado 61-3 (Xangari), 58089 Morelia, Michoacan, Mexico. *Polygonal billiards and homogeneous foliations.*

In this talk we present and discuss a new framework for the study of polygonal billiards. To each polygonal table we associate a holomorphic homogeneous foliation on the complex affine space of dimension 2. The dynamics of the billiard ball in the table corresponds to the directional (real) flow of the complex vector field defining the foliation. The leaves of the holomorphic foliation provided with their natural flat structure are isomorphic to the flat surfaces obtained from the polygonal billiard via unfolding. One application of this correspondence is the determination of the topological type of flat surfaces arising via unfold from an irrational polygonal table. There is only one possibility: the infinite genus topological surface with only one end. (Received April 09, 2010)

1061-37-120 **Jesus Muciño-Raymundo** (muciray@matmor.unam.mx), Instituto de Matemáticas, UNAM, Antigua Carretera a Pátzcuaro, La Huerta, 58089 Morelia, Michoacan, Mexico, and **Alvaro Alvarez-Parrilla*** (alvaro@uabc.edu.mx), Facultad de Ciencias, UABC, Km. 103 Carretera Tijuana-Ensenada, 22800 Ensenada, Baja Calif, Mexico. *Essential singularities of complex analytic vector fields on Riemann surfaces.* Preliminary report.

We describe the geometry and dynamics of complex analytic vector fields having essential singularities on Riemann surfaces. Under suitable growth conditions, the existence of a certain kind of local normal forms is possible and the local dynamics exhibits some self-similar properties. Also we explore its global behavior and the Poincaré-Hopf index theory. (Received April 10, 2010)

1061-37-139 **Mike Boyle**, **Jerome Buzzi** and **Ricardo Gomez*** (rgomez@math.unam.mx), Area de la Investigacion Cientifica, Circuito Exterior, Ciudad Universitaria, 04510 Mexico, D.F., Mexico. *Almost isomorphism for countable state Markov shifts.*

Markov shifts are dynamical systems that consist of sequences that correspond to doubly infinite paths in (countable) directed graphs together with the left shift map. Strong positive recurrent Markov shifts are those which are exponentially recurrent and this is the class that most resembles finite state Markov shifts. We will mainly focus on showing that entropy and period constitute a complete invariant of *almost isomorphism*, which can be viewed as an analogue of the Adler-Marcus classification of irreducible shifts of finite type up to almost topological conjugacy by entropy and period (this result provides simple invariants which classify the natural extensions of various smooth, piecewise smooth and symbolic systems up to *entropy conjugacy*: Borel conjugacies between sets which have full measure for all ergodic measures with entropy near the topological entropy). (Received April 12, 2010)

1061-37-155 **Pavel Bleher**, **Mikhail Lyubich** and **Roland Roeder*** (rroeder@math.iupui.edu). *Expanding Blaschke Products for the Lee-Yang zeros on the Diamond Hierarchical Lattice.*

In a classical work, Lee and Yang proved that zeros of certain polynomials (partition functions of Ising models) always lie on the unit circle. Distribution of these zeros control phase transitions in the model. We study this

distribution for a special "Migdal-Kadanoff hierarchical lattice". In this case, it can be described in terms of the dynamics of an explicit rational function in two variables.

More specifically, we prove that the renormalization operator is partially hyperbolic and has a unique central foliation. The limiting distribution of Lee-Yang zeros is described by a holonomy invariant measure on this foliation. These results follow from a general principal of expressing the Lee-Yang zeros for a hierarchical lattice in terms of expanding Blaschke products allowing for generalization to many other hierarchical lattices. (Received April 12, 2010)

1061-37-185 **Rodrigo A. Pérez*** (rperez@math.iupui.edu), 402 N. Blackford St., LD-224R, Indianapolis, IN 46202. *a brief but historic article of Siegel.*

I will give a brief introduction to small denominator problems, describe Siegel's strategy to prove the existence of Siegel disks, and patch a minor gap in his original proof. (Received April 13, 2010)

1061-37-205 **Edgardo Ugalde*** (ugalde@ifisica.uaslp.mx), Av. Manuel Nava 6, Zona Universitaria, 78290 San Luis Potosí, S.L.P., Mexico. *Zero–temperature limit of one–dimensional Gibbs states.*

Let A be a finite set and $\phi : A^{\mathbb{Z}} \to \mathbb{R}$ be a locally constant potential. For each $\beta > 0$ ("inverse temperature"), there is a unique Gibbs measure $\mu_{\beta\phi}$. We prove that, as $\beta \to +\infty$, the family $(\mu_{\beta\phi})_{\beta>0}$ converges (in weak-* topology) to a measure we characterize. It is concentrated on a certain subshift of finite type which is a finite union of transitive subshifts of finite type. The two main tools are an approximation by periodic orbits and the Perron-Frobenius Theorem for matrices à la Birkhoff. The crucial idea we bring is a "renormalization" procedure which explains convergence and provides a recursive algorithm to compute the weights of the ergodic decomposition of the limit. (Received April 14, 2010)

42 ► Fourier analysis

1061-42-135 **Tristan C. Collins**, **Allan Greenleaf** and **Malabika Pramanik*** (malabika@math.ubc.ca), Department of Mathematics, 1984 Mathematics Road, Vancouver, BC V6T1Z2, Canada. *Applications of a multidimensional resolution of singularities.* Preliminary report.

We describe an algorithm for analyzing the zero set of a multidimensional polynomial, and use it to compute the critical integrability exponent for polynomials and the L^2 decay exponent of certain oscillatory integral operators with polynomial phase. (Received April 11, 2010)

1061-42-142 **Michael Christ*** (mchrist@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720, and **Shuanglin Shao**, IMA, Minneapolis, MN. *Existence of extremals for a Fourier restriction inequality.* Preliminary report.

The celebrated Fourier restriction inequality of Tomas and Stein asserts, for dimension three, that the Fourier transform maps $L^2(S^2)$ to $L^4(R^3)$. We show that there exist functions which extremize the associated inequality, and that any extremizing sequence of nonnegative functions has a convergent subsequence. This was previously known for paraboloids, where all extremizers are Gaussians and vice versa.

Complex extremizers and extremizing sequences are related to nonnegative ones in a simple way. All critical points of the associated nonlinear functional are infinitely differentiable. Constant functions are local extremizers, but we do not know whether they are global extremizers, nor whether extremizers are unique modulo symmetries of the problem.

The proofs involve concentration compactness ideas, inequalities for convolutions, symmetrization, a characterization of approximate characters, a regularity theorem at critical scaling, an idea from additive combinatorics, facts about spherical harmonics and Gegenbauer polynomials, and several explicit computations. (Received April 12, 2010)

1061-42-175 **Michael J. VanValkenburgh*** (mjv@math.berkeley.edu), 895 Evans Hall, Berkeley, CA 94720-3840. *Elementary Experiments with Toeplitz Quantization.* Preliminary report.

I will discuss work in progress about a discrete phase space transform and its relation to Toeplitz quantization. (Received April 13, 2010)

43 ► Abstract harmonic analysis

1061-43-101 **Magali Folch-Gabayet*** (folchgab@matem.unam.mx). *A geometric inequality in harmonic analysis.*

We show how an affine invariant inequality for general rational functions can be used to obtain sharp universal estimates for various problems in euclidean harmonic analysis defined with respect to the so-called affine arclength measure.

This is joint work with Spyridon Dendrinos and James Wright. (Received April 09, 2010)

46 ► Functional analysis

1061-46-63 **Marc A. Rieffel*** (rieffel@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *Matrix algebras as quantum finite metric spaces that approximate the 2-sphere.*

I will sketch how the 2-sphere (and other coadjoint orbits) can be approximated by matrix algebras, and how the matrix algebras can be equipped with the structure of "quantum metric spaces" in such a way that they converge to the 2-sphere for a "quantum Gromov-Hausdorff distance". So equipped, the matrix algebras can be viewed as quantum finite metric spaces. Berezin symbols are used to prove the convergence. (Received April 01, 2010)

47 ► Operator theory

1061-47-26 **Hafedh Herichi*** (herichi@math.ucr.edu), Mathematics department, Surge 283., University of California, Riverside, 900 University Ave., Riverside, CA 92521, and **Michel. L. Lapidus**. *On The Spectral Operator and Some Conditions on its Invertibility.*

The spectral operator was introduced for the first time by M. L. Lapidus and his collaborator M. van Frankenhuijsen in their theory of complex dimensions in fractal geometry. The corresponding inverse spectral problem was first considered by M. L. Lapidus and H. Maier in their work on a spectral reformulation of the Riemann hypothesis in connection with the question "Can One Hear The Shape of a Fractal String?". The spectral operator is defined on a suitable Hilbert space as the operator mapping the counting function of a generalized fractal string η to the counting function of its associated spectral measure $\nu = \eta * h$, where $*$ is the operation convolution of measures and h is the generalized harmonic string. It relates the spectrum of a fractal string with its geometry. The spectral operator has also an Euler product representation, which provides a counterpart to the usual Euler product expansion for the Riemann Zeta function, but convergent in the critical strip of the complex plane. During this talk, we will be discussing some fundamental properties of this operator as well as its prime-factors, give an analysis of its spectrum, the spectra of its prime factors and present conditions providing its invertibility. (Received February 12, 2010)

1061-47-36 **Aleksandr Karelin*** (karelin@uaeh.edu.mx), Apostoles 122, Fracc. Paseo de las Reynas, 42180 Pachuca, Mexico, and **Anna Tarasenko**. *On a structure of the kernel of singular integral operators with involution.*

We denote the Cauchy singular integral operator along a contour Γ by

$$(S_\Gamma \varphi)(t) = \frac{1}{\pi i} \int\limits_\Gamma \frac{\varphi(\tau)}{\tau - t} d\tau,$$

the identity operator on Γ by $(I_\Gamma \varphi)(t) = \varphi(t)$.

