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* Indicates who will present the paper at the meeting.

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PAPERS PRESENTED AT MEETINGS

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MEETING #	DATE	PLACE	ABSTRACT DEADLINE	ABSTRACT ISSUE
1051	October 16–18, 2009	Waco, TX	August 25	Vol 30, No. 4
1052	October 24–25, 2009	University Park, PA	September 1	Vol 30, No. 4
1053	October 30–November 1, 2009	Boca Raton, FL	September 8	Vol 30, No. 4
1054	November 7–8, 2009	Riverside, CA	September 15	Vol 30, No. 4
1055	December 16–20, 2009	Seoul, South Korea	TBA	TBA
1056	January 13–16, 2010	San Francisco, CA	September 22	Vol 31, No. 1
1057	March 27–28, 2010	Lexington, KY	February 2	Vol 31, No. 2
1058	April 10–11, 2010	St. Paul, MN	February 16	Vol 31, No. 2
1059	April 17–18, 2010	Albuquerque, NM	February 23	Vol 31, No. 3
1060	May 22–23, 2010	Newark, NJ	March 30	Vol 31, No. 3
1061	June 2–5, 2010	Berkeley, CA	April 13	Vol 31, No. 3
1062	October 2–3, 2010	Syracuse, NY	August 10	Vol 31, No. 4
1063	October 9–10, 2010	Los Angeles, CA	August 17	Vol 31, No. 4
1064	October 29–31, 2010	Notre Dame, IN	September 7	Vol 31, No. 4
1065	November 6–7, 2010	Richmond, VA	September 14	Vol 31, No. 4

SAN FRANCISCO, CA, April 25–26, 2009

Abstracts of the 1049th Meeting.

00 ► General

1049-00-1 **Yehuda Shalom***, Department of Mathematics. *Bounded generation of arithmetic groups and some recent applications.*

A group G is said to be boundedly generated by a given finite family of subgroups, if there exists M such that every element in G is a product of at most M elements, each belonging to some subgroup in this family. In the talk we shall discuss the origin and three different recent applications of this deep group theoretic property to the study of arithmetic groups, focusing onthe concrete simplest example SL(n). (Received April 01, 2008)

1049-00-12 **Anthony Shaheen*** (ashahee@calstatela.edu), California State University Los Angeles, Mathematics Department, 5151 State University Drive, Los Angeles, CA 90032, and **Caleb Emmons** and **Mike Krebs**. *How to Differentiate an Integer Modulo n.*

One way to generate an undergraduate research project is to take a familiar mathematical object and attempt to make sense of it in a completely different setting. Here, we will make sense of the concept of differentiation in the setting of the integers modulo n. A number derivative on the integers modulo n is a map from the integers modulo n to itself which satisfies the product rule. After classifying these maps, we will present a list of undergraduate research projects one can pursue using these maps as a starting point. (Received January 05, 2009)

03 ► Mathematical logic and foundations

1049-03-41 **Makkuni Jayaram*** (jayaram@icmb.utexas.edu), Mol Genetics & Microbiology, 1 Univ Station A5000, UT Austin, Austin, TX. *Analyzing DNA Transposition and Recombination by Difference Topology.* Preliminary report.

DNA transactions in biological systems are often carried out by multi-subunit protein assemblies that confer a defined topology on their DNA target sites. Such 'topological filters' are thought to stabilize DNA-protein

configurations that are conducive to triggering the chemical steps of the respective reactions. 'Difference topology' is a simple method for deciphering the DNA topology within complex DNA-protein machines that are not readily amenable to standard structural analyses. The logic is to trap the crossings formed by distinct DNA segments by tying them into knots or links by site-specific DNA inversion and deletion, respectively, carried out by a recombinase. The number of such crossings can then be counted by analytical methods such as gel electrophoresis or electron microscopy. We have applied difference topology to decipher the topological, geometric and mechanistic aspects of DNA transposition and site-specific recombination reactions. (Received February 11, 2009)

05 ► Combinatorics

1049-05-18 **Sven Hermann**, **Anders Jensen**, **Michael Joswig** and **Bernd Sturmfels***, Department of Mathematics, UC Berkeley, Berkeley, CA 94720. *How to draw a tropical plane.*

The tropical Grassmannian parameterizes tropicalizations of linear spaces, while the Dressian parameterizes all planes in tropical projective $(n-1)$-space. We study these parameter spaces and we compute them explicitly for $n \leq 7$. Planes are identified with matroid subdivisions and with arrangements of trees. These representations are used to draw pictures. (Received January 19, 2009)

1049-05-29 **Persi Diaconis*** (diaconis@math.stanford.edu), Department of Mathematics, 450 Serra Mall, Bldg. 380, Stanford, CA 940352125. *Random Walks and Hyperplane Arrangements.*

Bidigare, Hanlon, and Rockmore introduced natural random walks on the chambers of a real hyperplane arrangement. In joint work with Christos Athanasiadis, we study these walks projected onto sub-arrangements. In the special case of shuffling cards, this amounts to studying how many times to shuffle until the Ace of Spades, or the descent pattern is random. There is still an elegant theory as evidenced by a recent paper with Sami Assaf and Kannan Soundararajan: A Rule of Thumb for Riffle Shuffling. (Received January 27, 2009)

1049-05-35 **Alan Michael Stapledon*** (astapldn@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church St, Ann Arbor, MI 4804. *Weighted Ehrhart Theory.*

In Ehrhart theory, one studies the number of lattice points in any dilation of a lattice polytope P. In this talk, we present a refinement of this theory in which every lattice point v is counted with a particular weight w(v), determined by the smallest rational number m such that v lies in mP. We will show how this leads to simple proofs and generalizations of some classical results of Ehrhart and Hibi. Secondly, we will explain the geometric motivation for this approach. More specifically, we will discuss the correspondence with orbifold Betti numbers of toric stacks. (Received February 04, 2009)

1049-05-49 **Kurt W. Luoto*** (kwluoto@math.washington.edu), University of Washington, Department of Mathematics, Box 354350, Seattle, WA 98195-4350. *Quasisymmetric functions and decomposability of matroid polytopes.*

In 2006, Billera, Jia, and Reiner invented a new invariant for matroids in the form of a quasisymmetric function. They demonstrated a necessary algebraic condition on the decomposability of matroid base polytopes in general. This suggests the question of whether this condition is sufficient for rank two matroids. We answer this question in the affirmative. Along the way, we discovered a new basis for the quasisymmetric functions which has some interesting properties, and found a simple formula for the quasisymmetric function of a loopless rank two matroid.

We conclude with some unpublished data from investigating which matroids on small ground sets have indecomposable polytopes. (Received February 14, 2009)

1049-05-79 **Ruriko Yoshida*** (ruriko.yoshida@uky.edu), 805A Patterson Office Tower, Department of Statistics, University of Kentucky, Lexington, KY 40506. *The balanced minimum evolution polytopes.*

The balanced minimum evolution (BME) is a well-known distance based method to reconstruct a phylogenetic tree from a dissimilarity map. In 2008, Eickmeyer et al. defined the notion of the BME polytopes and showed that the vertices of the BME polytope are the BME vectors of binary trees. The BME vector of the star phylogeny lies in the interior of the BME polytope, and all other BME vectors lie on the boundary of the BME polytope. In addition, Eickmeyer et al. showed that finding the BME tree is solving a linear programming problem over the BME polytope. In this talk we will discuss on the structures of the BME polytopes and also we will discuss some open problems. (Received February 21, 2009)

1049-05-90 **Federico Ardila**, **Carolina Benedetti** and **Jeffrey Doker*** (doker@math.berkeley.edu), 1336 Shotwell St., San Francisco, CA 94110. *Volumes of matroid polytopes.*

We express the matroid polytope P_M of a matroid M as a signed Minkowski sum of simplices, and obtain a formula for the volume of P_M. This gives a combinatorial expression for the degree of an arbitrary torus orbit closure in the Grassmannian $Gr_{k,n}$. We then derive analogous results for the independent set polytope and the associated flag matroid polytope of M. Our proofs are based on a natural extension of Postnikov's theory of generalized permutohedra. (Received February 25, 2009)

1049-05-92 **Marcelo Aguiar*** (maguiar@math.tamu.edu), 3368 Tamu, Department of Mathematics, Texas A&M University, College Station, TX 77843-3368, and **Federico Ardila**. *The Hopf monoid of generalized permutahedra.*

Joyal's notion of species constitutes a good framework for the study of certain algebraic structures associated to combinatorial objects. We discuss the notion of "Hopf monoid" in the category of species and illustrate it with several examples. We introduce the Hopf monoid of generalized permutahedra (the latter are certain polytopes recently studied by Postnikov, Reiner and Williams). Our main result is an explicit antipode formula for this Hopf monoid. We explain how reciprocity theorems of Stanley on graphs and of Billera, Jia and Reiner on matroids can be deduced from this result.

The talk is based on joint works with Swapneel Mahajan and with Federico Ardila. (Received February 24, 2009)

1049-05-93 **Andrew Berget*** (berget@math.umn.edu), School of Mathematics University of Minnesota, 127 Vincent Hall, 206 Church Street Southeast, Minneapolis, MN 55414. *Tensors, Products, and Tutte Polynomials.*

I will start by explaining how the number of no broken circuit bases of a matroid make an unexpected appearance in the smallest symmetric group representation containing a fixed decomposable tensor. Sketching the proof of this result suggests the consideration of the vector space spanned by certain products of linear forms. This vector space interprets the full two-variable Tutte polynomial of a matroid. After indicating the proof of this result, I will pose some open problems. (Received February 24, 2009)

1049-05-99 **Karola Meszaros*** (karola@math.mit.edu). *Triangulation of root polytopes and reduced forms.*

A type A_{n-1} root polytope is the convex hull in $\mathbb{R}^n$ of the origin and some of the points $e_i - e_j$ for $1 \leq i < j \leq n$. We will discuss a connection between triangulations of root polytopes and reduced forms of a monomial in an algebra generated by n^2 variables x_{ij}, for $1 \leq i < j \leq n$. We show that the reduced form is unique, and corresponds to a shellable triangulation of the root polytope in which each simplex corresponds to a noncrossing alternating tree. We also show generalizations to other types. (Received February 25, 2009)

1049-05-112 **Federico Ardila**, **Alex Fink** and **Felipe Rincon*** (feliper84@gmail.com), feliper84@gmail.com. *Valuations for matroid polytope subdivisions.*

I will talk about valuations for matroid polytope subdivisions, i.e., functions that are "well behaved" under subdivisions of a matroid polytope into smaller matroid polytopes. I will show that this is a very interesting class of functions that contains many well-known matroid invariants, including the functions that encode the activities on the bases, the ranks of the subsets, or even the ranks of all maximal flags in a matroid. (Received March 02, 2009)

1049-05-113 **Benjamin J Braun*** (braun@ms.uky.edu), Dept of Mathematics, University of Kentucky, Lexington, KY 40506, and **Matthias Beck** (beck@math.sfsu.edu), Dept of Mathematics, San Francisco State University, 1600 Holloway Ave, San Francisco, CA 94132. *Nowhere harmonic colorings of graphs.* Preliminary report.

Given a simple graph, proper graph colorings and nowhere-zero integer flows are combinatorial structures with interesting enumerative properties. We describe a related combinatorial structure, nowhere harmonic colorings, and show that they are also interesting from an enumerative perspective. Using the theory of inside out polytopes, we obtain enumerative results regarding nowhere harmonic colorings involving quasipolynomials and a combinatorial reciprocity theorem. (Received February 27, 2009)

1049-05-116 **Alex R Fink*** (finka@math.berkeley.edu), Department of Mathematics, 970 Evans Hall #3840, Berkeley, CA 94720-3840. *Universality for valuations of matroid polytope subdivisions.*

Continuing thematically from Felipe Rincon's talk on matroid valuations, I'll prove a conjecture of Harm Derksen (proved jointly with him and David Speyer) providing a basis for the group of valuations. I'll also discuss some bases with nice combinatorics of the group of matroids modulo subdivisions which arise from this approach. (Received March 02, 2009)

1049-05-126 **Suho Oh*** (suho@mit.edu), 70 Pacific #446B, Cambridge, MA 02139. *Positroids and Schubert Matroids.*

Postnikov gave a combinatorial description of the cells in a totally-nonnegative Grassmannian. These cells correspond to a special class of matroids called positroid. We show that a positroid is exactly an intersection of cyclically permuted Schubert matroids induced from a Grassmann necklace. This leads to some nice combinatorial properties. (Received February 28, 2009)

1049-05-136 **Karsten Gimre**, **Indra Shottland** and **Elizabeth Stanhope*** (stanhope@lclark.edu), 0615 SW Palatine Hill Rd, MSC 110, Portland, OR 97219. *What is an orbifold graph, and what do they sound like?* Preliminary report.

Questions in the spectral geometry of Riemannian orbifolds examine the relationship of the singular set of an orbifold to its Laplace spectrum. Recent interest in orbifolds in the mathematics and mathematical physics communities has led to a burst of energy in this area. One may ask if spectral questions about orbifolds can be transferred to the setting of graph theory. There already are nice results linking manifold spectral geometry to spectral graph theory. To do this for orbifolds one first needs to define an orbifold graph. Finding such a definition is the topic of this talk. (Received March 01, 2009)

1049-05-142 **Volkmar Welker*** (welker@mathematik.uni-marburg.de), Philipps-Universität Marburg, Fachbereich Mathematik und Informatik, 35032 Marburg, Germany, and **Martina Kubitzke**. *On the Lefschetz Property for Vernonese Rings.*

We study the Lefschetz property of Cohen-Macaulay standard graded algebras for Veronese rings. In particular, we study the question if for high enough r the rth Veronese algebra of a given algebra is Lefschetz. We collect evidence that this is so by studying the enumerative consequences of the Lefschetz property on the h-vector of the algebra. (Received March 02, 2009)

1049-05-145 **Michael Joswig**, **Benjamin Mueller** and **Andreas Paffenholz*** (paffenholz@math.fu-berlin.de), Freie Universitaet Berlin, Institut fuer Mathematik, Arnimallee 3, 14195 Berlin, Germany. *Lattice Polytopes in polymake.* Preliminary report.

The polymake software system by Gawrilow and Joswig deals with convex polytopes and related objects from geometric combinatorics. The forthcoming polymake release 3 will contain an application that deals with specific properties of lattice polytopes. The main focus of the provided methods is on toric geometry. polymake provides a unified interface to several existing software packages for lattice polytopes (e.g. 4ti2, latte, normaliz), as well as various new methods that link between the programs and compute additional properties. In my talk I will give a short introduction to the polymake system and then report on the lattice polytope application. (Received March 02, 2009)

1049-05-151 **R Basri**, **P Felzenszwalb**, **R Girshick**, **D Jacobs** and **C Klivans*** (cjk@math.uchicago.edu), 1100 E. 58th St., Chicago, IL 60637. *Oriented Matroids and the Geometry of Visibility.*

Object recognition, the ability to recognize what objects are present in a given image, is a major goal of computer vision. One important challenge in visual object recognition involves modeling the variations in appearance that can occur as three-dimensional objects are viewed from different directions.

Given a limited number of images of an object taken from unknown viewpoints, we would like to determine which subsets of features might be simultaneously visible in other views. This leads to the problem of determining whether a set of images, each containing a set of features, is consistent with a single 3D object.

I will talk about how oriented matroids provide a natural model for the geometry of visibility. This perspective leads to complexity results and algorithms that perform well on both synthetic and real image data. (Received March 02, 2009)

1049-05-165 **Sam Payne***, Department of Mathematics, Bldg 380, 450 Serra Mall, Stanford University, Stanford, CA 94305. *Frobenius splittings for lattice polytopes.*

I will discuss some of the combinatorial aspects of diagonal splittings of toric varieties, with a focus on their interpretation and consequences for lattice polytopes. In particular, I will present a combinatorial solution to Oda's Problem for diagonally split lattice polytopes, based on joint work with Christian Haase. (Received March 02, 2009)

1049-05-172 **Alexander Postnikov*** (apost@math.mit.edu), 77 Massachusetts Ave, Cambridge, MA 02139, and **Thomas Lam**, Cambridge, MA. *Polypositroids.*

Cells of the totally nonnegative Grassmannian correspond to a special class of matroids, called positroids. We investigate these matroids in terms of their matroid polytopes. We introduce a more general class of convex polytopes, which we call polypositroids. Polypositroids appear as moment polytopes of torus orbits in the affine Grassmannian. These polytopes have beautiful combinatorial properties. Polypositroids are related to generalized permutohedra, alcoved polytopes, triangulations of products of simplices. A typical polypositroid is the cyclohedron. There are possible relations with cluster algebras. This is a joint work with Thomas Lam. (Received March 02, 2009)

1049-05-179 **Anton Dochtermann*** (anton.dochtermann@gmail.com), Institut fuer Mathematik MA 6-2, TU Berlin, Strasse des 17. Juni 136, 12047 Berlin, Germany, and **Michael Joswig** and **Raman Sanyal**. *Cellular resolutions of monomial ideals from coarse tropical type decompositions.*

In analogy with the (oriented) matroid ideals of Novik, Postnikov, and Sturmfels, we construct cellular resolutions of monomial ideals associated to arrangements of tropical half-spaces. For us, the generators of the ideals are given by the 'coarse type' decomposition of tropical space determined by the arrangement. These coarse type ideals (and their Alexander duals) are related to other well-studied objects, and in particular we use our methods to show that every fine mixed subdivision of the dilated simplex $n\Delta_{d-1}$ supports a minimal resolution of the nth power of the homogeneous maximal ideal in $k[x_1, ..., x_d]$. (Received March 03, 2009)

1049-05-185 **J.A. De Loera**, **Jon Lee**, **Peter N. Malkin** and **Susan Margulies***, Computational and Applied Math Department, Rice University, 6100 Main St. - MS 134, Houston, TX 77005-1892. *Computing Infeasibility Certificates for Combinatorial Problems via Hilbert's Nullstellensatz.*

Systems of polynomial equations with coefficients over a field K can be used to concisely model combinatorial problems. In this way, a combinatorial problem is feasible (e.g., a graph is 3-colorable, hamiltonian, etc.) if and only if a related system of polynomial equations has a solution over the algebraic closure of the field K. In this paper, we investigate an algorithm aimed at proving combinatorial infeasibility based on the observed low degree of Hilbert's Nullstellensatz certificates for polynomial systems arising in combinatorics, and based on fast large-scale linear-algebra computations over K. We also describe several mathematical ideas for optimizing our algorithm, such as using alternative forms of the Nullstellensatz for computation, adding carefully constructed polynomials to our system, branching and exploiting symmetry. We report on experiments based on the problem of proving the non-3-colorability of graphs. We successfully solved graph instances with almost two thousand nodes and tens of thousands of edges. (Received March 03, 2009)

1049-05-187 **Mahshid Atapour*** (atapour@mathstat.yorku.ca), Department of Mathematics, 4700-Keele Street, Toronto, Ontario M3J 1P3, Canada. *Exponential Growth of the Number of n-edge Linked Clusters in $\mathbb{Z}^3$ and the Consequences in Entanglement Percolation.*

An animal in the simple cubic lattice is a finite connected subgraph of $\mathbb{Z}^3$. Let a_n be the number (up to translation) of n-edge animals in $\mathbb{Z}^3$. In 1967, Klarner proved that a_n grows exponentially. Let e_n be the number (up to translation) of all n-edge linked clusters, i.e. subgraphs of $\mathbb{Z}^3$ in which the connected components (animals) are (topologically) non-splittable. In this presentation, I will briefly explain how it can be proved that e_n also has a finite exponential growth rate. I will then mention some of the important consequences of this result in entanglement percolation.

This is a joint work with my postdoc supervisor N. Madras. (Received March 03, 2009)

1049-05-188 **Kevin Woods*** (Kevin.Woods@oberlin.edu), Department of Mathematics, Oberlin College, Oberlin, OH 44074. *A Finite Calculus Approach to Ehrhart Polynomials.* Preliminary report.

Given a polytope P, the lattice point enumerator counts, as a function of t, the number of integer points in the dilated polytope tP. If P has rational vertices, this function is a quasi-polynomial in t, called the Ehrhart

quasi-polynomial. Inspired by the analogy of Ehrhart quasi-polynomials as a discrete version of the volume of a polytope, we present a new proof of the existence of these quasi-polynomials. This proof uses finite calculus and induction, and provides quick proofs of two other related results: McMullen's theorem about the periods of the individual coefficients of the quasi-polynomial, and the Ehrhart-Macdonald theorem on reciprocity. This is joint work with Steven Sam. (Received March 03, 2009)

1049-05-190 **Serkan Hosten*** (serkan@math.sfsu.edu), 1600 Holloway Avenue, San Francisco, CA 94530. *Growth series of cyclotomic and root lattices.*

Given a set of monoid generators of a lattice, one can define the word length function on the elements of the lattice, and the corresponding generating function also known as the growth series of the lattice. This series is the Hilbert series of a toric algebra. In interesting instances, such as in the case of root lattices A_n, C_n and D_n (where the generators are all roots), or for cyclotomic lattices (where the generators are all roots of unity), this algebra is the coordinate ring of a projective toric variety defined by the convex hull of the generators. Methods from toric Groebner bases and Ehrhart theory gives us a unifying approach to compute the growth series of these lattices. (Received March 03, 2009)

1049-05-195 **Olga Holtz***, University of California-Berkeley, Department of Mathematics, 951 Evans Hall #3840, Berkeley, CA 94720, and **Amos Ron** (amos@cs.wisc.edu), University of Wisconsin-Madison, Computer Science Department, 1210 W. Dayton street, Madison, WI 53706. *Zonotopal combinatorics.*

This is a graph-theoretic sequel to our prior algebraic work on the theory of three multivariate polynomial algebras: external, central and external, associated to a given linear endomorphism, its zonotope, and its hyperplane arrangements. When the said endomorphism is induced by a graph, the external algebra provides information about the spanning forests, the central algebra about the spanning trees, and the internal algebra about the spanning trees without internal activity. Correspondingly, three families of parking functions: external, central and internal, are associated to an arbitrary graph. These three classes of parking functions can be also viewed as monomizations of the kernels of the corresponding multivariate polynomial ideals from our earlier work, and the Tutte polynomial of a graph is closely connected to the Hilbert series of its external, central and external algebras. This line of work is motivated by earlier results of Postnikov, B. Shapiro and M. Shapiro on central and external parking functions. (Received March 03, 2009)

1049-05-211 **Raman Sanyal*** (sanyal@math.berkeley.edu). *b-transshipments, modular flow reciprocity, and a combinatorial interpretation of the Tutte polynomial.*

In analogy to the beautiful reciprocity for the chromatic polynomial of a graph we give a combinatorial interpretation for the values of the modular flow polynomial evaluated at a negative integer. The proof involves Ehrhart polynomials of a family of b-transshipment polytopes that encode the combinatorial objects in question. With the modular flow reciprocity we can give a combinatorial meaning to (almost) all evaluations of the Tutte polynomial of a graph. This is joint work with Felix Breuer. (Received March 04, 2009)

11 ► Number theory

1049-11-5 **Hung-ping Tsao*** (hptsao@hotmail.com), 1151 Highland Drive, Novato, CA 94949. *Powered sums as linear combinations of binomial coefficients.*

We shall introduce an inductive method to express the sum of any power of the first n terms of an arithmetically progressive sequence as a linear combination of binomial coefficients. A rather simple recursive formula is also obtained. In general, this method can be applied to any sequence with the sum of the first kn (k is a constant) terms being a linear combination of C(n,2)and C(n,1). For example, for the sequence 1, 2, 4, 5, 7, 8, ..., 3n-2, 3n-1, ... , the sum of the first 2n terms can be expressed as 6C(n,2)+3C(n,1) and that of the second power of which is 36C(n,3)+36C(n,2)+5C(n,1). The iterative method of using integration will also be presented. (Received August 06, 2008)

1049-11-95 **Lenny Fukshansky*** (lenny@cmc.edu), Department of Mathematics, Claremont McKenna College, 850 Columbia Avenue, Claremont, CA 91711. *Points of small height missing a union of varieties.*

Let K be a number field, $\overline{\mathbb{Q}}$, or the field of rational functions on a smooth projective curve of genus 0 or 1 over a perfect field, and let V be a subspace of K^N, $N > 1$. Let Z_K be a union of varieties defined over K such that V is not contained in Z_K. We prove the existence of a point of small height in V outside of Z_K, providing an explicit upper bound on the height of such a point in terms of the height of V and the degree of a hypersurface

containing Z_K, where dependence on both is optimal. Our method is based on some counting lattice points in slices of a cube, a version of combinatorial nullstellensatz, and a version of Siegel's lemma with inhomogeneous heights. As a corollary of the method, we derive an explicit lower bound for the number of algebraic integers of bounded height in a fixed number field. (Received February 24, 2009)

1049-11-118 **Akshay Venkatesh***, akshayv@stanford.edu. *Computing L-functions with homogeneous dynamics.* Preliminary report.