Let Γ be the unit circle $\mathbb{T}$ o the real axis $\mathbb{R}$.

In the space $L_2(\Gamma)$, we consider an operator

$$A_\Gamma = a_\Gamma I_\Gamma + c_\Gamma S_\Gamma + b_\Gamma W_\Gamma + d_\Gamma S_\Gamma W_\Gamma, \quad A_\Gamma \in [L_2(\Gamma)],$$

where coefficients a, b, c, d are bounded measurable functions on Γ; $(W_\mathbb{T}\varphi)(t) = \varphi(-t)$.

We study a structure of the kernel of singular integral operators with involution A_Γ.

Operators equalities are main tools. (Received March 10, 2010)

1061-47-62 **Dennis Courtney** and **Donald Sarason*** (sarason@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *A mini-max problem for inducers of self-adjoint Toeplitz matrices.* Preliminary report.

An (N+1)-by-(N+1) self-adjoint Toeplitz matrix determines an operator on the space of complex polynomials of degrees at most N. We regard that space in the usual way as a Hilbert space (the monomials of orders 0 to N form the standard orthonormal basis). The operator in question is induced, via multiplication followed by projection, by the real part of any Hardy-space function whose coefficients suitably match the matrix entries. The essential supremum norm of the inducer is at least as large as the norm of the operator. For a given operator of unit norm, there is an inducer of minimum essential supremum norm. We consider the problem of maximizing that minimum, for a given N, over all operators (of the type under discussion) of unit norm. In this talk, the origins of the problem will be explained, the extremal functions for the problem will be identified, the method of attack will be described, and the question of numerical values will be discussed. (Received April 01, 2010)

1061-47-66 **Ronald G. Douglas*** (rdouglas@math.tamu.edu), Department of Mathematics, Texas A & M University, TAMU-3368, College Station, TX 77843=3368, and **Yun-Su Kim**, **Hyun Kwon** and **Jaydeb Sarkar**. *Canonical Models Over Other Kernel Function Hilbert Spaces.*

One can view the canonical model theory for contraction operators in terms of quotient Hilbert modules, where the building blocks are taken to be vector-valued Hardy spaces over the unit disk. Such canonical models can be generalized by replacing the Hardy space by other kernel function Hilbert spaces such as the Bergman or weighted Bergman spaces. Using a geometrical approach and the language of Hilbert modules, the authors investigate unitary equivalence and similarity questions for such models showing that, somewhat surprisingly, the equivalence of such models over the same vector-valued kernel function Hilbert space does not depend on the kernel function Hilbert space used. (Received April 02, 2010)

1061-47-77 **Zeljko Cuckovic*** (zcuckovi@math.utoledo.edu), Department of Mathematics, 2801 W. Bancroft Street, University of Toledo, Toledo, OH 43606, and **Sonmez Sahutoglu**. *Compactness of products of Hankel operators.*

We discuss compactness of products of Hankel operators acting on Bergman spaces on some product domains in C^n. (Received April 06, 2010)

1061-47-86 **Nikolai Vasilevski*** (nvasilev@math.cinvestav.mx), Department of Mathematics, CINVESTAV del IPN, Av. Instituto Politécnico Nacional # 2508, Col. San Pedro Zacatenco, 07360 Mexico, D.F., Mexico. *On compactness of commutators and semi-commutators of Toeplitz operators on the Bergman space.*

Given a C^*-subalgebra A of algebra $L_\infty(\mathbb{D})$, denote by $\mathcal{T}(A)$ the C^*-algebra generated by all Toeplitz operators with symbols in A and acting on the Bergman space over the unit disk $\mathbb{D}$. We will discuss the compactness properties of commutators and semi-commutators of Toeplitz operators from $\mathcal{T}(A)$ as well structural properties of $\mathcal{T}(A)$ and other operator algebras related to the above compactness properties. (Received April 07, 2010)

1061-47-88 **Nikolai Vasilevski*** (nvasilev@math.cinvestav.mx), Department of Mathematics, CINVESTAV del IPN, Av. Instituto Politécnico Nacional # 2508, Col. San Pedro Zacatenco, 07360 Mexico, D.F., Mexico. *Commutative algebras of Toeplitz operators and Berezin quantization.*

We will discuss a quite unexpected phenomenon in the theory of Toeplitz operators on the Bergman space: the existence of a reach family of commutative C^*-algebras generated by Toeplitz operators with non-trivial symbols. The complete classification of such commutative algebras involves the Berezin quantization procedure. (Received April 07, 2010)

1061-47-98 **Armando Sánchez-Nungaray*** (armandos@cimat.mx), Jalisco s/n, Mineral de Valenciana, 36240 Guanajuato, Guanajuato, Mexico. *Commutative algebras of Toeplitz operators on the super disc.* Preliminary report.

The spectral theory of commutative C^*-algebras of Toeplitz operators on Bergman spaces was constructed and developed by Nikolai Vasilevski and his coauthors during the last decade.

They show that on the unit disc the C^* algebra generated by Toeplitz operators is commutative on each (commonly con- sidered) weighted Bergman space if and only if there is a maximal commutative subgroup of the Möbius transformation such that the symbols of the Toeplitz operators are invariant under the action of this subgroup, these algebras coinside exactly with the three known types (circle(S^1), reals($\mathbf{R}$) and positive reals($\mathbf{R}_+$)) of the commutative algebras on the unit disk.

In this talk, we extended this ideas to supermathematics in particular by the super disc and found five types of commutative algebras of Toeplitz on the super disc. This types corresponding to super-circle, super-reals, torus, $S^1 \times \mathbf{R}$ and $S^1 \times \mathbf{R}_+$ which are maximal commutative subgroups of isometries on the super disc. (Received April 08, 2010)

1061-47-112 **Yuri Karlovich*** (karlovich@uaem.mx), Universidad Autonoma del Estado de Morelos, Facultad de Ciencias, Av. Universidad 1001, Col. Chamilpa, 62209 Cuernavaca, Morelos, Mexico. *Nonlocal singular integral operators.*

The talk is devoted to studying Banach algebras of generalized singular integral operators with non-regular data and their extensions by finite and infinite groups of weighted shift operators. The study is based on the theory of pseudodifferential operators with non-regular symbols, limit operators techniques and local-trajectory methods. Fredholm symbol calculi are constructed, and Fredholm criteria in terms of Fredholm symbols are established. (Received April 09, 2010)

1061-47-127 **Raul E Curto*** (rcurto@math.uiowa.edu), Department of Mathematics, The University of Iowa, Iowa City, IA 52242. *Spectral properties of commuting 2-variable weighted shifts.*

I will discuss joint work with J. Yoon on spectral properties of commuting 2-variable weighted shifts. By contrast with all previously known results in the theory of (single and 2-variable) weighted shifts, we show that the Taylor essential spectrum can be disconnected. We do this by obtaining a simple sufficient condition that guarantees disconnectedness, based on the norms of the horizontal slices of the shift. We also show that for every k >= 1 there exists a k-hyponormal 2-variable weighted shift whose horizontal and vertical slices have 1- or 2-atomic Berger measures, and whose Taylor spectrum is disconnected.