I'll discuss the possibility – not yet realized! – of using homogeneous dynamics to (rapidly) compute values of L-functions. This will be a report on the ongoing work of Pankaj Vishe. (Received February 28, 2009)

1049-11-163 **Manfred Einsiedler** and **Jimmy Tseng***, Department of Mathematics, Ohio State University, 231 West 18th Avenue, Columbus, OH 43210. *Badly approximable systems of affine forms, fractals, and Schmidt games.*

We show that various subsets of badly approximable systems of affine forms, which we can even intersect with a suitable fractal, are winning in the sense of Schmidt games and thus have full Hausdorff dimension and the countable intersection property. Hence, the intersection over a countable family of winning sets for the suitable fractal also has full Hausdorff dimension. (Received March 02, 2009)

13 ► Commutative rings and algebras

1049-13-147 **Hidefumi Ohsugi*** (ohsugi@rkmath.rikkyo.ac.jp), College of Science, Rikkyo University, 3-34-1 Nishi-Ikebukuro, Toshima-ku, Tokyo, 171-8501, Japan. *Toric ideals of nested configurations.*

This is a joint work with Satoshi Aoki, Takayuki Hibi and Akimichi Takemura. Segre product and Veronese subring are important operations to study semigroup rings. We introduce the notion of nested configurations which is a generalization of these operations. In particular, Gröbner bases of toric ideals of nested configurations are studied. As an application, we discuss quadratic Grönber bases of toric ideals arising from certain convex polytopes. (Received March 02, 2009)

14 ► Algebraic geometry

1049-14-81 **Diane Maclagan*** (d.maclagan@warwick.ac.uk). *Combinatorial bounds on nef cones.* Preliminary report.

The nef cone is a convex, but not necessarily polyhedral, cone associated to a variety X. When X is a (complete) toric variety determined by a polytope P, the nef cone is a well-understood polyhedral cone. I will describe joint work with Angela Gibney (Georgia) bounding the nef cone of X using information from a suitably chosen embedding of X into a (non-complete) toric variety. (Received February 22, 2009)

1049-14-146 **H. Schenck*** (schenck@math.uiuc.edu), Math Dept, UIUC, 1409 W. Green St, Urbana, IL 61801, and **M Stillman** (mike@math.cornell.edu). *Toric specializations of the Rees algebra of Koszul cycles.*

We describe obstructions to a conjecture that the length of the 2-linear strand of a homogeneous, prime, nondegenerate ideal I with degree two piece generated by quadrics of rank at most four is governed by a determinantal subideal of I, and prove a variant of the conjecture. The obstructions arise from toric specializations of the Rees algebra of Koszul cycles, and we give an explicit construction of toric varieties with minimal linear syzygies of arbitrarily high rank. (Received March 02, 2009)

1049-14-166 **Milena Hering***, The Mathematical Sciences Research Institute, 17 Gauss Way, Berkeley, CA 94720, and **Benjamin Howard**. *The caterpillar polytope and its relatives.*

To a trivalent tree on n leaves with a positive weight attached to each leaf is associated a lattice polytope. The corresponding toric embeddings arise as toric degenerations of the moduli space of n weighted ordered points on $\mathbb{P}^1$. I will discuss the Ehrhart polynomials of these polytopes and show that the toric ideals admit a quadratic Gröbner basis. This is joint work with Ben Howard. (Received March 02, 2009)

1049-14-177 **Dimitri Zvonkine*** (dimitri.zvonkine@gmail.com). *Completed cycles and singularities of stable maps.*

For every family of genus 0 stabe maps to $\mathbb{C}P^1$ we can consider the locus of points where the map presents some given kind of singularity (chosen from the list of all possible singularities for genus 0 stable maps). We provide an effective method to compute the cohomology class Poincaré dual to this locus in terms of several "basic" classes. These expressions are universal, i.e., they do not depend on the family. They are called (generalized) Thom polynomials.

In the second part of the talk, insofar as time permits, we will present several conjectures concerning Thom polynomials for genus g stable maps. They are related to the representation theory of the symmetric group (more precisely, to the so-called completed cycles), to the Gromov-Witten invariants of curves and to a conjectural ELSV formula for the space of r-spin structures. (Received March 03, 2009)

15 ► Linear and multilinear algebra; matrix theory

1049-15-9 **Mostafa Ghandehari*** (ghandeha@uta.edu), civil engineering, Univ. of Texas at Arlington, Box 19308, Arlington, TX 76019, and **Shiva Keramati**, San Francisco, CA. *A Discrete Pharmacokinetics Compartmental Model.* Preliminary report.

A system of differential equations for compartmental model of pharmacokinetics is discussed. Discrete approximation of the system will result in a system of difference equations. Eigenvalues and eigenvectors are used to find powers of a matrix which will be used to find an approximate solution of the system. Examples of medications for comparmental models are given. (Received November 30, 2008)

16 ► Associative rings and algebras

1049-16-71 **Tom Braden**, **Anthony Licata** and **Nicholas Proudfoot*** (njp@uoregon.edu), Department of Mathematics, 122 University of Oregon, Eugene, OR 97403, and **Ben Webster**. *Gale duality and Koszul duality.*

I will explain a new way to associate a finite-dimensional noncommutative algebra to a real hyperplane arrangement. Though motivated by the symplectic and algebraic geometry of hypertoric varieties, the definition is purely combinatorial. I will discuss some of the beautiful features of this algebra, including the fact that Gale dual hyperplane arrangements give rise to Koszul dual algebras. (Received February 20, 2009)

17 ► Nonassociative rings and algebras

1049-17-4 **Efim Zelmanov***, Department of Mathematics. *Asymptotic properties of finite groups and finite dimensional algebras.*

We will discuss asymptotic properties of finite groups and finite-dimensional algebras. (Received April 01, 2008)

1049-17-47 **Ya. S. Krylyuk*** (krylioukiaroslav@deanza.edu), 21250 Stevens Creek Boulevard, Cupertino, CA 95014. *The enveloping algebra of the Petrogradsky-Shestakov-Zelmanov algebra is not graded-nil in critical characteristics.* Preliminary report.

Generalizing Petrogradsky's construction, I.P. Shestakov and E. Zelmanov gave an example of a two-generated infinite-dimensional nil Lie algebra of finite Gelfand-Kirillov dimension over any field of positive characteristic. For "generic" characteristics of a ground field the algebra is graded by free abelian group of rank two. This grading collapses for the characteristics, which we call the critical ones. We prove that in the critical characteristics the enveloping algebra of the Petrogradsky-Shestakov-Zelmanov algebra is not graded-nil. (Received February 15, 2009)

20 ► Group theory and generalizations

1049-20-3 **Karen Vogtmann*** (vogtmann@math.cornell.edu), Mathematics Department, 503 Malott Hall, Ithaca, NY 14853-4201. *Actions of automorphism groups of free groups.*

In recent years, automorphism groups of free groups have been shown to have many features in common with lattices in semisimple Lie groups, though they are not in fact lattices. Many of these features are proved using analogs of classical spaces such as homogeneous spaces and representation varieties, on which these groups

act in interesting ways. I will survey our progress on understanding these spaces, and also on understanding rigidity-type phenomena which prevent these groups from acting on very simple spaces. (Received March 02, 2009)

1049-20-11 **Claire Wladis*** (cwladis@gmail.com). *Unusual Geodesics in Generalizations of Thompson's Group.*

We prove that seesaw words exist in Thompson's Group $F(N)$ for $N = 2, 3, 4, ...$ with respect to the standard finite generating set X. A seesaw word w with swing k has only geodesic representatives ending in g^k or g^{-k} (for given $g \in X$) and at least one geodesic representative of each type. The existence of seesaw words with arbitrarily large swing guarantees that $F(N)$ is neither synchronously combable nor has a regular language of geodesics. Additionally, we prove that dead ends (or k–pockets) exist in $F(N)$ with respect to X and all have depth 2. A dead end w is a word for which no geodesic path in the Cayley graph Γ which passes through w can continue past w, and the depth of w is the minimal $m \in \mathbb{N}$ such that a path of length $m+1$ exists beginning at w and leaving $B_{|w|}$. We represent elements of $F(N)$ by tree-pair diagrams so that we can use Fordham's metric. This generalizes results by Cleary and Taback, who proved the case $N = 2$. (Received January 05, 2009)

1049-20-91 **Matthew B Day*** (mattday@caltech.edu), Department of Mathematics, Caltech, Pasadena, CA 91125. *Symplectic structures on right-angled Artin groups: between the mapping class group and the symplectic group.*

We define a family of groups that include the mapping class group of a genus g surface with one boundary component and the integral symplectic group $\mathrm{Sp}(2g, \mathbb{Z})$. We then prove that these groups are finitely generated. These groups, which we call mapping class groups over graphs, are indexed over labeled simplicial graphs with $2g$ vertices. The mapping class group over the graph Γ is defined to be a subgroup of the automorphism group of the right-angled Artin group A_Γ of Γ. We also prove that the kernel of the map $\mathrm{Aut}\, A_\Gamma$ to $\mathrm{Aut}\, H_1(A_\Gamma)$ is finitely generated, generalizing a theorem of Magnus. (Received February 24, 2009)

1049-20-106 **Jon McCammond*** (jon.mccammond@math.ucsb.edu), University of California Santa Barbara, Mathematics Department, Santa Barbara, CA 93106. *Braids, posets and orthoschemes.*

An orthoscheme is the convex hull of a piecewise linear path that proceeds in mutually orthogonal directions. These shapes arise naturally in the barycentric subdivision of a regular polytope and the "standard" n-orthoscheme arises in the subdivision of an n-cube. In the first part of the talk I will discuss how using orthoschemes to add a metric to the order complex of a bounded graded poset leads to a metric simplicial complex whose curvature properties are easier to assess. In particular I will present a theorem characterizing when the orthoscheme complex of a bounded graded poset of rank at most 4 is CAT(0) and as a consequence conclude that the 5-string braid group is a CAT(0) group. This is joint work with Tom Brady. In the second part, I will discuss the context in which this result occurs. In particular, there is a broad program to (eventually) understand an arbitrary Artin group by viewing it as a group that has been "pulled apart". The Artin program and its results to date will be described as time permits. (Received February 26, 2009)

1049-20-107 **Sang-hyun Kim*** (shkim@math.utexas.edu), the Univ. of Texas at Austin, Austin, TX 78712. *Surface Subgroups of Graph Products of Groups.*

For a given group, finding a surface subgroup (namely, a subgroup isomorphic to the fundamental group of a closed hyperbolic surface) is an important question motivated by 3-manifold theory. In particular, a conjecture raised by Gromov asserts that every 1-ended word-hyperbolic group contains a surface subgroup. In this talk, I will present results concerning surface subgroups of groups defined by graphs: right-angled Artin and Coxeter groups, and graph products of finite groups. More precisely, I will describe lower and upper bounds for the classes of graphs on which these groups contain surface subgroups. As a corollary, the class of all the finitely generated groups satisfying the Gromov conjecture (i.e. groups which are either not 1-ended, not word-hyperbolic or having surface subgroups) is closed under taking graph products. (Received February 26, 2009)

1049-20-181 **Alexandra R Pettet*** (apettet@umich.edu), Department of Mathematics, University of Michigan, 2074 East Hall, 530 Church St, Ann Arbor, MI 48109, and **Matt Clay**. *Twisting out fully irreducible automorphisms.*

By a theorem of Thurston, in the subgroup of the mapping class group generated by Dehn twists around two curves which fill, every element not conjugate to a power of one of the twists is pseudo-Anosov. We prove an analogue of this theorem for the outer automorphism group of a free group. (Received March 03, 2009)

1049-20-199 **Hanna Bennett*** (hbennett@math.uchicago.edu), IL. *Area distortion in groups.*
Given a finite presentation for a group H, a word representing the identity in H can be written as a product of conjugates of relators. If H is a subgroup of a finitely presented group G, it may be the case that the number of relators needed in the presentation for H is much greater than the number needed for G. I will define the area distortion function, which measures this difference, and compute some key examples. (Received March 03, 2009)