We use tools and techniques from multivariable operator theory and from the groupoid machinery developed by the author and P. Muhly to analyze the structure of the C*-algebra generated by multiplication operators acting on the Bergman space of an arbitrary Reinhardt domain. As a by-product, we show that, for 2-variable weighted shifts, the Taylor essential spectrum is not necessarily the boundary of the Taylor spectrum. (Received April 10, 2010)

1061-47-130 **Dennis Courtney*** (dennis-courtney@uiowa.edu), **Paul Muhly** and **Samuel Schmidt**. *Composition operators and endomorphisms.*

Under appropriate technical hypotheses, a local homeomorphism σ of the circle induces both bounded operators Γ_σ on Hilbert spaces associated to the circle, and $*$-endomorphisms π_σ of various function algebras associated to the circle. We study some questions related to these objects— for example, under what circumstances is there a $*$-endomorphism of the appropriate Toeplitz C* algebra sending the Toeplitz operator with symbol f to a compact perturbation of the Toeplitz operator with symbol $\pi_\sigma(f)$? How are properties of σ reflected in various C* algebras associated to the operator Γ_σ? We have partial answers to these questions and some guesses about what we do not know. (Received April 11, 2010)

1061-47-143 **G. Hernández-Dueñas*** (gerahdez@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043, and **A. Uribe**. *Quantum cutting: A Szegö limit theorem and propagation.*

Given a representation of the circle group by semiclassical Fourier integral operators, we construct an algebra of semiclassical pseudodifferential operators that are a quantum generalization of the notion of symplectic cutting of Lerman. We develop a symbol calculus, prove a Szegö limit theorem and discuss propagation of coherent states. (Received April 12, 2010)

1061-47-160 **Raul Quiroga-Barranco***, Centro de Investigacion en Matematicas, A.C., Jalisco S/N, Colonia Mineral de Valenciana, 36240 Guanajuato, Guanajuato, Mexico. *Lagrangian foliations on bounded domains and Toeplitz operators.*

In joint work with N. Vasilevski, we discovered that on the unit ball there is a strong relationship between commutative algebras of Toeplitz operators and certain Lagrangian foliations. In this talk we will show that there is a similar behavior for other bounded domains. (Received April 12, 2010)

1061-47-167 **M A Bastos**, Lisbon, Portugal, **A Bravo**, Lisbon, Portugal, **Yuri I Karlovich**, Cuernavaca, Mexico, and **Ilya M Spitkovsky*** (ilya@math.wm.edu), Williamsburg, VA. *On explicit inversion of Toeplitz operators with 2-by-2 almost periodic triangular matrix symbols having quadrinomial off diagonal entry.*

the function $e^{i\mu x}$ on the real line $\mathbb{R}$, let $G = \begin{bmatrix} e_\lambda & 0 \\ f & e_{-\lambda} \end{bmatrix}$, where f is a linear combination of the functions e_α, e_β, $e_{\alpha-\lambda}$, $e_{\beta-\lambda}$ with some $(0 <) \alpha, \beta < \lambda$. The criterion for G to admit a canonical factorization was established recently by Avdonin, Bulanova and Moran. We give an alternative approach to the matter, proving the existence (when it does take place) via deriving explicit factorization formulas. Thus, the explicit inverses of the respective Toeplitz operators also are obtained. (Received April 12, 2010)

1061-47-174 **J. A. Virtanen*** (virtanen@cims.nyu.edu), Courant Institute of Mathematical Sciences, New York University, 251 Mercer Street, New York, NY 10012. *Weighted BMO and Toeplitz operators.*

Bounded mean oscillation plays an important role in the theory of Toeplitz and Hankel operators acting on Bergman spaces A^p, especially in connection with their boundedness and compactness properties. I discuss some recent results that suggest one should consider the weighted BMO (and VMO) in order to deal with the properties of these operators on the Bergman space A^1, as in the case of the Hardy space H^1. (Received April 12, 2010)

1061-47-192 **Erick Lee** and **Maribel Loaiza*** (mloaiza@math.cinvestav.mx), Av. Instituto Politecnico Nacional 2508, Col. San Pedro Zacatenco, 07360 Mexico, D.F., Mexico, and **Nikolai Vasilevski**. *On the algebra of Toeplitz operators with piecewise continuous symbols.*

We study the Toeplitz algebra $\mathcal{T}$ generated by Toeplitz operators, acting on the Bergman space of the unit disk, with symbol of the form $a(r,t) = b(r)c(t)$, where $b(r)$ is a slowly oscillating function defined on $[0,1)$ and $c(t)$ is a piecewise continuous function defined on the unit circle. It is important to mention that, in this work, each piecewise continuous function has its own finite set of discontinuities. (Received April 13, 2010)

49 ► Calculus of variations and optimal control; optimization

1061-49-49 **Hector F Sanchez Morgado*** (hector@math.unam.mx), Instituto de Matematicas, Ciudad Universitaria, 04510 Mexico, DF, Mexico, and **Diogo A Gomes**, **Renato G Iturriaga** and **Yifeng Yu**. *Mather measures selected by an approximation scheme.*

Evans's variational approach approximates Mather measures and solutions of the Aronnsson's equation wich is related to the Hamilton Jacobi equation. We identify which measure and solution are selected by this scheme in 1-d. (Received March 23, 2010)

52 ► Convex and discrete geometry

1061-52-117 **Deborah Oliveros*** (dolivero@matem.unam.mx), Instituto de Matematicas, Circuito Exterior C.U., Mexico City, D.F. 04510. *Helly type therems and its relation with graph theorey.*

Perhaps one of the most widely used theorems in convex geometry is Helly theorem which states the following: Helly's Theorem (1913). Let F be a finite family of at least $d+1$ convex sets in R^d. If every $d+1$ members of F have a point in common, then there is a point common to all members of F. Helly's theorem also holds for infinite families of compact convex sets, and has stimulated numerous generalization and variants. Results of the type "if every m members of a family of objects have property P then the entire family has the property P " are called Helly-type theorems. The minimum positive integer m that makes this theorem possible is called the Helly number. A very nice natural generalization of Helly's theorem is the piercing problem, also known as the (p,q) problem, and was first investigated by Hadwiger and Debrunner. We will discuss how some of this Helly type theorems particularly how the piercing problem can be investigated from the combinatorial point of view of graph theory specially how does chromatic number of the complement of intersection graphs may give good bounds to this problems. (Received April 10, 2010)

1061-52-141 **Bernardo M. Ábrego*** (bernardo.abrego@csun.edu), Department of Mathematics, California State University, Northridge, 18111 Nordhoff St., Northridge, CA 91330-8313, and **Ruy Fabila-Monroy**, **Silvia Fernández-Merchant**, **David Flores-Peñaloza**, **Ferran Hurtado**, **Vera Sacristán** and **Maria Saumell**. *On crossing numbers of Geometric Proximity Graphs.* Preliminary report.

Let P be a set of n points in the plane. A geometric proximity graph on P is a graph where two points are connected by a straight-line segment if they satisfy some prescribed proximity rule. We consider four classes of higher order proximity graphs, namely, the k-nearest neighbor graph, the k-relative neighborhood graph, the k-Gabriel graph and the k-Delaunay graph. For $k = 0$ ($k = 1$ in the case of the k-nearest neighbor graph) these graphs are plane, but for higher values of k they contain crossings. In this talk we provide lower and upper bounds on their minimum and maximum number of crossings. We give general bounds and we also study particular cases that are especially interesting from the viewpoint of applications. These cases include the 1-Delaunay graph and the k-nearest neighbor graph for small values of k. (Received April 12, 2010)

1061-52-178 **Ricardo Strausz*** (strausz@math.unam.mx), Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, Av. Universidad, Coyoacan, 04510 Mexico, D.F., Mexico. *How does 9 points look like in 3-space?*

We describe the space of transversal lines to the convex closed 3-balanced-partitions of nine points in the 3 dimensional space... in such a description, we will use the fact that the complete bipartite graph $K_{3,3}$ cannot be embedded into the sphere. (Received April 13, 2010)

1061-52-207 **Luis Montejano*** (luis@matem.unam.mx), Instituto de Matematicas, UNAM, 04510 Mexico, DF, Mexico. *Topology and transversals.*

We will talk about general results of the topological space of transversals to a family of convex sets. We shall discuss some colorful geometrical results obtained from these topological facts. (Received April 14, 2010)

53 ► Differential geometry

1061-53-32 **Rafael Herrera*** (rherrera@cimat.mx), Centro de Investigacion en Matematicas, 36240 Guanjuato, Guanajuato, Mexico, and **Haydee Herrera** (haydee@crab.rutgers.edu), Department of Mathematical Sciences, Rutgers University, Camden, NJ 08102. *Complex contact manifolds and circle actions.*

We study the rigidity of certain holomorphic Euler characteristics under circle actions on complex contact manifolds. In particular, we obtain certain vanishing theorems analogous to those of LeBrun and Salamon under positive curvature assumptions. (Received February 22, 2010)

1061-53-33 **Ovidiu Munteanu*** (omuntean@math.columbia.edu). *Gradient Ricci Solitons.*

We present some recent development in the study of gradient shrinking and steady Ricci solitons. We will discuss the classification of locally conformally flat ones, bounds on volume or other geometric quantities and some questions related to the existence of harmonic functions. (Received March 02, 2010)

1061-53-56 **Jian Song** and **Ben Weinkove*** (weinkove@math.ucsd.edu), Mathematics Department UCSD, 9500 Gilman Drive #0112, La Jolla, CA 92093. *Contracting exceptional divisors by the Kahler-Ricci flow.*

We give a criterion under which a solution g(t) of the Kahler-Ricci flow contracts exceptional divisors on a compact manifold and can be uniquely continued on a new manifold. This is a joint work with Jian Song. (Received March 29, 2010)

1061-53-81 **Jimmy Petean*** (jimmy@cimat.mx), Callejon Jalisco s/n, 36000 Guanajuato, GTO, Mexico. *The Yamabe equation on products.*

We will discuss some results on the multiplicity of solutions of the Yamabe equation on Riemannian products and use this to try to understand the Yamabe constants of certain products which are basic for the understanding of the Yamabe invariant of manifolds. (Received April 06, 2010)

1061-53-105 **Ailana Fraser***, Department of Mathematics, University of British Columbia, Vancouver, BC V6T 1Z2, Canada, and **Richard Schoen**. *The first eigenvalue of the Dirichlet-to-Neumann map, conformal geometry, and minimal surfaces.*

I will talk about joint with with R. Schoen on a spectral problem for manifolds with nonempty boundary. We consider the relationship of the geometry of compact Riemannian manifolds with boundary to the first nonzero

eigenvalue of the Dirichlet-to-Neumann map (Steklov eigenvalue). For surfaces with boundary we obtain an upper bound on the first Steklov eigenvalue in terms of the genus and the number of boundary components of the surface. This generalizes a result of Weinstock from 1954 for surfaces homeomorphic to the disk. We attempt to find the best constant in this inequality for annular surfaces. Motivated by the annulus case, we explore an interesting connection between the Dirichlet-to-Neumann map and minimal submanifolds of the ball that are solutions to the free boundary problem. We then prove general upper bounds for the first Steklov eigenvalue for conformal metrics on manifolds of any dimension which can be properly conformally immersed into the unit ball in terms of certain conformal volume quantities. (Received April 09, 2010)

1061-53-107 **Lan-Hsuan Huang*** (lhhuang@math.columbia.edu), Department of Mathematics, Columbia University, 2990 Broadway, New York, NY 10027. *Center of mass and constant mean curvature foliations for isolated systems in general relativity.*

Initial data sets in general relativity are Riemannian manifolds satisfying the constraint equations. An important class of initial data sets which model the isolated systems is the class of asymptotically flat manifolds.

I will discuss the existence and uniqueness of constant mean curvature foliations near infinity for asymptotically flat manifolds which satisfy the Regge–Teitelboim condition. It is known that the (Hamiltonian) center of mass is well-defined under this condition. To construct the surfaces with constant mean curvature, we first identify an integral quantity of the mean curvature with the center of the sphere and the center of mass. By applying the normal perturbations on spheres of large radius twice carefully, we can find a constant mean curvature surface near the sphere centered correctly. Moreover, from our construction, the foliation is asymptotically concentric, and its geometric center is the center of mass. (Received April 09, 2010)

1061-53-108 **Fernando Galaz-Garcia** and **Catherine Searle*** (csearle@matcuer.unam.mx), Avenida Universidad s/n, Colonia Lomas de Chamilpa, 62270 Cuernavaca, Morelos, Mexico. *Cohomogeneity one Alexandrov spaces.*

We give a structure theorem for Alexandrov spaces of cohomogeneity one and classify dimensions less than or equal to 4. (Received April 09, 2010)

1061-53-115 **Jingyi Chen*** (jychen@math.ubc.ca), Department of Mathematics, The University of British Columbia, Vancouver, B.C. V6T 1Z2, Canada. *Recent progress on mean curvature flow for entire Lagrangian graphs.*

I will discuss some recent developments on mean curvature flow for entire Lagrangian graphs. This includes: existence of longtime solutions, uniqueness of solutions and self-similar solutions (translators, expanders and shrinkers). Most results that I will present are joint works with Albert Chau, Weiyong He, Chao Pang and Yu Yuan. (Received April 09, 2010)

1061-53-119 **Pierre Bayard*** (bayard@ifm.umich.mx), Instituto de Fisica y Matematicas, U.M.S.N.H., Edificio C-3, Ciudad Universitaria, C.P. 58040 Morelia, Michoacan, Mexico. *A spinor representation of surfaces in four-dimensional euclidean space (with J. Roth, Paris).*

The second fundamental form of a surface in $\mathbb{R}^4$ satisfies the equations of Gauss, Ricci and Codazzi. We prove that this system of equations is equivalent to a Dirac equation on the surface. Moreover, a solution of this Dirac equation permits to represent the surface in $\mathbb{R}^4$. This representation generalizes to an arbitrary surface the Weierstrass representation formula of a minimal surface in $\mathbb{R}^4$. These results extend to the codimension 2 a previous work by T.Friedrich on surfaces in $\mathbb{R}^3$. (Received April 10, 2010)

1061-53-121 **Oscar Palmas*** (oscar.palmas@ciencias.unam.mx), Departamento de Matemáticas, Circuito Exterior, Ciudad Universitaria, 04510 México, DF, Mexico, and **Antonio Gervasio Colares**. *Riemannian and Lorentzian manifolds foliated by $(n-1)$-umbilical hypersurfaces.*

We define closed partially conformal vector fields and give examples of them in both Riemannian/Lorentzian settings. We also show that manifolds admitting such kind of vector fields can be foliated by $(n-1)$-umbilical hypersurfaces and use this foliation to give a decomposition of the ambient space. Finally we stablish conditions for a hypersurface to be a leaf of the aforementioned foliation. (Received April 10, 2010)

1061-53-136 **Chuu-Lian Terng*** (cterng@math.uci.edu), Chuu-Lian Terng, Department of Mathematics, University of California, Irvine, CA 92697-3875. *The Hodge star mean curvature flow for curves in flat 3-space.* Preliminary report.

The Hodge star Mean curvature flow for curves in 3-dimensional Euclidean space or Lorentzian space is the curve flow $\gamma_t = *H$, where H is the mean curvature vector and $*$ is the Hodge star operator on the normal bundle

of the curve $\gamma(\cdot, t)$. I will explain the relation between this curve flow and soliton theory. (Received April 12, 2010)

1061-53-144 **Steve Zelditch*** (zelditch@math.northwestern.edu), Department of Mathematics, Northwestern University, Evanston, IL 60208, and **Yanir Rubinstein** (yanir@math.stanford.edu), Department of Mathematics, Stanford University, Stanford, CA 94305, Albania. *Geodesics in spaces of metrics and Toeplitz operators.* Preliminary report.

My talk describes ongoing work with Yanir Rubinstein on the use of Toeplitz operators to approximate the exponential map in the space of Kahler metrics in a fixed class. We also mention the recent result of Renjie Feng giving a complete asymptotic expansion for Bergman geodesic approximations to the endpoint problem in the case of Abelian Varieties (improving results of Phong-Sturm and Song-Zelditch in the toric case). (Received April 12, 2010)

1061-53-147 **Pablo Suárez-Serrato*** (p.suarez-serrato@matem.unam.mx), IMUNAM, Área de la investigación, científica, Circuito Exterior, C U Coyoacán, D.F., Gran Tenochtitlán, Mexico. *Entropy decrease along Ricci flow on convex-cocompact surfaces.*

We shall see that the entropy of smooth metrics on convex-cocompact surfaces decreases along Ricci flow. This extends a result of Manning to the convex-cocompact setting and also shows that in this case constant curvature metrics minimize entropy.

A program to obtain similar conclusions for compact and also convex-cocompact manifolds of arbitrary dimension using a related geometric flow will be outlined.

This is joint work with S. Tapie (Bonn University). (Received April 12, 2010)

1061-53-209 **Robert L. Bryant***, MSRI, 17 Gauss Way, Berkeley, CA 94720. *A visit to the Finsler world.*

Many people aren't aware that, when Bernard Riemann revolutionized the study of differential geometry in his famous 1854 lecture, he had in mind a more general concept of geometry than what we now call Riemannian geometry. His original vision included a kind of geometry that could be used to study a wide range of problems in the calculus of variations and optimization, but the development of this more general geometry, nowadays called Finsler geometry, had to wait many more years before being explored in depth.

It is now in a vigorous phase of development, and, in this short lecture, I want to (re-)introduce Riemann's original idea and sketch some of the new developments. I'll emphasize how the Finsler world compares and contrasts with the more familiar Riemannian world and illustrate some of its applications and surprising connections with other areas of mathematics. (Received April 21, 2010)

55 ► Algebraic topology

1061-55-2 **Alejandro Adem***, University of British Columbia, Department of Mathematics, Vancouver, BC. *Homotopy theory and spaces of representations.*

In this talk we will discuss properties of spaces of homomorphisms $\mathrm{Hom}(Q, G)$ where Q is a discrete group and G a Lie group. The example given by the ordered commuting n-tuples in a compact Lie group will be discussed in some detail. We will also discuss how spaces of homomorphisms and the descending central series of the free groups, can be used to construct simplicial spaces for each integer $q > 1$ with realizations $B(q, G)$ that filter the classifying space BG. In particular for $q = 2$ this yields a single space $B(2, G)$ assembled from all the n-tuples of commuting elements in G. Homotopy properties of the $B(q, G)$ will be described for finite groups, and cohomology calculations provided for compact Lie groups. Results on understanding both the number and stable homotopy type of the components of related spaces of representations will also be discussed. This is joint work with F.Cohen, E.Torres and J.Gomez. (Received April 23, 2009)

1061-55-37 **Dev P. Sinha*** (dps@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *New results on the cohomology of symmetric groups.*

I will present a basis for the mod-2 cohomology of symmetric groups, given by generalizations of Young diagrams called skyline diagrams. I will give formulae for cup products and Steenrod algebra action. I will also describe some work in progress on applications to homotopy theory, in particular to higher-order cohomology operations and framed cobordism invariants. (Received March 11, 2010)

1061-55-38 **Daniel Juan Pineda*** (daniel@matmor.unam.mx), Instituto de Matematicas, Morelia, UNAM. Campus Morelia, 58190 Morelia, Michoacan, Mexico, and **John Guaschi** and **Silvia Millan Lopez**. *Algebraic K theory of group rings of braid groups of surfaces.*

We will present ingredients for computing the algebraic K theory of the integral group ring of braid groups of surfaces. The only non trivial are those of the projective plane and the sphere. We will provide interesting features that show up and some of the details and the geometry involved in these calculations. (Received March 12, 2010)

1061-55-50 **Sadok Kallel*** (sadok.kallel@math.univ-lille1.fr), Laboratoire Painleve, Universite des sciences et technologies, 59650 Villeneuve-d'Ascq, France. *On the topology of rational curves in Grassmann manifolds and moduli spaces of linear systems.* Preliminary report.