1049-20-200 **Ethan Berkove** (berkovee@lafayette.edu), Department of Mathematics, Lafayette College, Easton, PA 18042, **Sejal Dharia** (skdharia1@yahoo.com), Department of Mathematics, San José State University, San José, CA 95192-0103, and **Tim Hsu*** (hsu@math.sjsu.edu), Department of Mathematics, San José State University, San José, CA 95192-0103. *The ℓ^2-invariants of clean 2-complexes.* Preliminary report.
A *clean 2-complex* has a graph of spaces decomposition where the vertex and edge spaces are graphs and the attaching maps are graph embeddings. We discuss algebraic, topological, and combinatorial aspects of the computation of the ℓ^2-Betti numbers of clean 2-complexes. (Received March 03, 2009)

1049-20-201 **Kevin Wortman*** (wortman@math.utah.edu). *Dehn functions of linear groups.*
I'll describe some examples of groups that have polynomial Dehn functions. (Received March 03, 2009)

1049-20-207 **Angela Kubena Barnhill*** (barnhill@math.northwestern.edu), Department of Mathematics, Northwestern University, Evanston, IL 60208, and **Anne Thomas**. *Commensurability and unfoldings of uniform lattices in right-angled buildings.*
In the Lie group setting, Margulis proved that a lattice is arithmetic if and only if its commensurator is dense. In the case of automorphism groups of trees, Liu showed that every cocompact lattice has dense commensurator. We consider commensurators of cocompact lattices in the automorphism groups of right-angled buildings and use a technique of "unfolding" to show that the commensurator of the standard uniform lattice is dense. (Received March 03, 2009)

32 ► Several complex variables and analytic spaces

1049-32-31 **Alexander J. Izzo*** (aizzo@math.bgsu.edu), Department of Mathematics and Statistics, Bowling Green State University, Bowling Green, OH 43403. *Function Algebras Invariant under Group Actions.*
We will answer a question raised by Ronald Douglas in connection with his work on a conjecture in operator theory due to William Arveson. Let S denote the unit sphere in $\mathbf{C}^n$. If A is a function algebra on S that contains the ball algebra $A(S)$ and whose maximal ideal space is S, and if A is invariant under the action of the n-torus on S, does it follow that $A = C(S)$? When $n = 1$, Wermer's maximality theorem gives immediately that the answer is yes. Surprisingly, in higher dimensions the answer depends on the dimension. The proof is related to a peak point theorem of John Anderson and the speaker and counterexamples to the peak point conjecture due to Richard Basener and the speaker.

We will also present a related result of a more general nature concerning function algebras that are invariant under a transitive group action. (Received February 03, 2009)

1049-32-43 **John Wermer***, Department of Mathematics, Brown University, Providence, RI. *A Cauchy-Riemann equation for generalized analytic functions.*
In (1),"Generalized Analytic Functions",TAMS 81 (1956), R.Arens and I. Singer studied the following generalization of the disk algebra.T^2 is the 2-torus and α is a positive irrational number .A_α is the algebra of all continuous functions on T^2 with Fourier coefficients in the half-plane :$n + m\alpha| \geq 0$.The maximal ideal space of A_α identifies with the set M of $(z, w)||w| = |z|^\alpha, |z| \leq 1$ in C^2. Helson and Lowdenslager in 1959 developed a rich theory of A_α.Define the differential operator $X = \bar{z}\delta_{\bar{z}} + \alpha\bar{w}\delta_{\bar{w}}$ on C^2. X is well-defined on the 3-manifold M. $(0, 0)$. Using results in (1), we prove Theorem: A_α consists of all f in $C(T^2)$ which have a continuous extension F to M such that $X(F) = 0$ in the sense of distributions on M minus $(0, 0)$. (Received February 12, 2009)

1049-32-205 **Marshall A. Whittlesey*** (mwhittle@csusm.edu), Department of Mathematics, California State University San Marcos, San Marcos, CA 92069. *Extremal problems for analytic discs and analytic balls, and polynomial hulls.*
We will consider an extremal problem for analytic functions on a general domain D in $\mathbf{C}^n$. If we demand that an analytic function f continuous up to the boundary of D satisfy $f(z) \in S_z$ for a prescribed set S_z, what are

the possible values of $f(0)$? What are the extremal values of $f(0)$? We will in particular consider the sitation where $f(0)$ could be any value that could be reached by an analytic function defined on an analytic subdisc of D, subject to the same boundary values. That is, suppose there exists an analytic subdisc $R \subset D$ which passes through 0 and has boundary $\partial R \subset \partial D$, ϕ is analytic on R, and $\phi(z) \in S_z$ for all $z \in \partial R$. Does there exist an analytic f with the above constraints such that $f(0) = \phi(0)$? We shall see when this is indeed the case. (Received March 03, 2009)

35 ► Partial differential equations

1049-35-10 **Yuncheng You*** (you@math.usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 East Fowler Avenue, PHY 114, Tampa, FL 33620. *Exponential Attractors for Reversible Cubic Autocatalytic Reaction-Diffusion Systems.*

The existence of a global attractor and an exponential attractor for a class of reversible cubic autocatalytic reaction-diffusion systems represented by the Gray-Scott equations is proved. The key methodology is rescaling and grouping estimation combined with a new decomposition in showing the asymptotical compactness.

This result reveals that even though these reaction-diffusion systems feature oppositely signed, coupled nonlinear terms that do not satisfy the dissipative sign condition, the solution semiflow still admits dissipativity and all the trajectories converge to a compact, positively invariant subset of finite fractal dimension at a uniform exponential rate. (Received January 05, 2009)

1049-35-13 **Shusen Ding*** (sding@seattleu.edu), Department of Mathematics, Seattle University, Seattle, WA 98122. *A-Harmonic Equations for Differential Forms.*

The A-harmonic equations belong to the nonlinear elliptic equations written in terms of an operator A satisfying certain structural assumptions. The study of the A-harmonic equation for differential forms has developed rapidly in recent years. The A-harmonic equation is an important extension of the p-harmonic equation in $\mathbf{R}^n$, $p > 1$. In the meantime, the p-harmonic equation is a natural generalization of the usual Laplace equation. The A-harmonic equation is closely connected to the fields such as potential theory, quasiconformal mappings and the theory of elasticity, etc.

In this presentation, we will first introduce different versions of the A-harmonic equation. Then, we study the integral properties of the solutions of the A-harmonic equation in different domains. (Received January 07, 2009)

1049-35-16 **Jeremy Marzuola** and **Sarah Raynor*** (raynorsg@wfu.edu), Department of Mathematics, Wake Forest University, P.O. Box 7388, Winston Salem, NC 27109, and **Gideon Simpson** and **Catherine Sulem**. *A system of ODEs for a Perturbation of a Minimal Mass Soliton.*

In this work we study soliton solutions to the nonlinear Schrödinger equation with a saturated nonlinearity. It is known that these nonlinearities have minimal-mass soliton solutions. We consider a small perturbation of the minimal mass soliton, and provide analysis to find a system of ODEs which model the behavior of the perturbation for short times. We then provide numerical evidence that under this system of ODEs a generic initial perturbation tends to the stable side of the soliton curve. This provides some initial evidence that even though the minimal mass soliton itself is known to be unstable,[**?**] small initial perturbations of the minimal mass soliton do tend to approach a stable soliton over time. (Received January 15, 2009)

1049-35-17 **Thomas R Bewley*** (bewley@ucsd.edu), Dept of MAE, UC San Diego, La Jolla, CA 92037. *Filtering, smoothing, and quasi-reversibility, and their relationship to the estimation and forecasting problems in chaotic PDE systems with diffusion.*

Motivated by problems ranging from global-scale weather forecasting and urban-scale contaminant plume forecasting all the way down to feedback flow control in agile unmanned aerial vehicles, it is often desirable to estimate the current state of a PDE system given an approximate model of the system and noisy measurements thereof.

This talk will begin with a review of the two existing classes of tractable "data assimilation" methods designed to estimate the state of such complex multiscale systems. We will then outline the new hybrid Ensemble/Variational Estimation (EnVE) approach which our lab has developed to address such problems, which consistently combines these two classes of methods in a clever way. We will focus in particular on the peculiar utility of approximate backwards-in-time marches of diffusive PDE systems in this setting. (Received January 17, 2009)

1049-35-25 **Thomas Chen** and **Natasa Pavlovic*** (natasa@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *The quintic NLS as the mean field limit of a Boson gas with three-body interactions.*

In this talk we will discuss the dynamics of a boson gas with three-body interactions in dimensions $d = 1, 2$. We prove that in the limit where 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. The solutions of the GP hierarchy are shown to be determined by solutions of a quintic nonlinear Schrödinger equation. Our proof is based on, and extends, methods of Erdös-Schlein-Yau, Klainerman-Machedon, and Kirkpatrick-Schlein-Staffilani. (Received January 24, 2009)

1049-35-27 **Thomas Chen** and **Natasa Pavlovic*** (natasa@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *On the Cauchy problem for focusing and defocusing Gross-Pitaevskii hierarchies.*

We consider the dynamical Gross-Pitaevskii (GP) hierarchy on $\mathbb{R}^d$, $d \geq 1$, for cubic, quintic, focusing and defocusing interactions. For both the focusing and defocusing case, and any $d \geq 1$, we prove local wellposedness of the Cauchy problem in weighted Sobolev spaces $\mathcal{H}^\alpha_\xi$ of sequences of marginal density matrices, for

$$\alpha \begin{cases} > & \frac{1}{2} & \text{if } d = 1 \\ > & \frac{d}{2} - \frac{1}{2(p-1)} & \text{if } d \geq 2 \text{ and } (d,p) \neq (3,2) \\ \geq & 1 & \text{if } (d,p) = (3,2)\,, \end{cases}$$

where $p = 2$ for the cubic, and $p = 4$ for the quintic GP hierarchy; the parameter $\xi > 0$ is arbitrary and determines the energy scale of the problem. This result includes the proof of an a priori spacetime bound conjectured by Klainerman and Machedon for the cubic GP hierarchy in $d = 3$.

Also, in the defocusing case, we prove global wellposedness in $\mathcal{H}^1_\xi$ of the cubic GP hierarchy for $1 \leq d \leq 3$, and of the quintic GP hierarchy for $1 \leq d \leq 2$. For the focusing GP hierarchies, we prove lower bounds on the blowup rate. All of these results hold without the assumption of factorized initial conditions. (Received January 24, 2009)

1049-35-36 **Nikolaos Tzirakis*** (tzirakis@math.uiuc.edu), Department of Mathematics, University of Illinois, 1409 W Green Street, Urbana, IL 61801. *Remarks on global a priori estimates for the nonlinear Schroedinger equation.*

I will present a unified approach for obtaining global a priori estimates for solutions of nonlinear Schroedinger equations with power type nonlinearities. (Received February 04, 2009)

1049-35-42 **Jiahong Wu*** (jiahong@math.okstate.edu), 401 Mathematical Sciences, Department of Mathematics, Stillwater, OK 74078. *Global regularity for the 2D MHD equations with mixed partial dissipation and magnetic diffusion.*

This talk presents a recent work with Chongsheng Cao on the 2D MHD equations [1]. Whether or not classical solutions of the 2D incompressible MHD equations without full dissipation and magnetic diffusion can develop finite-time singularities is a difficult issue. A major result of this work establishes the global regularity of classical solutions for the MHD equations with mixed partial dissipation and magnetic diffusion. In addition, the global existence, conditional regularity and uniqueness of a weak solution is obtained for the 2D MHD equations with only magnetic diffusion.

References

[1] C. Cao and J. Wu, Global regularity for the 2D MHD equations with mixed partial dissipation and magnetic diffusion, arXiv:0901.2908v1 [math.AP] 19 Jan 2009 (http://arxiv.org/abs/0901.2908).