The study of rational curves in algebraic varieties is a vast topic with connections to Gromov-Witten theory and Gauge theory. We will discuss the special case of holomorphic maps from $\mathbb{C}P^1$ into a complex Grassmann manifold and this space has strong connections with moduli spaces of so-called *controllable and observable linear systems* in control theory. Important work on the topology of this moduli space has been done by B. Mann and R.J. Milgram in the nineties. We review some of this work then use it to describe some homotopy types and give some homological calculations for holomorphic maps of small degrees. This work is joint with Paolo Salvatore (Rome) and Walid Ben Hammouda (Tunis). (Received March 24, 2010)

1061-55-64 **Benjamin M Mann*** (ben@ayasdi.com). *Jim Milgram and Applied Homotopy Theory.* Preliminary report.

This talk is in honor of Jim Milgram's 70th birthday celebration. It will recount some of Jim's vision and contributions to topology and its applications. (Received April 02, 2010)

1061-55-69 **Jeffrey H Smith***, jhs@math.ubc.ca. *Beyond Operads.*

Operads provide a way of discussing homotopy theoretic analogues of many different discrete algebraic structures. However, more complicated algebraic structures, such as Hopf algebras, do not fit the language of operads. On the other hand, there where are examples where the use of operads to describe higher homotopies can be replaced by a rigid construction. I discuss examples of both. (Received April 03, 2010)

1061-55-74 **Sam Gitler*** (sgitler@math.cinvestav.mx), CINVESTAV, Mexico City, Mexico, and **Anthony Bahri**, **Frederick R Cohen** and **Martin Bendersky**. *Some results in toric topology.*

This is work partly in progress by A. Bahri, M. Bendersky, F.R. Cohen and S. Gitler. I will present a general splitting theorem of the suspension of a generalized moment angle complex (GMAC) as a suspension of a one point union of smashed generalized moment angle complexes (SGMAC). We give the homotopy type of the SGMACS in two general cases. We present a few of the applications that follow. Davis and Januszkiewicz introduced quasitoric manifolds, a generalization of toric varieties, which consist of a differentiable manifold of dimension 2n with an action of the n-torus so that the orbit space is an n-polytope.and similarly a small cover of a polytope, which consists of an n-manifold with a $(Z/2)^k$ action which has an n-polytope as orbit space I will present a construction of an infinite family of polyopes associated to given one and similarly an infinite family of abstract simplicial complexes associated to given one. It will be applied to construct infinite families of Gmacs associated to a given one, to quasitoric manifols and small covers of polytopes . We will mention some results about relations in each family and interrelations among the various families. (Received April 05, 2010)

1061-55-82 **Ralph L Cohen*** (ralph@math.stanford.edu), Dept. of Mathematics, Stanford University, Stanford, CA 94305. *Fiberwise Duality and String Topology.*

In this talk I will explain how many of the constructions of string topology are the result of Poincare and Spanier-Whitehead duality in the fiberwise setting. These include the "umkehr" maps that are prevalent throughout the subject. (Received April 06, 2010)

1061-55-95 **Gunnar E Carlsson*** (gunnar@math.stanford.edu), Department of Mathematics, Stanford University, Serra Street, Stanford, CA 94305. *Topology of finite metric spaces and other discrete geometric structures.*

I will a number of topologically inspired constructions on finite metric spaces, including persistence of various forms. Examples will be included, as well as discussion of patterns of application. (Received April 08, 2010)

1061-55-97 **Jesus Gonzalez*** (jesus@math.cinvestav.mx), Departamento de Matematicas del Cinvestav, Apartado Postal 14-740, 07000 Mexico City, Mexico. *On the cohomology ring of* $B(RP^m, 2)$.

In this talk I will describe the integral cohomology groups of ordered and unordered configuration spaces of pairs of points in a real projective space (joint work with Peter Landweber). I will also describe work in progress leading to the corresponding ring structure and applications. (Received April 08, 2010)

1061-55-132 **Dennis Sullivan***, SUNY, NY. *Algebraic Topology and Applied Math.* Preliminary report.

Computation in non linear problems often use cell decompositions, the boundary and coboundary operators, and chains and cochains. these are excellent discrete models of forms and vector fields and the classical operations of vector calculus. Difficulties arise from the algebraic structures related to wedge products , lie brackets and hodge star. There are discrete analogues of these but without some of the algebraic properties ...like the impossibility of a graded commutative cup product. Ideas from algebraic topology , like infinity algebras and rational homotopy theorie's notion of homotopy for dga maps can be brought to bear here. the program is to create effective algebraic models of the classical continuum algebraic operations for each cell decomposition of space. A key requirement is to have compatible maps between these structures for one decomposition and its subdivision. (Received April 11, 2010)

1061-55-140 **Miguel A. Xicotencatl*** (xico@math.cinvestav.mx), Depto. de Matematicas, CINVESTAV, Ave. IPN 2508, 07360 Mexico City, Mexico. *On mapping class groups of non-orientable surfaces.*

The mapping class group (m.c.g.) Γ_g^+ of an oriented surface M_g, is the group of isotopy classes of orientation preserving diffeomorphisms of M_g. Variations of this group include the full m.c.g. $\Gamma_g^{\pm}$, and the m.c.g. with marked points. Recently, the study of m.c.g.'s has also been extended to the non-orientable case. For instance, N. Wahl proved the analogue of Harer's homology stability theorem in the non-orientable case, E. Hanbury extended this result to the case with marked points, while G. Hope and U. Tillmann studied the p-periodicity of of the Farrel cohomology of $\Gamma(M)$. When considering all diffeomorphims, one shows the m.c.g. of a surface M (oriented or not) with k marked points, surjects onto the full m.c.g. $\Gamma(M)$ with kernel $\tilde{\Gamma}^k(M)$, the reduced m.c.g. with k marked points. Moreover, using configuration spaces we construct a space with fundamental group $\tilde{\Gamma}^k(M)$. In the case when M is the projective plane or the Klein bottle, we use these spaces to study the cohomology of $\tilde{\Gamma}^k(M)$ and groups related to the braid groups of M. We also study the question of the p-periodicity in the case with marked points. This is joint work with Miguel A. Maldonado. (Received April 12, 2010)

1061-55-168 **Soren Galatius***, Department of Mathematics, Stanford University, Stanford, CA 94305, and **Oscar Randal-Williams**. *Monoids of moduli spaces of manifolds.*

The homology of the moduli space of Riemann surfaces, in the limit where the genus tends to infinity, is determined by Madsen and Weiss' theorem. If we consider surfaces equipped with continuous maps to some background space B, the analogous question was solved by Cohen and Madsen, provided B is simply-connected. Our result shows that the condition of simple connectivity can be removed. We also give a new proof of Madsen-Weiss' theorem, the first proof that doesn't rely on Harer's homological stability. (Received April 12, 2010)

57 ► Manifolds and cell complexes

1061-57-3 **Ernesto Lupercio***, CINVESTAV. *Orbifolds and quantum field theories.*

In this talk I will review the work of our group at Cinvestav on orbifold quantum field theories, specifically I will explain how orbifold string topology is related to Chen-Ruan orbifold cohomology. The talk will be geared towards a general mathemtical audience. (Received May 05, 2009)

1061-57-4 **Alberto Verjovsky***, IM-UNAM. *A smooth codimension-one foliation of the 5-sphere by symplectic leaves.*

We will present the construction of a smooth codimension-one foliation of the 5-sphere by symplectic leaves. In other words, we will construct a smooth foliation by 4-dimensional leaves which are symplectic manifolds and such that the symplectic structure varies smoothly. Therefore, the 5-sphere is a regular Poisson manifold. This is joint work with Pablo Suáez Sarrato. (Received May 05, 2009)

1061-57-52 **Gabriela Hinojosa*** (gabriela@uaem.mx), Faculty of Science, UAEM, Av. Universidad 1001. Col. Lomas de Chamilpa, 62209 Cuernavaca, Morelos, Mexico. *Wild knots in higher dimensions and Kleinian groups.*

Higher dimensional Kleinian groups are certain discrete subgroups of the group of diffeomorphisms of the $(n+2)$-sphere ($n \geq 1$), consisting of those diffeomorphisms which preserve angles and which we denote by $M\ddot{o}b(\mathbb{S}^{n+2})$. If $\Gamma \subset M\ddot{o}b(\mathbb{S}^{n+2})$ is a discrete subgroup acting conformally on the $(n+2)$-sphere then this action extends naturally to a conformal action on the disk $\mathbb{D}^{n+3}$. Its limit set, $\Lambda(\Gamma)$, is the set of points of $\mathbb{S}^{n+2}$ which are accumulation points of some orbit of Γ in $\mathbb{D}^{n+3}$. If $\Omega(\Gamma) := \mathbb{S}^{n+2} - \Lambda(\Gamma) \neq \emptyset$ we say that Γ is a *Kleinian group*. The set $\Omega(\Gamma)$ is called the *discontinuity set* of Γ. One interesting question is whether a topological n-sphere ($n \geq 1$) which is not a round sphere can be the limit set of a higher dimensional *geometrically finite* Kleinian group. In this case we can show that the sphere is necessarily fractal (possibly unknotted).

The purpose of this talk is to construct an infinite number of wild knots $\mathbb{S}^n \hookrightarrow \mathbb{S}^{n+2}$ for $n = 1, \cdots, 5$ which are limit sets of geometrically finite Kleinian groups. (Received March 25, 2010)

1061-57-54 **Marion Moore Campisi*** (marion@math.ucdavis.edu) and **Matt Rathbun**. *High distance knots in closed 3-manifolds.*

Let M be a closed 3-manifold with a given Heegaard splitting. We show that after a single stabilization, some core of the stabilized splitting has arbitrarily high distance with respect to the splitting surface. This generalizes a result of Minsky, Moriah, and Schleimer for knots in S^3. We also show that in the complex of curves, handlebody sets are either coarsely distinct or identical. We define the *coarse mapping class group of a Heegaard splitting*, and show that if (S, V, W) is a Heegaard splitting of genus ≥ 2, then $\mathcal{CMCG}(S, V, W) \cong \mathcal{MCG}(S, V, W)$. (Received March 26, 2010)

1061-57-57 **Piotr Przytycki** and **Jennifer Schultens*** (jcs@math.ucdavis.edu), 1 Shields Ave, Davis, CA 95616. *Topology of Kakimizu Complex.* Preliminary report.

Nearly two decades ago, Osamu Kakimizu embarked on the study of spanning surfaces for knots. He defined a complex in which vertices correspond to isotopy classes of spanning surfaces and higher dimensional simplices correspond to collections of such isotopy classes admitting disjoint representatives. This complex is interesting in its own right. An understanding of its topology sheds light on the relation between the various Seifert surfaces of a knot and thus informs our understanding of the knot. We will discuss key features of the topology of the Kakimizu complex. (Received March 29, 2010)

1061-57-58 **Henry Segerman*** (henrys@math.utexas.edu), 1 University Station C1200, Austin, TX 78712. *A generalisation of the deformation variety.*

The deformation variety is similar to the representation variety in that it describes (generally incomplete) hyperbolic structures on 3-manifolds with torus boundary components. However, the deformation variety depends crucially on a triangulation of the manifold: there may be entire components of the representation variety which can be obtained from the deformation variety with one triangulation but not another, and it is unclear how to choose a "good" triangulation that avoids these problems. I will describe the "extended deformation variety", which deals with many situations that the deformation variety cannot. In particular, given a manifold which admits some ideal triangulation we can construct a triangulation such that we can recover any irreducible representation (with some trivial exceptions) from the associated extended deformation variety. (Received March 30, 2010)

1061-57-75 **Matt Rathbun*** (mrathbun@math.ucdavis.edu), Davis, CA. *Tunnel One, Fibered Links.*

All fibered links can be constructed from the unknot by a sequence of operations called plumbing (and then de-plumbing) Hopf bands. Interestingly, if a fibered link has an unknotting tunnel that happens to lie in the fiber, then plumbing a Hopf band along the tunnel results in a new fibered link that is again tunnel number one. Natural questions are whether this restricted plumbing can always be performed, and whether this is sufficient to construct all tunnel one, fibered links. I will answer the first question affirmatively, and discuss progress towards answering the second. (Received April 05, 2010)

1061-57-78 **Neil R Hoffman*** (nhoffman@math.utexas.edu), Dept of Mathematics, 1 University Station C1200, Austin, TX 78712-0257. *Commensurability classes containing three knot complements.*

Reid and Walsh recently conjectured that hyperbolic knot complements are commensurable with at most two other knot complements. Work of Boileau, Boyer and Walsh has shown that the conjecture holds given the condition that the knot complements have no hidden symmetries. In addition to introducing these ideas, I

will construct an infinite family of hyperbolic knot complements that are commensurable with two other knot complements and do not admit hidden symmetries. (Received April 06, 2010)

1061-57-90 **Brandy Guntel*** (bguntel@math.utexas.edu), 1 University Station C1200, Austin, TX 78751. *Primitive/primitive and primitive/Seifert representatives of knots.*

Berge described a class of knots that lie on the genus 2 Heegaard surface F in S^3 that are primitive/primitive with respect to F. Later Dean described a similar class of knots that are primitive/Seifert with respect to F. After an introduction to these two types of knots, we will discuss two families of such knots that have distinct embeddings in F. (Received April 07, 2010)

1061-57-110 **John Luecke*** (luecke@math.utexas.edu), The University of Texas at Austin, Mathematics Department, 1 University Station C1200, Austin, TX 78712-0257, and **Kenneth Baker** and **Cameron Gordon**. *Dehn surgery on a knot in the 3-sphere and the bridge number of its dual knot.* Preliminary report.

Let K be a knot in the 3-sphere. Let $K(p/q)$ denote the Dehn surgery on K along a curve representing p meridians and q longitudes. Let K' represent the dual knot in $K(p/q)$ – that is, the core of the attached solid torus in $K(p/q)$. Assume $K(p/q)$ contains no closed surface with Euler characteristic -1 for which the boundary of its regular neighborhood is incompressible. Assume furthermore that $K(p/q)$ has a one or two-sided Heegaard splitting of genus 2. If $|q| > 2$, we show that there is such a Heegaard splitting of $K(p/q)$ with respect to which K' is at most 1-bridge. (Received April 09, 2010)

1061-57-111 **Jesús Rodríguez-Viorato*** (viorato@matem.unam.mx), Área de la investigación científica, Circuito Exterior, Ciudad Universitaria, Coyoacán, 04510 México, DF, Mexico. *ICON surfaces in Montesinos Knots complement.* Preliminary report.

An ICON surface in a knot $k \subset S^3$ is an incompressible, compact, orientable and non-separating surface in $E = \overline{S^3 - N(k)}$. We want to classify, or just understand, the ICON surfaces in Montesinos knots complement. I am going to show some advances in this direction. (Received April 09, 2010)

1061-57-133 **Oliver Dasbach** and **Adam Lowrance*** (alowrance@math.uiowa.edu). *Turaev genus, knot signature, and the knot homology concordance invariants.*

The Turaev surface of a link diagram is a certain cobordism between the all A and all B resolutions capped off with disks. The Turaev genus of a link is the minimum genus of any Turaev surface for the link. We use a relationship between knot signature and the spanning tree complexes for Khovanov and knot Floer homology to give new lower bounds for the Turaev genus of a knot. (Received April 11, 2010)

1061-57-138 **Fabiola Manjarrez-Gutierrez***, Instituto de Matematicas, UNAM, Area de la Investigacion Cientifica, Circuito Exterior. CU Coyoacan, 04510 Mexico DF, Mexico. *Additivity of circular width for knots in S^3.* Preliminary report.