(Received February 11, 2009)

1049-35-48 **A. V, Balakrishnan*** (bal@ee.ucla.edu). *AeroElastic Stability in Viscous Flow.*

The dynamics of a wing structure (airfoil) in compressible viscous flow is modelled using the Navier Stokes Equation (Received February 14, 2009)

1049-35-61 **Alexandre J. Chorin*** (chorin@math.berkeley.edu), Dept. of Mathematics, University of California, Berkeley, Berkeley, CA 94720. *Commuting conditional expectations and nonlinear evolution.*

Let a vector u satisfy a (possibly stochastic) nonlinear equation du/dt=R(u), and suppose you measure u at time t=0; how do you estimate u at a later time t? This question is answered by tools borrowed from the statistical mechanics of irreversible systems, which allow one to commute nonlinear evolution and conditional averaging.

The resulting construction makes it possbile to estimate solutions of differential equations with partial or uncertain data, and to overcome some of technical difficulties in the statistical mechanics of partial differential equations. The applications include problems from hydrodynamics.

(Work joint with O. Hald, R. Kupferman, and P. Stinis) (Received February 17, 2009)

1049-35-73 **Zoran Grujic*** (zg7c@virginia.edu), Department of Mathematics, Kerchof Hall, University of Virginia, Charlottesville, VA 22904. *Localization of vortex-stretching in the 3D NSE.*

Vortex-stretching is localized to an arbitrarily small parabolic cylinder. This yields a complete localization of the geometric conditions for the regularity involving coherence of the vorticity direction as well as some local analytic conditions for preventing the formation of singularities. (Received February 20, 2009)

1049-35-109 **Daniel Tataru*** (tataru@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, Berkeley, CA 94720. *Blow up phenomena in energy critical dispersive equations.*

I will give an overview of current results, methods and open problems concerning blow-up for energy critical dispersive equations. The type of blow-up considered here occurs along families of rescaled solitons. (Received February 26, 2009)

1049-35-111 **Marius Beceanu***, 5734 S. University Ave., University of Chicago Mathematics Department, Chicago, IL 60637. *A Centre-Stable Manifold in $H^{1/2}$ for the $H^{1/2}$ Critical NLS.*

Consider the $H^{1/2}$-critical Schrödinger equation with a cubic nonlinearity in $\mathbb{R}^3$

$$i\partial_t\psi + \Delta\psi + |\psi|^2\psi = 0.$$

It admits an eight-dimensional manifold of periodic solutions called solitons

$$e^{i(\Gamma + vx - t|v|^2 + \alpha^2 t)}\phi(x - 2tv - D, \alpha),$$

where $\phi(x, \alpha)$ is a positive ground state solution of the semilinear elliptic equation

$$-\Delta\phi + \alpha^2\phi = \phi^3.$$

We prove that in the neighborhood of the soliton manifold there exists a $H^{1/2}$ Lipschitz manifold N of asymptotically stable solutions of the equation, meaning they are the sum of a moving soliton and a dispersive term. Furthermore, a solution starting on N remains on N for all positive time and for some finite negative time and N can be identified as the centre-stable manifold for this equation.

The proof is based on the method of modulation, introduced by Soffer and Weinstein and adapted by Schlag to the L^2-supercritical case.

The main result depends on a spectral assumption concerning the absence of embedded eigenvalues.

New estimates for the time-dependent and time-independent linear Schrödinger equation are also established. (Received February 26, 2009)

1049-35-114 **M. Burak Erdogan*** (berdogan@math.uiuc.edu). *Exponential decay of dispersion managed solitons.*

We study the decay and smoothness of the solutions of the dispersion managed nonlinear Schrodinger equation in the case of vanishing average dispersion. We prove that the soliton-like solutions and their Fourier transforms decay exponentially at infinity. The proof uses exponentially weighted multilinear estimates. This is a joint work with D. Hundertmark and Y.-R. Lee. (Received February 27, 2009)

1049-35-123 **Kiril Datchev*** (datchev@math.berkeley.edu) and **Ivan Ventura** (iventura@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *Soliton evolution in the Hartree equation with slowly varying potential.*

We study the Hartree equation with a slowly varying smooth potential, $V(x) = W(hx)$, and with an initial condition which is ϵ away in H^1 norm from a soliton. We show that up to time $\log(1/h)/h$ and errors of size $\epsilon + h^2$ in H^1, the solution is a soliton evolving according to the classical dynamics of a natural effective Hamiltonian, which we compute explicitly. This result is based on methods of Holmer-Zworski, who prove a similar theorem for the Gross-Pitaevskii equation, and on spectral estimates for the linearized Hartree operator recently obtained by Lenzmann. (Received February 28, 2009)

1049-35-137 **Mihai Horia Tohaneanu*** (mihai@math.berkeley.edu), 2135 Cedar St, Berkeley, CA 94709. *Local Energy Decay on Schwarzschild and Kerr black hole backgrounds.*

Understanding the decay of linear waves is crucial in dealing with the problem of stability of the Kerr space time. I will talk about one way to measure this decay, namely local energy estimates, from which one can deduce many other useful estimates (uniform energy bounds, pointwise bounds, Strichartz estimates etc). This is joint work with Jeremy Marzuola, Jason Metcalfe and Daniel Tataru (for Schwarzschild) and Daniel Tataru (for Kerr). (Received March 01, 2009)

1049-35-138 **Irena M Lasiecka*** (il2v@virginia.edu), Department of Mathematics, University of Virginia, Charlottesvile, VA 22901. *Well-posedness and long time behavior of weak solutions to Boussinesq-Kirchoff equations.*

Dynamics for a class of nonlinear 2D Kirchhoff-Boussinesq models will be considered. These nonlinear plate models are characterized by a presence of a nonlinear source that alone leads to finite -time blow up of solutions. In order to counteract, restorative forces are introduced, which however are of a supercritical nature. This raises natural problems related to existence and wellposedness of finite energy (weak) solutions.

It is shown that finite energy solutions do exist globally , are unique and satisfy Hadamard wellposedness criterium. In addition, existence of global attractors is established. The proof is based on logarithmic control of the lack of Sobolev's embedding along with the method introduced in I. Chueshov and I. Lasiecka,Long-time behavior of second order evolution equations with nonlinear damping, Memoirs of AMS, vol.195, no. 912, AMS, 2008, and J. Ball, Global attractors for semilinear wave equations DCDS, 2004. (Received March 01, 2009)

1049-35-154 **Steve Shkoller*** (shkoller@math.ucdavis.edu), Department of Mathematics, University of California Davis, Davis, CA 95616. *A degenerate hyperbolic free-boundary problem for 3D compressible Euler flow in physical vacuum and the method of artificial phase.*

We prove existence and uniqueness for the three-dimensional compressible Euler equations with moving *physical* vacuum boundary, with an equation of state given by $p(\rho) = C_\gamma \rho^\gamma$ for $\gamma > 1$. The vacuum condition necessitates the vanishing of the pressure, and hence density, on the dynamic boundary, which creates a degenerate and characteristic hyperbolic *free-boundary* system to which standard methods of symmetrizable hyperbolic equations cannot be applied. We introduce a new method, which we call the *method of artificial phase*, to construct solutions for degenerate hyperbolic systems of equations, and apply it the degenerate compressible Euler equations. With this method, solutions to the compressible Euler equations are constructed as a limit of a sequence of two-phase problems, where one phase consists of non-degenerate Euler equations with initial density function $\rho_0^\epsilon = \rho_0 + \epsilon$ for $\epsilon > 0$, and the other artificial phase consists of a specially chosen elliptic system coupled to the Euler equations in such a way as to a priori smooth the moving vacuum boundary. This work is in collaboration with D. Coutand and H. Lindblad. (Received March 02, 2009)

1049-35-157 **Jalal Shatah** and **Chongchun Zeng*** (zengch@math.gatech.edu). *Free boundary problems of the Euler equation: local well-posedness and hydrodynamical instabilities.*

We consider the evolution of fluid-vacuum surfaces and fluid-fluid interfaces, which may involve vorticity, gravity, or surface tension. The evolution of these free fluid surfaces and the velocity fields is determined by the free boundary problem of the Euler's equation. These problems can be considered in a Lagrangian formulation on infinite dimensional Riemannian manifolds of volume preserving diffeomorphisms. In this setting, the physical pressure turns out to come from the combination of the gravity, surface tension, and the Lagrangian multiplier. The vorticity is naturally related to an invariant group action. In the absence of surface tension, the well-known Rayleigh-Taylor and Kelvin-Helmholtz instabilities appear naturally related to the signs of the curvatures of those infinite dimensional manifolds. The surface tension produces a stronger conservative force than the instabilities and thus regularizes the surface evolution. Based on these considerations, we obtain the local well-posedness of these problems with surface tension in a rather uniform energy method. In particular, for the cases without surface tension which do not involve hydrodynamical instabilities, we obtain the local existence of solutions by taking the vanishing surface tension limit. (Received March 02, 2009)

1049-35-159 **Matthew D Blair*** (blair@math.unm.edu). *Strichartz estimates for the Schrödinger equation in exterior domains.*

Strichartz estimates are a family of space-time integrability estimates for the Schrödinger equation that rely on the dispersive effect of the solution map. Generally speaking, these estimates are well-understood when the equation is posed over Euclidean space. However, the situation is much more complicated when one starts to consider the obstacle problem, as the local and global geometry of the boundary can influence how waves develop. We will survey recent parametrix constructions that yield these inequalities, including a recent joint

work with H. Smith and C. Sogge. A key feature of such constructions is the use of related local smoothing estimates which handle the error terms. Applications to semilinear Schrödinger equations will also be discussed. (Received March 02, 2009)

1049-35-167 **Qi S. Zhang***, Math. Dept., UCR, Riverside, CA 92521, and **Jenn Burke**, Math. Dept. UC Riverside, Riverside, CA 92521. *A Priori Bounds for the Vorticity of Axis Symmetric Solutions to the Navier-Stokes Equations.*

We obtain a pointwise, a priori bound for the vorticity of axis symmetric solutions to the 3 dimensional Navier-Stokes equations. The bound is in the form of a reciprocal of a power of the distance to the axis of symmetry. It seems to be the first general pointwise upper bound established for the axis symmetric Navier-Stokes equations.

This is a joint work with Jenn Burke. (Received March 02, 2009)

1049-35-171 **Maria Elena Schonbek*** (schonbek@math.ucsc.edu), UCSC, Math department, Santa Cruz, CA 95060, and **Clayton BJorland**. *Questions on steady state Navier-Stoke equations.*

I will consider the steady-state Navier-Stokes equation in the whole space $\mathbb{R}^3$ driven by a forcing function f. I will show that given any $M > 0$ we can find a class of forcing terms for which there exists solutions U with bounds $\|U\|_{L^2(\mathbb{R}^3)} \leq M$. The main conditions on the source terms f is absence of low modes and the ratio of f to viscosity is sufficiently small in a natural norm. These solutions are unique among all solutions with finite energy and finite Dirichlet integral. Using Fourier-splitting tools, the constructed solutions will be shown to be stable in the following sense: If U is such a solution then any viscous, incompressible flow in the whole space, driven by f and starting with finite energy, will return to U. (Received March 02, 2009)

1049-35-173 **Ning Ju*** (ningju@math.okstate.edu), Department of Mathematics, Oklahoma State University, 401 Mathematical Sciences, Stillwater, OK 74078. *Global Wellposedness for the 2D Boussinesq Equations with Fractional Dissipation.*

Consider the following initial value problem of the two dimensional Boussinesq equation with fractional dissipation:

$$\begin{cases} \partial_t v + (v\cdot\nabla)v &= -\nabla p + \theta e_2 - \nu\Lambda^{2\beta} v, \quad \Lambda = (-\Delta)^{\frac{1}{2}}, \\ \nabla\cdot v &= 0, \\ \theta_t + v\cdot\nabla\theta &= -\kappa\Lambda^{2\alpha}\theta, \\ v(\cdot,0) &= v_0, \\ \theta(\cdot,0) &= \theta_0. \end{cases}$$

where $v(x,t)$ is the velocity vector field of the incompressible fluid, $\theta(x,t)$ is the fluid temperature, p is the fluid pressure and e_2 is the vector $(0,1)$ in the physical domain. The parameters $\alpha, \beta \in [0,1)$, $\nu, \kappa > 0$ are constants.

We prove existence and uniqueness of the global (in time) strong solution to the above Cauchy problem in Sobolev space for $\alpha \geqslant \frac{1}{2}$ and $\beta \geqslant \frac{1}{2}$. Other related issues will also be discussed. (Received March 03, 2009)

1049-35-174 **Stephen Gustafson** (gustaf@math.ubc.ca), Department of Mathemtics, The University of British Columbia, Vancouver, BC V6T 1Z2, Canada, and **Tuoc Van Phan*** (phan@math.ubc.ca), Department of Mathematics, The University of British Columbia, Vancouver, BC V6T 1Z2, Canada. *Stable Directions for Degenerate Excited States of Nonlinear Schrödinger Equations.*

We consider the nonlinear Schrödinger equations $i\partial_t\psi = H_0\psi + \lambda|\psi|^2\psi$ in $\mathbb{R}^3$ where $H_0 = -\Delta + V$ and λ is an order one constant which can be positive or negative. Assume that the potential V is radial and decays sufficiently fast at infinity. Assume also that the linear Halmitonian H_0 has only two discrete eigenvalues $e_0 < e_1 < 0$ where e_0 is simple and e_1 has multiplicity three. We show that there exist two classes of nonlinear excited states of the equation and for certain finite codimension subset in the space of initial data, we construct solutions ψ converging to these excited states in both non-resonant and resonant cases. (Received March 03, 2009)

1049-35-175 **Doyoon Kim*** (doyoonki@usc.edu), University of Southern California, Department of Mathematics, 3620 Vermont Ave KAP108, Los Angeles, CA 90089. *Elliptic and parabolic equations with partially BMO coefficients in Sobolev spaces.*

Second order elliptic and parabolic equations in Sobolev spaces are studied. The leading coefficients are only measurable in one spatial variable and have small mean oscillations as functions of the other variables. The unique solvability of equations in the whole space is established. Then this result is applied to Dirichlet and Neumann boundary value problems for equations defined on a half-space or on a bounded domain. (Received March 03, 2009)

1049-35-183 **Jason Metcalfe*** (metcalfe@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250. *Abstract Strichartz estimates and the Strauss conjecture for the wave equation in exterior domains.*

This regards joint work with K. Hidano, H. Smith, C. Sogge, and Y. Zhou. First, it is shown that known local-in-time "abstract Strichartz" estimates can be combined with the corresponding global-in-time estimates for the free wave equation and some localized energy estimates to produce global-in-time estimates in exterior domains. These "abstract Strichartz" estimates include a class of weighted estimates which yield a proof of the Strauss conjecture for the wave equation in exterior domains in three and four dimensions. (Received March 03, 2009)

1049-35-191 **ROBERTO TRIGGIANI*** (rt7u@virginia.edu), Mathematics Department, Kerchof hall, Charlottesville, VA 22903. *Semigroup-wellposedness, strong and uniform stability of a hyperbolic-parabolic Stokes-Lame fluid-structure interaction model.*

We consider an established hyperbolic-parabolic Stokes-Lame fluid-structure interaction model, with coupling taking place at the interface. We address the following problems: (i) contraction wemigroup well-posedness in the finite energy space, with explicit generator; (ii) spectral properties of the generator and their dependence on the geometry of the structure; (iii) higher level regularity (in connection with (iv) below); (iv) lack of compactness of the resolvent operator and lack of even strong stability in the whole energy space (the origin is always a simple eigenvalue); (v) backward uniqueness of the entire coupled system; (vi) insertion of a linear dissipative term at the interface to reproduce semigrup generation but, in addition, uniform stability as well, without geometrical conditions; (vii) the case of non-linear dissipative term. Problems (i),(ii),(iv),(v),(vi) are joint work with G.Avalos (U of Nebraska, Lincoln). Problems (iii), (vii) are joint work with G.Avalos and I.Lasiecka, U. of Virginia) (Received March 03, 2009)

1049-35-193 **Mickaël David Chekroun*** (chekro@lmd.ens.fr), 24 Rue Lhomond, 75005 Paris, France. *Local Bifurcations in Random Dynamical Systems.* Preliminary report.

It is well-known that bifurcation theory is far from being complete in the framework of random dynamical systems, as introduced by Ludwig Arnold and his Bremen group, even in finite dimension. In this talk we will introduce the main issues and present results of local bifurcations that can be however obtained for some random partial differential equations. Our approach is based on a center manifold theorem in a random context and some abstract results of classical bifurcation theory that can be adapted within our framework. Applications to concrete examples will support the theoretical developments. This talk is based on a joint work with Michael Ghil (ENS & UCLA) and Shouhong Wang (Indiana University). (Received March 03, 2009)

1049-35-194 **Jesenko Vukadinovic*** (vukadino@math.csi.cuny.edu), 2800 Victory Boulevard, College of Staten Island, Staten Island, NY 10314. *Inertial manifolds for a class of Burgers' and nonlinear Fokker-Planck equations.* Preliminary report.

The spectral-gap condition has long been the constraint that stalled a lot of the development of the theory of inertial manifolds, as most of the physically relevant dissipative parabolic differential equations fail to satisfy it. A Cole-Hopf-like transformation is used to circumvent the spectral-gap condition by transforming a class of Burgers' and nonlinear Fokker-Planck equations into a form suitable for the application of the theory of inertial manifolds. The systems which can be handled in this way are the Smoluchowski equation arising in the theory of nematic polymers, as well as the Burgers-Sivashinsky equation and the Quasy-Steady equation of cellular flames, which are closely related to Kuramoto-Sivashinsky equations. The procedure works in both one and two space dimensions. (Received March 03, 2009)

1049-35-196 **Nathan E Glatt-Holtz***, Rawles Hall, 831 East 3rd St., Bloomington, IN 47404. *New Well-Posedness Results for the Equations of Stochastic Fluid Dynamics with Multiplicative Noise.*

The addition of white noise driven terms to the fundamental equations of physics and engineering are used to model numerical and empirical uncertainties. In the context of fluid dynamics such forcing terms have also been employed in the theory of turbulence. Although the study of well posedness for the Stochastic Navier-Stokes Equations goes back to the 1970's with the work of Bensoussan and Temam, many basic questions remain unaddressed. In particular the case of nonlinear multiplicative noise remains a challenging problem. In this talk we introduce some recently developed technical machinery, the so called "comparison lemmas" which may be used to circumvent the difficulty of compactness for certain nonlinear systems. In particular our techniques have led to novel local and global existence results concerning pathwise solutions for both the Navier-Stokes and Primitive Equations. This is joint work with M. Ziane. (Received March 03, 2009)

1049-35-210 **Alexey Cheskidov*** (acheskid@math.uic.edu), University of Illinois at Chicago, 322 Science and Engineering Offices, 851 S. Morgan Street, Chicago, IL 60607. *On the global attractor for the 3D Navier-Stokes equations.*

In this talk we will discuss some new results concerning the long-time behavior of weak solutions to the 3D Navier-Stokes equations. (Received March 04, 2009)

37 ► Dynamical systems and ergodic theory

1049-37-70 **Barak Weiss*** (barakw@math.bgu.ac.il), Dept of mathematics, Ben Gurion University, Be'er Sheva, Israel. *Real REL is a flow.*

Let $\mathcal{H}$ be a stratum of translation surfaces with $k>1$ singularities. It is locally modelled on $H^1(S,\{x_1,\dots,x_k\};\mathbb{R}^2)$. The kernel foliation, or REL foliation, is a foliation on $\mathcal{H}$; two translation surfaces are in the same plaque if their restriction to the absolute homology group is the same. A subfoliation called real REL is obtained by decreeing that two translation surfaces are in the same plaque if they are in the same rel leaf and relative periods differ only in their x coordinate. This foliation has also been called HORIZ, and has been studied by several authors; it is of interest in connection with the study of the horocycle flow.

In joint work with Yair Minsky, we show that leaves of real REL may be extended indefinitely, modulo the obvious obstruction of two singularities colliding. In the full measure subset of $\mathcal{H}$ consisting of translation surfaces with no horizontal saddle connections joining distinct singularities, the leaves are orbits of an $\mathbb{R}^{k-1}$-action. Moreover the action may be extended to a measurable action of the semidirect product of B with $\mathbb{R}^{k-1}$, where B is the group of upper triangular matrices in $\mathrm{SL}(2,\mathbb{R})$. (Received February 20, 2009)

1049-37-119 **Howard Masur*** (masur@math.uchicago.edu), Department of Mathematics, 57384S. University, Chicago, IL 60637, and **Yitwah Cheung** and **Pascal Hubert**. *Billiards in rectangles with slits.*

Let R be a 1/2 by 1 rectangle with a horizonal barrier of length alpha based midway along one of the vertical sides. The dynamics of billliards in this rectangle with barrier was first discussed by Veech forty years ago. For irrational values of alpha there are directions for the billiard flow such that the flow is minimal but not ergodic. In this talk I will discuss the Hausdorff dimension of this set of directions as a function of the number theory of alpha. (Received February 28, 2009)

1049-37-128 **rod freed*** (raf12@cox.net), 25832 empresa, mission viejo, CA 92691. *Stability of Nonlinear Differential Equations.*

Nonlinear differential equations which are disturbed by random factors are used to model many situations in the physical seicnes. And in many cases, we cannont know the exact form of the nonlinear functions which comprise the system. None the less, it is important to know whether or not our system is stable. We prove that the asymptotic probability distribution of the nonparametric kernel estimates of the derivatives of the nonlinear functions can be used to determine "how confident we can be" that the system of nonlinear differential equations is stable, even when we don't know the exact functional form of this system. (Received March 01, 2009)

1049-37-144 **Erwan Lanneau***, Centre de Physique Theorique, 163 avenue de Luminy, case 907, 13010 Marseille, France. *On the minimum dilatation of pseudo-Anosov diffeomorphisms on surfaces of small genera.*

I will explain how one can calculate the least dilatation of pseudo-Anosov diffeomorphisms that stabilize an orientable measured foliation on a surface of genus less than five. These techniques also provide a calculation of the least dilatation of pseudo-Anosov diffeomorphisms on a genus two surface. This is a joint work with Jean-Luc Thiffeault. (Received March 02, 2009)

43 ► Abstract harmonic analysis

1049-43-80 **Brian Forrest**, **Hun Hee Lee** and **Ebrahim Samei*** (samei@math.usask.ca). *Projectivity of modules over Segal algebras.*

In this paper we will study the projetivity of various natural modules associated operator Segal algebras of the Fourier algebra of a locally compact group. In particular, we will focus on the question of identifying when such modules will be projective in the category of operator spaces. We will show that projectivity often implies that the underlying group is discrete or even finite. We will also look at projectivity for modules of $A_cb(G)$,

the closure of $A(G)$ in the space of completely bounded mutiplier. Here we give evidence to show that weak amenability of G plays an important role.

This is a joint work with Brian Forrest and Hun Hee Lee. (Received February 22, 2009)

1049-43-87 **Volker Runde*** (vrunde@ualberta.ca), Department of Math. and Stat. Sciences, CAB 632, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Biflatness and biprojectivity of the Fourier algebra.*

We show that the biflatness—in the sense of A. Ya. Helemskiĭ—of the Fourier algebra $A(G)$ of a locally compact group G forces G to either have an abelian subgroup of finite index or to be non-amenable without containing $\mathbb{F}_2$, the free group in two generators, as a closed subgroup. An analogous dichotomy is obtained for biprojectivity. (Received February 23, 2009)

1049-43-131 **Marius Beceanu** and **Michael Goldberg*** (mikeg@math.jhu.edu), Department of Mathematics, Johns Hopkins University, 3400 N. Charles St, Baltimore, MD 21218. *An operator-valued Wiener inversion theorem leading to Schrödinger dispersive estimates.*

We prove an extension of the Wiener inversion theorem for the $\ell^1(\mathbb{Z})$ convolution algebra, allowing functions to take values in the space of bounded linear operators over any Banach space. One direct application is a dispersive estimate for Schrödinger operators $-\Delta + V(x)$ in $\mathbb{R}^3$, using a class of potentials that is invariant under the natural inverse-square scaling law. (Received March 01, 2009)

1049-43-132 **Nico Spronk** (nspronk@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, Waterloo, ON N2L 3G1, Canada, and **Ross Stokke*** (r.stokke@uwinnipeg.ca), Department of Mathematics and Statistics, University of Winnipeg, 515 Portage Avenue, Winnipeg, MB R3B 2E9, Canada. *Unitary representations and the Eberlein compactification of a locally compact group.*