A circular handle decomposition of a knot exterior $E(K)$ is a structure $E(K) = (R \times I) \cap N_1 \cap T_1 ... \cap T_l \cap N_l/(R \times 0 \sim R \times 1)$, each N_i is a collection of 1-handles, each T_i is a collection of 2-handles and R is a Seifert surface for K. We can reorder the handles in such a way that the intermediate steps are as "simple" as possible, giving rise to the definition of *circular width of the knot exterior*, denoted by $cw(E(K))$, and *circular thin position of the knot exterior*. Let $K_1 \sharp K_2$ be the connected sum of two knots K_1 and K_2 in S^3, it is not hard to see that $cw(E(K_1 \sharp K_2)) \leq cw(E(K_1)) \sharp cw(E(K_2))$. It is natural to ask: Is it true that $cw(E(K_1 \sharp K_2)) = cw(E(K_1)) \sharp cw(E(K_2))$?. We will show special cases for which the answer is positive, as well as a partial result that could let us to answer the question in the more general set. (Received April 12, 2010)

1061-57-145 **Eric Harper*** (harper@math.miami.edu), Ungar 515, 1365 Memorial Drive, Coral Gables, FL 33146, and **Nikolai Saveliev**. *Casson-Lin type invariants for links.*

In 1992, Xiao–Song Lin constructed an invariant $h(K)$ of knots $K \subset S^3$ that is a signed count of conjugacy classes of irreducible trace–free $SU(2)$ representations of $\pi_1(S^3 \backslash K)$. Lin shows $h(K)$ is one half the knot signature of K. Using methods similar to Lin's, we construct an invariant $h(L)$ of two–component links $L \subset S^3$. Our invariant is a signed count of conjugacy classes of *projective* $SU(2)$ representations of $\pi_1(S^3 \backslash L)$ with a fixed 2–cocycle and corresponding non-trivial w_2. We show that $h(L)$ is, up to a sign, the linking number. (Received April 12, 2010)

1061-57-146 **Melissa Macasieb** and **Kathleen Petersen*** (petersen@math.fsu.edu), Department of Mathematics, Florida State University, 1017 Academic Way, Room 208, Tallahassee, FL 32306, and **Ronald van Luijk**. *Character Varieties of a Family of Two-Bridge Knots.*

Explicit models for character varieties of hyperbolic 3-manifolds are, in general, very difficult to compute. Character varieties encapsulate much important data about the original manifold. I will discuss the construction of explicit models for the PSL(2,C) and SL(2,C) character varieties of complements of a family of two-bridge knots and discuss some consequences of this work. This family of knots contains the twist knots and is the first infinite family of knots for which explicit models have been constructed. (Received April 12, 2010)

1061-57-183 **E. Fanny Jasso-Hernandez*** (fjasso@matem.unam.mx), Instituto de Matematicas, U.N.A.M., Area inv. cientifica, Circuito Exterior, Ciudad Universitaria, Coyoacan, Mexico, DF 04510, and **Yongwu Rong**. *Relations between graph homologies and Khovanov homology.*

The similarities between the bracket state sum for the Jones polynomial and a state sum for graphs when computing the chromatic and the Tutte polynomial provide connections between the categorification of these polynomials. We discuss these connections, as well as a relation with the Potts model given by L. Kauffman. (Received April 13, 2010)

1061-57-186 **Lorena Armas-Sanabria*** (larmas@matem.unam.mx), Universidad Autonoma Metropolitana, Unidad Cuajimalpa, Artificios 40, Col. Hidalgo, 01120 Mexico, DF, Mexico. *Artin presentations and fundamental groups of 3-manifolds.*

In this talk I will speak about Artin presentations. We give a proof of the fact that the set of Artin presentations has a group structure. We apply this to calculate the fundamental group of the 3-manifolds obtained by integral Dehn surgery on links which are the closure of pure 3-braids. In some cases we say when these groups are nontrivial. (Received April 13, 2010)

1061-57-187 **Max Neumann-Coto*** (max@matem.unam.mx). *Words and geodesics in surfaces.* Preliminary report.

I will talk about some geometric properties of immersed geodesics in surfaces and their preimages in the universal covering that arise from their representation in the fundamental group (in collaboration with Peter Scott). (Received April 13, 2010)

1061-57-191 **Mario Eudave-Munoz*** (mario@matem.unam.mx), Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, Circuito Exterior, Ciudad Universitaria, 04510 Mexico, DF, Mexico, and **Enrique Ramirez-Losada** (kikis@cimat.mx), Centro de Investigacion en Matematicas, Jalisco S/N, Col. Valenciana, 36240 Guanajuato, Gto, Mexico. *Toroidal Dehn surgeries of hitting number 4.* Preliminary report.

Let k be a hyperbolic knot in S^3. Suppose that the manifold obtained by r-Dehn surgery on k, r an integer, contains a separating incompressible torus T. Let t be the hitting number of T, that is, the minimal number of intersections between T and the core of the attached solid torus. If $t = 2$, then it is possible to give a general description of all knots with such a surgery. The first examples of knots with a toroidal surgery with $t = 4$ were given by M. Eudave-Muñoz; more examples have been given recently by M. Teragaito. Both sets of examples were given via tangles and double branched covers. In this talk we give an explicit construction of hyperbolic knots with a toroidal surgery of hitting number 4, and give a general description of many knots with that kind of surgery. (Received April 13, 2010)

1061-57-195 **Mariel Vazquez*** (mariel@math.sfsu.edu), Mathematics Department, 1600 Holloway Ave, San Francisco, CA 94116. *Topological analysis of difference topology experiments: applications to a Mu-DNA complex.*

We develop topological methods for analyzing difference topology experiments involving 3 string tangles. Difference topology is a novel technique used to unveil the structure of stable protein-DNA complexes. We analyze such experiments for the Mu protein-DNA complex. We show that there is a unique biologically relevant solution. That is, we show there is a unique rational tangle solution, which is also the unique solution with small crossing number. These techniques can be applied to any stable protein-DNA complex in order to determine the topology of protein-bound DNA. This is joint work with john Luecke and Isabel Darcy. (Received April 13, 2010)

1061-57-197 **Luis G Valdez-Sanchez*** (lvsanchez@utep.edu), Department of Mathematical Sciences, 500 West University Ave, El Paso, TX 79968-0514. *Distance three toroidal Dehn fillings of hyperbolic knots and manifolds.*

For a hyperbolic 3-manifold M with a torus boundary component T_0, a Dehn filling $M(r) = M \cup_{T_0} S^1 \times D^2$ of M along a slope $r \subset T_0$ (where r bounds a disk in $S^1 \times D^2$) is said to be *toroidal* if $M(r)$ contains an incompressible torus. We present the classification of all such pairs (M, T_0) admitting toroidal Dehn fillings $M(r_1)$ and $M(r_2)$ at distance $\Delta(r_1, r_2) = 3$, where one of the manifolds $M(r_i)$ contains an incompressible *positive torus*, ie a torus intersected by the core of the Dehn filling solid torus of $M(r_i)$ always in the same direction. We also outline the classification of hyperbolic knots in S^3 admitting toroidal surgeries at distance 3, where in each surgery manifold there is an incompressible torus intersected twice by the core of the solid torus used in the surgery. (Received April 13, 2010)

58 ► Global analysis, analysis on manifolds

1061-58-31 **I Barkas**, **S Kong** and **L Ni*** (lni@math.ucsd.edu). *Ancient solutions to the Ricci flow.*

In this paper we present ancient solutions to Ricci flow on spheres and complex projective spaces which generalize Fateev's examples on three spheres. We also study in detail the geometric and asymptotic properties of Fateev's three dimensional examples. Our higher dimensional examples on the total space of the generalized Hopf fibrations, as well as Fateev's three dimensional examples on $\mathbb{S}^3$, supply counter-examples to some folklore conjectures on ancient solutions of Ricci flow on compact manifolds. Our high dimensional examples are mostly non-collapsed. As a by-product, we showed that the nonstandard Einstein metrics on spheres and complex projective spaces are unstable fixed points of the Ricci flow. (Received February 21, 2010)

1061-58-55 **Pengfei Guan*** (guan@math.mcgill.ca), Department of Mathematics and Statistics, McGill University, Montreal, Quebec H3A 2K6, Canada. *Analysis of the Monge-Ampère type equations.*

We discuss problems related to the Monge-Ampère type equations. This type of equations naturally arise from geometry. The talk will devote to the analysis of the geometric properties of the solutions of these equations. (Received March 28, 2010)

1061-58-89 **Roberto Paoletti*** (roberto.paoletti@unimib.it), Via Roberto Cozzi 53, 20125 Milano, Italy. *Tian-Zelditch expansions for Hamiltonian torus actions.*

We shall discuss some analogues of the Tian-Zelditch expansion in the presence of a Hamiltonian torus action on a compact quantizable Khaeler manifold. (Received April 07, 2010)

1061-58-91 **Tatsuya Tate*** (tate@math.nagoya-u.ac.jp), Fro-cho, Chikusa-Ku, Nagoya, Aichi 464-8602, Japan. *Asymptotic Euler-Maclaurin expansion over Delzant polytopes.*

Formulas for the Riemann sums over lattice polytopes given by the lattice points in the polytopes are often called Euler-Maclaurin formulas. We call the asymptotic expansion formula for such Riemann sums asymptotic Euler-Maclaurin formulas. An asymptotic Euler-Maclaurin formula over simple polytopes was first obtained by Guillemin-Sternberg, which generalized the classical Euler-Maclaurin expansion on the interval. Thus, the problem is to find effective formulas for each term of the asymptotic expansion. In this talk, a new asymptotic Euler-Maclaurin formula over Delzant polytopes will be presented. This formula is rather similar to the so-called local (exact) Euler-Maclaurin formula due to Berline-Vergne. Indeed, although this formula is proved without using results of Berline-Vergne, the differential operators appeared in each term of the asymptotics coincide with Berline-Vergne operators. This new formula enables us to obtain explicit formula for every terms in the asymptotics in two dimension, explicit formula for the third term in arbitrary dimension. In the talk, a sketch of the proof of the formula and some comments on further problems will also be explained. (Received April 07, 2010)

1061-58-103 **Colin Guillarmou** and **Jie Qing***, UC Santa Cruz, Santa Cruz, CA 95064. *Spectral characterization of Poincaré-Einstein manifolds with infinity of positive Yamabe type.*

In this paper, we give a sharp spectral characterization of conformally compact Einstein manifolds with conformal infinity of positive Yamabe type. More precisely, we prove that the largest real scattering pole of a conformally compact Einstein manifold (X, g) is less than $\frac{n}{2} - 1$ if and only if the conformal infinity of (X, g) is of positive Yamabe type. (Received April 09, 2010)

1061-58-203 **Xianzhe Dai***, Math, UCSB, Santa Barbara, CA 93106. *Analytic torsion and intersection R-torsion for manifolds with conical singularity.* Preliminary report.