We study the extension of unitary representations on a locally compact group, G, to the involutive dual Banach algebra $E(G)^*$, where $E(G)$ denotes the uniform closure of the Fourier-Stieltjes algebra, $B(G)$, of G. The spectrum, εG, of $E(G)$ is a semitopological $*$-semigroup compactification of G, which we call the Eberlein compactification of G. We characterize εG as the minimum semigroup compactification of G to which every unitary representation can be continuously extended, and we describe εG in a manner which is analogous to M. Walter's description of the spectrum of $B(G)$. This latter result is applied to show that G is completely determined by εG. (Received March 01, 2009)

1049-43-160 **Zhiguo Hu*** (zhiguohu@uwindsor.ca), 401 Sunset Ave, Windsor, Ontario N9B 3P4, Canada, and **Matthias Neufang** (mneufang@math.carleton.ca), 1125 Colonel By Drive, Ottawa, Ontario K1S 5B6, Canada. *A comparison of some Arens irregularities.*

Let A be a Banach algebra. The dual A-module actions extend the product on A to two Banach algebra multiplications on the second dual of A, called the left and the right Arens products. When these two products coincide, A is said to be Arens regular. Every operator algebra, in particular, every C*-algebra, is Arens regular. However, Banach algebras studied in abstract harmonic analysis are typically far from being Arens regular. In this talk, we will discuss and compare some Arens irregularities. (Received March 02, 2009)

1049-43-168 **Matthias L Neufang*** (mneufang@math.carleton.ca), School of Mathematics and Statistics, Carleton University, Ottawa, Ontario K1S 5B6, Canada. *On Farhadi–Ghahramani's multiplier problem.*

In 1979, Duncan and Hosseiniun asked if, for a locally compact group G, the natural involution on $L_1(G)$ extends to an involution on its bidual (with the left Arens product). In 2007, Farhadi and Ghahramani partially answered this question - in the negative - and in particular showed that the answer is negative for all (infinite) groups with the following multiplier property: (*) every w^*-continuous surjective right $L_1(G)$-module map on $L_1(G)^{***}$ is implemented by an element from $L_1(G)^{****}$ through the canonical action. They thus asked whether any group satisfies (*). We show that this is not the case for infinite countable discrete abelian groups. Note, however, that it might hold for (infinite countable discrete) groups without infinite amenable subgroups which provide the main motivation for Farhadi–Ghahramani's approach, Duncan–Hosseiniun's question being still open for this class of groups. (Received March 02, 2009)

45 ► Integral equations

1049-45-104 **Yajni M. Warnapala** (ywarnapala-yehiya@rwu.edu), Dept. Of Mathematics, Roger Williams University, One Old Ferry Rd, Bristol, RI 02809, and **Elizabeth Morgan*** (emorgan404@hawks.rwu.edu), Dept. Of Mathematics, Roger Williams University, One Old Ferry Rd, Bristol, RI 02809. *The Numerical Solution for the Exterior Dirichlet Problem for the Helmholtz Equation via the Jones integral equation approach specifically for the 'peanut' shape.* Preliminary report.

The search for the best method to approximate solutions to the Helmholtz equation for the exterior Dirichlet problem has been a popular topic for decades. Reducing the problem to a boundary integral equation has proved to be an effective way to numerically solve this problem. However, there is a non-uniqueness of the solution that follows this reformulation. In 1974 Jones suggested the modfied integral equation approach in order to over come this non-uniqueness. Warnapala and Lin implemented this method for the sphere, ellipsoid, and perturbation of the sphere. We have furthered the research in an attemp to apply this method to less well-behaved shapes, in this case the peanut shaped Oval of Cassini. (Received February 26, 2009)

46 ► Functional analysis

1049-46-86 **Lajos Molnar*** (molnarl@math.klte.hu), Institute of Mathematics, University of Debrecen, P.O. Box12, Debrecen, H-4010, Hungary. *Transformations on the space of positive operators.*

The study of the space of positive operators acting on a Hilbert space is of some importance for several reasons. In this talk we consider transformations on that space (or some of its subspaces) which preserve certain operations or numerical quantities. Namely, we give complete descriptions of bijective transformations which preserve operations such as the Jordan triple product or an operator mean (geometric, harmonic, arithmetic). Similar results for bijective transformations preserving numerical quantities such as the Thompson distance or the Hilbert projective distance are also presented. (Received February 23, 2009)

1049-46-89 **Sandy Grabiner*** (sgrabiner@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Ave., Claremont, CA 91711. *Good Weights and Good-enough Weights on* $\mathbb{R}^+$.

When people started seriously studying the structure of the weighted convolution algebras $L^1(\omega)$ and $M(\omega)$ of functions and of measures on $\mathbb{R}^+$, it was shown first for (properly normalized) continuous weights and then for right continuous weights that $M(\omega)$ was isometric to the dual space of a (weighted) space of continuous functions. This showed that such weights were "good" weights in the sense that one had the same basic results isometrically as in the unweighted case. Many examples showed that right continuity was too restrictive, but it was shown that a weight for which $L^1(\omega)$ was an algebra was "good enough" so that one could replace $\omega(x)$ with an equivalent "good" weight; hence all results involving the norm topology remained true isomorphically. As the theory developed, the weak* topology on $M(\omega)$ and its restriction to $L^1(\omega)$ became important so that a weight was not really "good enough" unless there was an equivalent "good" weight for which both $M(\omega)$ and $L^1(\omega)$ were unchanged. We will characterize which weights are "good enough" in this more restrictive sense (Received February 23, 2009)

1049-46-102 **Osamu Hatori*** (hatori@math.sc.niigata-u.ac.jp). *Isometries between the groups of invertible elements in Banach algebras.*

We will consider a problem that isometries between the groups of invertible elemetns of Banach algberas induces isometrical real algebra isomorphisms. In particular, we show that for certain Banach algebras A (commutative) and B if T is an surjective isometry from A^{-1} onto B^{-1}, then $T/T(1)$ is an isometrical real algebra isomorphism. Thus we see that A^{-1} and B^{-1} are isometric as a metric space if and only if A^{-1} and B^{-1} are isometrically isomorphic as metrizable group. (Received March 02, 2009)

1049-46-110 **Hugo Arizmendi Peimbert***, Instituto de Matematicas, Circuito Exterior, Ciudad Universitaria, Mexico D.F. , 04510, 04510 Mexico, D.F., Mexico. *On the maximal ideals of normed and m-convex algebras.* Preliminary report.

A complex commutative normed unital algebra A have three good properties:

i) The codimension of every closed maximal ideal of A is 1.

ii) A is a Q_t-algebra (the set $G_t(A)$ of topologically invertible elements of A is open)

iii) A is a simplicial algebra (every closed ideal is contained in some maximal closed ideal)

Also it is easy to show that

1. All maximal ideals of A are closed if and only if A is a Q-algebra.

These properties and some others about normed and m-locally convex algebras and its maximal ideals are discussed in this talk. (Received February 26, 2009)

1049-46-117 **Yong Zhang*** (zhangy@cc.umanitoba.ca), Department of Mathematics, University of Manitoba, Winnipeg, MB R3T 2N2, Canada. *Approximate amenability of Beurling algebras.*

Whether or not there is a weight function ω on a locally compact group G such that the Beurling algebra $L^1(G,\omega)$ is approximately amenable but not amenable is an open problem. In this talk I will prove that for any weight function ω on a discrete group G, if $L^1(G,\omega)$ (which is really $\ell^1(G,\omega)$) is approximately amenable then it is already amenable. In fact, the result remains true if G is an [IN] group.

This is joint work with F. Ghahramani and E. Samei. (Received February 27, 2009)

1049-46-129 **A. Azimifard**, **E. Samei** and **N. Spronk*** (nspronk@uwaterloo.ca), Department of Pure Math, 200 University Ave W, Waterloo, ON N2L 3G1, Canada. *Amenability properties of centres of group algebras.*

Let G be a locally compact group, and $ZL^1(G)$ be the centre of its group algebra. We show that when G is compact $ZL^1(G)$ is not amenable when G is either nonabelian and connected, or is a product of infinitely many finite nonabelian groups. We also, study, for some non-compact groups G, some conditions which imply amenability and hyper-Tauberian property, for $ZL^1(G)$.

This talk represents work which is to appear in *J. Func. Anal.* (Received March 01, 2009)

1049-46-133 **Lourdes Palacios*** (pafa@xanum.uam.mx), Avenida San Rafael Atlixco 186, Colonia Vicentina, 09340 Mexico City, Mexico. *On some Q-like properties in Topological Algebras.* Preliminary report.

In a unital Banach algebra A the set $G(A)$ of its invertible elements is an open set and the application $x \to x^{-1}$ from $G(A)$ onto $G(A)$ is continuous. More generally, if A is a metrizable and complete topological algebra, then the mapping $x \to x^{-1}$ is continuous if and only if $G(A)$ is a G_δ set.

We say that a topological algebra A is a Q-algebra if the set $G(A)$ is an open set. If A is a commutative Q-algebra and the mapping $x \to x^{-1}$ is continuous, i.e. it is a Waelbroeck algebra, then all the maximal ideals are closed and of codimension 1

Q-topological algebras have some interesting properties as the following: the spectrum $\sigma(x)$ is compact for every $x \in A$ and if A is commutative, then the set $\mathfrak{M}(A)$ of all non-zero linear, multiplicative and continuous functionals of A is non empty if and only if A is not a field and A is a *Gelfand-Mazur algebra*.

We will examine some properties related to Q-algebras and their relations with some other algebras. We will also provide some interesting examples. (Received March 01, 2009)

1049-46-134 **Gabor Lukacs*** (lukacs@cc.umanitoba.ca), Winnipeg, Manitoba R3T 2N2, Canada, and **Rachid El Harti**, Settat, Morocco. *Gelfand duality for pro-C^*-algebras and non-commutative k-spaces.*

A *pro-C^*-algebra* is a limit of C^*-algebras in the category of topological $*$-algebras (and continuous $*$-homomorphisms). Such algebras were studied under various names (LMC^*-algebras, locally C^*-algebras, and σ-C^*-algebra in the metrizable case) by Schmüdgen [8], Inoue [6], Arveson [1], Phillips [7], and El Harti [5].

In the first half of the talk, we consider commutative unital pro-C^*-algebras. It turns out that the Gelfand duality can be extended to a close relative of the so-called k-spaces (cf. [3.3, 2], [9], and [3]), and the topological $*$-algebras thus obtained are commutative unital pro-C^*-algebras.

In the second half of the talk, we focus on the functor $(-)_b$ that assigns to a pro-C^*-algebra the C^*-algebra of its bounded elements. For commutative pro-C^*-algebras, this functor is the dual of the the Stone-Čech-compactification. We show that $(-)_b$ preserves exact sequences, and it is a coreflector.

References

[1] William Arveson. The harmonic analysis of automorphism groups. In *Operator algebras and applications, Part I (Kingston, Ont., 1980)*, volume 38 of *Proc. Sympos. Pure Math.*, pages 199–269. Amer. Math. Soc., Providence, R.I., 1982.

[2] R. Brown. Function spaces and product topologies. *Quart. J. Math. Oxford Ser. (2)*, 15:238–250, 1964.

[3] Eduardo J. Dubuc and Horacio Porta. Convenient categories of topological algebras, and their duality theory. *J. Pure Appl. Algebra*, 1(3):281–316, 1971.