The R-torsion, introduced by Reidemeister in 1935, is the first topological invariant that are not homotopy invariant. The analytic torsion is introduced by Ray-Singer in the '70s as an analytic analogue of R-torsion. The famous Ray-Singer conjecture says that these two are indeed equal on closed manifolds. The Ray-Singer conjecture was proved independently by Cheeger and Mueller in the late '70s. Now both the R-torsion and analytic torsion can be generalized to singular manifolds, at least for manifolds with conical singularity. It is thus an intriguing question whether and how the Ray-Singer conjecture generalize to this setting. We will discuss some of the recent work in this direction. (Received April 14, 2010)

60 ► Probability theory and stochastic processes

1061-60-172 **Estelle L Basor*** (ebasor@aimath.org), 960 Portage Ave., Palo Alto, CA 94306. *The largest eigenvalue distribution via orthogonal polynomials.*

In random matrix theory, for ensembles of Hermitian matrices, an object of interest is the distribution of the largest eigenvalue. For many classical ensembles, the distribution is related to a Painlevé equation. This talk will describe a simple method to find the Painlevé equation using basic complex analysis and recursion identities for orthorgonal polynomials. (Received April 12, 2010)

65 ► Numerical analysis

1061-65-189 **Mutlu Akar*** (makar@yildiz.edu.tr), Yildiz Technical University, Faculty of Arts, Sciences, Mathematics Department, Davutpasa Campus, Esenler, 34210 Istanbul, Turkey, and **Mustafa Bayram** (mbayram@fatih.edu.tr), Fatih University,Faculty of Arts and Sciences, Mathematics Department, Buyukcekmece, 34500 Istanbul, Turkey. *Laguerre Polynomials Approximation for Numerical Solution of Differential Algebraic Equations (DAEs).*

This paper is concerned with numerical solution of differential algebraic equations (DAEs) using the Laguerre polynomials approximation. Two different problems are solved using the Laguerre polynomials approximation and the solutions are compared with the exact solutions. Firstly, we calculate the power series of a given equation system and then transform it into Laguerre polynomials approximation form, which gives an arbitrary order for solving the DAE numerically. Furthermore, we extend to the Maple algorithm for numerical solution of differential algebraic equations (DAEs) with Laguerre polynomials approximation, which was developed by Wang (2005). (Received April 14, 2010)

70 ► Mechanics of particles and systems

1061-70-19 **Yury M. Vorobiev*** (yurimv@guaymas.uson.mx), Departamento de Matematicas, Universidad de Sonora, Blvd. Luis Encinas y Rosales, 83000 Hermosillo, Sonora, Mexico, and **Guillermo Davila-Rascon** (davila@gauss.mat.uson.mx), Departamento de Matematicas, Universidad de Sonora, Blvd. Luis Encinas y Rosales, 83000 Hermosillo, Sonora, Mexico. *Weak Poisson Coupling and the Hamiltonian Normalization on Slow-Fast G-Spaces.*

In the context of the averaging method, we study a class of perturbed Hamiltonian dynamics on the so-called "slow-fast" G-spaces equipped with Poisson brackets of the adiabatic type. The main feature of our perturbed Hamiltonian model is that the unperturbed part is G-invariant but not Hamiltonian. To get a G-symmetric Hamiltonian approximation to the original system, we construct a normalization transformation by using the homotopy method for weak coupling Poisson structures. In particular, in the adiabatic case, our approach can be viewed as an alternative to the method of generating functions which is common in the theory of adiabatic approximation. (Received January 18, 2010)

81 ► Quantum theory

1061-81-6 **Maciej Zworski***, University of California Berkeley, Berkeley, CA. *Random perturbations in discrete quantization.*

A version of discrete quantization associates to functions on a $2n$-dimensional torus a family of N^n-by-N^n matrices. The high energy limit then corresponds to N tending to infinity.

When the function (classical observable) is not real the matrices are typically not normal and the spectrum is very unstable. This comes from a reinterpretation of Hörmander's celebrated commutator condition.

However, small random perturbations produce spectra with a lot structure, in particular, satisfying probabilistic Weyl laws expressed using the classical observable.

In my talk I will explain all the concepts involved and illustrate the results and conjectures with simple numerical experiments (one great advantage of discrete quantization).

The talk is based on joint work with T. J. Christiansen and on earlier works of J. Sjöstrand and his collaborators. (Received May 05, 2009)

1061-81-51 **Razvan Gelca*** (rgelca@gmail.com), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79410, and **Alejandro Uribe**, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *From classical theta functions to topological quantum field theory.*

Abelian Chern-Simons theory relates classical theta functions to the linking number of knots. In this talk we will show that, by starting with the theory of classical theta functions in the representation theoretic viewpoint introduced by A. Weil, one can arrive at the skein modules of the linking number and at the corresponding topological quantum field theory, without the insights of quantum field theory. Classical theta functions and the action of the Heisenberg group on them are obtained via Weyl quantization in the holomorphic polarization, and the same quantization in the real polarization yields a combinatorial model that can be interpreted topologically. A close analysis of the discrete Fourier transform points to the existence of 3-manifold invariants. (Received March 25, 2010)

1061-81-124 **Stephen Bruce Sontz*** (sontz@cimat.mx), CIMAT, Jalisco s/n, Mineral de Valenciana, 36024 Guanajauto, Gto., Mexico. *Segal-Bargmann theory - math-physics aspects.* Preliminary report.

This will be a report on recent work in Segal-Bargmann theory with an emphasis on its math-physics aspects. This complements a talk to be give in the special session on Complex Analysis and Operator Theory. (Received April 10, 2010)

1061-81-166 **Carlos Villegas-Blas*** (villegas@matcuer.unam.mx), Av. Universidad S/N, Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico. *Szego-type theorems for the n-sphere and the hydrogen atom problem.*

We describe Szego-type theorems involving perturbations of the Laplacian on the n-sphere and the hydrogen atom Hamiltonian. A suitable representation for the corresponding projectors in terms of coherent states will be included. We will also give an Egorov type theorem for Toeplitz operators in related Bargmann spaces. (Received April 12, 2010)

1061-81-204 **Stephane Nonnenmacher*** (snonnenmacher@cea.fr), Institut de Physique Theorique, CE-Saclay, 91191 Gif-sur-Yvette, France. *Open baker's map: a toy model for dissipative quantum chaos.* Preliminary report.

We are interested in the high-energy spectrum of certain nonselfadjoint operators appearing in the study of damped waves on compact manifolds of negative curvature, or wave scattering on manifolds of infinite volume. One common feature of these systems is that the corresponding classical flow is chaotic (such problems belong to the realm of "quantum chaos").

In order to shed more light on those spectral problems, we introduce a simple toy model (the Walsh-quantized baker's map), for which the spectrum can be computed explicitly. In particular, this model provides tentative answers to several open questions concerning the spectral distribution (existence of a fractal Weyl law, of a spectral gap). (Received April 14, 2010)

92 ► Biology and other natural sciences

1061-92-93 **Javier Arsuaga***, 1600 Holloway Av., Thornton Hall 925, San Francisco, CA 94116, **Yuanan Diao**, Charlotte, NC , and **Robert Kaplan**. *Modeling the linking of DNA in trypanosomes.* Preliminary report.

Trypanosomatid parasites, trypanosoma and lishmania, are the cause of disease and death in many third world countries. One of the most unusual features of these organisms is the 3 dimensional organization of their mitochondrial DNA into maxi and minicircles. Minicircles are confined into a small volume and are interlocked forming a huge network. It has been estimated that in C. fasciculata the network containes 5,000 minicircles and that every minicircle is linked to three other minicircles. How this network is maintained, replicated and segregated while preserving the correct degree is mostly unknown. Here we investigate the effects of the confinement on the network formation. Our approach is inspired on a theorem from percolation theory that states that when the minicircles are confined into a small volume and the number of minicircles is large enough a percolating network (ie a network that fills the space), arises. We propose that the density of DNA minicircles in trypanosomes is beyond the percolation density and discuss whether this is the pathway that nature chose for the formation of the network. (Received April 08, 2010)

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0192-5857(2010)31:3;1-8

Periodicals postage paid at Providence, RI and additional mailing offices

ABSTRACTS

Volume 31 • Number 3 • Summer 2010

AMS

Abstracts of Papers Presented to the AMS
ISSN 0192-5857
American Mathematical Society
201 Charles Street, Providence, RI 02904-2294 USA
GST No. R121892046