[4] Eduardo J. Dubuc and Horacio Porta. Uniform spaces, Spanier quasitopologies, and a duality for locally convex algebras. *J. Austral. Math. Soc. Ser. A*, 29(1):99–128, 1980.
[5] Rachid El Harti. Contractible Fréchet algebras. *Proc. Amer. Math. Soc.*, 132(5):1251–1255 (electronic), 2004.
[6] Atsushi Inoue. Locally C^*-algebra. *Mem. Fac. Sci. Kyushu Univ. Ser. A*, 25:197–235, 1971.
[7] N. Christopher Phillips. Inverse limits of C^*-algebras. *J. Operator Theory*, 19(1):159–195, 1988.
[8] Konrad Schmüdgen. Über LMC-Algebren. *Math. Nachr.*, 68:167–182, 1975.
[9] N. E. Steenrod. A convenient category of topological spaces. *Michigan Math. J.*, 14:133–152, 1967. (Received March 01, 2009)

1049-46-141 **George Alver Willis*** (george.willis@newcastle.edu.au), Mathematical and Physical Sciences, Building V, Callaghan, NSW 2308, Australia. *Contraction subgroups of locally compact groups.*

The *contraction group* of an element, x, in a locally compact group, G, is

$$U_x := \{g \in G \mid x^n g x^{-n} \to 1 \text{ as } n \to \infty\}.$$

Contraction groups play a role in representation theory through the *Mautner phenomenon*, which is the observation that every point, ξ, that is fixed by x is also fixed by every element of the contraction group of x. Contraction subgroups of Lie groups are necessarily nilpotent. The talk will describe what is known about contraction subgroups of totally disconnected groups. (Received March 02, 2009)

1049-46-149 **Sergey G Bobkov*** (bobkov@math.umn.edu), 127 Vincent Hall, 206 Church St. S.E., School of Mathematics, University of Minnesota, Minneapolis, MN 55455. *Hensley's theorem and isotropic positions of convex measures.*

Hensley's theorem (1980) asserts that, for any symmetric convex body in the Euclidean space, one can choose a coordinate system with respect to which all body's central sections have approximately equal size. This observation will be considered for finite symmetric convex measures in terms of suitable isotropic positions. As a basic tool, we extend K. Ball's relationship between convex bodies and finite logarithmically concave measures to a larger class of distributions, satisfying convexity conditions of the Brunn–Minkowski type. (Received March 02, 2009)

1049-46-162 **Thomas Tonev** and **Rebekah Yates*** (ryates@mso.umt.edu). *Norm–Linear and Norm–Additive Operators Between Uniform Algebras.*

Let $A \subset C(X)$ and $B \subset C(Y)$ be uniform algebras with Choquet boundaries δA and δB. A map $T\colon A \to B$ is called *norm–linear* if $\|\lambda Tf + \mu Tg\| = \|\lambda f + \mu g\|$, *norm–additive* if $\|Tf + Tg\| = \|f + g\|$, and *norm–additive in modulus* if $\big\||Tf| + |Tg|\big\| = \big\||f| + |g|\big\|$ for each $\lambda, \mu \in \mathbb{C}$ and all algebra elements f, g. We show that if a surjection $T\colon A \to B$ is norm–additive in modulus, then there exists a homeomorphism $\psi\colon \delta A \to \delta B$ such that $|(Tf)(y)| = |f(\psi(y))|$ for every $f \in A$ and $y \in \delta B$. We prove that every norm–linear surjection T, not assumed to be linear or continuous, but for which either $T(1) = 1$ and $T(i) = i$ or the peripheral spectra of $\mathbb{C}$–peaking functions are preserved is a unital isometric algebra isomorphism. We also give sufficient conditions for norm–additive surjections to be unital isometric algebra isomorphisms. In addition, we show that if a surjective norm–preserving linear operator T between two uniform algebras satisfies $T(1) = 1$ and $T(i) = i$ or preserves the peripheral spectra of $\mathbb{C}$–peaking functions, then it is an isometric algebra isomorphism. (Received March 03, 2009)

1049-46-184 **John T Anderson*** (anderson@mathcs.holycross.edu), Dept. of Mathematics and Computer Science, College of the Holy Cross, 1 College St., Worcester, MA 01610-2395. *Peak point theorems.* Preliminary report.

It was once conjectured that if A is a uniform algebra on its maximal ideal space X, and if each point of X is a peak point for A, then A = C(X). This peak point conjecture was disproved by Brian Cole in 1968. However, in the last ten years the conjecture has been established in a number of special settings. I will survey (1) some results concerning uniform algebras on smooth manifolds and (2) results when X is a rationally convex subset of the unit sphere in complex Euclidean space. (Received March 03, 2009)

1049-46-197 **Aaron Luttman** and **Scott Lambert*** (slambert@colby.edu), Mayflower Hill 5830, Waterville, ME 04901. *Norm Conditions for Uniform Algebra Isomorphisms.*

In recent years much work has been done analyzing maps, not assumed to be linear, between uniform algebras that preserve the norm, spectrum, or subsets of the spectra of algebra elements, and it is shown that such maps must be linear and/or multiplicative. Letting A and B be uniform algebras on compact Hausdorff spaces X and Y, respectively, it is shown here that if $T\colon A \to B$ is a surjective map, not assumed to be linear, satisfying

$$\|T(f)T(g) + 1\| = \|fg + 1\| \quad \forall\, f, g \in A,$$

then T is an $\mathbb{R}$-linear isometry. Moreover, if T is unital, i.e. $T(1) = 1$, then $T(i) = i$ implies that T is an isometric algebra isomorphism whereas $T(i) = -i$ implies that T is a conjugate-isomorphism. Some details will be given on how this is proved and some directions given for further investigation. (Received March 03, 2009)

1049-46-206 **Miura Takeshi*** (miura@yz.yamagata-u.ac.jp), Jonan 4-3-16, yonezawa, 992-8510.
Peripherally multiplicative surjections between uniform algebras.

Let A and B be uniform algebras. If S and T are surjections from A onto B satisfying $S(1) = T(1) = 1$ and $\sigma_\pi(S(f)T(g)) = \sigma_\pi(fg)$ for all $f, g \in A$, then there exists a homeomorphism ϕ from $\mathrm{Ch}(B)$ to $\mathrm{Ch}(A)$ such that $S(f)(y) = T(f)(y) = f(\phi(y))$ for every $f \in A$ and $y \in Ch(B)$, where σ_π denotes the peripheral spectrum and $\mathrm{Ch}(\cdot)$ denotes the Choquet boundary. (Received March 04, 2009)

47 ► Operator theory

1049-47-15 **Thomas Tonev** and **Aaron Luttman*** (aluttman@clarkson.edu), Clarkson University, Division of Mathematics and Computer Science, Box 5815, Potsdam, NY 13699. *Peripheral Multiplicativity and Isomorphisms Between Standard Operator Algebras.*

If X and Y are Banach spaces, then subalgebras $\mathfrak{A} \subset B(X)$ and $\mathfrak{B} \subset B(Y)$, not necessarily unital nor complete, are called *standard operator algebras* if they contain all finite-rank operators on X and Y respectively. The peripheral spectrum of $A \in \mathfrak{A}$ is the set $\sigma_\pi(A) = \{\lambda \in \sigma(A) : |\lambda| = \max_{z \in \sigma(A)} |z|\}$ of spectral values of A of maximum modulus, and a map $\varphi\colon \mathfrak{A} \to \mathfrak{B}$ is called *peripherally-multiplicative* if it satisfies the equation $\sigma_\pi\big(\varphi(A) \circ \varphi(B)\big) = \sigma_\pi(A\,B)$ for all $A, B \in \mathfrak{A}$. We show that any peripherally-multiplicative and surjective map $\varphi\colon \mathfrak{A} \to \mathfrak{B}$, neither assumed to be linear nor continuous, is a bijective bounded linear operator such that either φ or $-\varphi$ is multiplicative or anti-multiplicative. This holds in particular for the algebras of finite rank operators or of compact operators on X and Y and extends earlier results of Molnár. (Received January 12, 2009)

49 ► Calculus of variations and optimal control; optimization

1049-49-6 **Florian Wagener*** (wagener@uva.nl), CeNDEF/KE, Roetersstraat 11, 1018 WB AMSTERDAM, Netherlands. *On the Leitmann equivalent problem approach.*

The purpose of this paper is to show how Leitmann's equivalent problem approach ties in with the classical notions of the Calculus of Variations, and how it can be exploited to give a rapid and elegant approach to Weierstrass' theory of sufficient conditions. Various endpoint conditions are considered. (Received August 13, 2008)

51 ► Geometry

1049-51-94 **Jing Tao*** (jingtao@math.uic.edu), 3425 W Drummond Pl, 2B, Chicago, IL 60647.
Linear Bound for the Length of a Conjugating Element in the Mapping Class Group.

Given two conjugate mapping classes f and g, we produce a conjugating element ω such that $|\omega| \leq K(|f| + |g|)$, where $|\cdot|$ denotes the word metric with respect to a fixed generating set, and K is a constant depending only on the generating set. As a consequence, the conjugacy problem for mapping class groups is exponentially bounded. (Received February 24, 2009)

1049-51-98 **Arkady Berenstein**, Department of Mathematics, University of Oregon, Eugene, OR 97403, and **Michael Kapovich*** (kapovich@math.ucdavis.edu), Department of Mathematics, University of California, Davis, CA 95616. *Rank 2 nondiscrete affine buildings.*

In his work classifying spherical and affine buildings, J.Tits proved that every (irreducible) thick affine building of rank at least 3 is associated with an algebraic group over a field. In particular, it follows that the finite Weyl groups of such buildings have to be crystallographic. We complete this picture by constructing rank 2 thick nondiscrete affine buildings associated with an arbitrary finite dihedral group. (Received February 25, 2009)

1049-51-180 **Ian Biringer*** (biringer@math.uchicago.edu), 5734 S University Ave, Chicago, IL 60637, and **Juan Souto**. *Sequences of Unfaithful Representations into PSL(2,C).*

If Γ is a finitely generated group, then every representation $\rho : \Gamma \to PSL(2, C)$ with discrete and torsion-free image gives a hyperbolic 3-manifold M_ρ, the quotient of hyperbolic 3-space by the image of ρ. I will present some new results linking the pointwise convergence of a sequence of such representations with Gromov-Hausdorff convergence of the corresponding quotient manifolds. A detailed analysis already exists for sequences of faithful representations; I will give an example that illustrates the failure of these theorems in the unfaithful setting, and offer some useful replacements. Joint work with Juan Souto. (Received March 03, 2009)

1049-51-198 **Moon Duchin*** (mduchin@umich.edu), **Christopher Leininger** and **Kasra Rafi**. *Degeneration of flat structures.*

I'll discuss a new boundary for the space of flat structures on a surface which comes from viewing flat metrics as geodesic currents. (Received March 03, 2009)

52 ► Convex and discrete geometry

1049-52-8 **Daniel N Dadush*** (dndadush@gmail.com), 1715 Defoor Ave NW, Apt A, Atlanta, GA 30318, and **Vempala S Santosh**. *An Elementary Technique to Prove some Basic Inequalities in Convex Geometry.*

The development of convex geometry has led to the discovery of some striking inequalities: the Brunn-Minkowski inequality, Grunbaum's theorem, the Milman-Pajor inequality. It is common in proving geometric inequalities to identify the corresponding "worst-case" convex body from which the inequality follows by explicit computation. In particular, n-dimensional cones and truncated cones appear as worst-case bodies for many of the basic geometric inequalities. The general strategy in these cases usually involves a reduction to a one-dimensional inequality followed by an often tedious and unenlightening sequence of computations. The purpose of this research is to illustrate a simple geometric technique that naturally exhibits cones and truncated cones as "worst-cases" in the one-dimensional setting. We apply this technique to rederive some basic inequalities as well as to prove some new ones. (Received October 07, 2008)

1049-52-44 **Rekha Thomas*** (rrthomas@u.washington.edu), Box 354350, Department of Mathematics, University of Washington, Seattle, WA 98195, and **Joao Gouveia** and **Pablo Parrilo**. *Theta bodies for Polynomial Ideals.*

We extend Lovasz's construction of the theta body of a graph to create a hierarchy of semidefinite relaxations for the convex hull of any real variety. These relaxations tie into the literature via work by Lasserre. When the variety is finite, i.e., the convex hull is a polytope, we give a complete characterization of when the first theta body equals the polytope, answering partially a question by Lovasz. For all varieties, the first theta body has a precise geometric description that I will describe. Joint work with Joao Gouveia and Pablo Parrilo. (Received February 13, 2009)

1049-52-46 **Sven Verdoolaege*** (sven@cs.kuleuven.be), Celestijnenlaan 200A, B-3001 Leuven, Belgium. *An Integer Set Library for Program Analysis.* Preliminary report.

Many program analysis techniques are based on manipulations of sets of integers bounded by linear constraints. These integers typically represent iterations of a loop nest or elements of an array. Double description based libraries have little or no explicit support for parameters and existentially quantified variables, which are essential for some program analysis tasks, and focus on rationals instead of integers. Furthermore, in our applications, the number of constraints describing a set is usually fairly small, while a vertex based description can be very large.

We present a new library exclusively based on constraints and geared towards the manipulation of integer sets. The library supports some operations not typically available in other libraries, such as parametric integer linear programming (through PIP) and the computation of the integer affine hull, and produces significantly improved results in some applications. Operations such as the convex hull are more easily implemented using a double description. Both Fourier-Motzkin elimination and "wrapping" have been used to compute the convex hull using only constraints. The first is slow, while the second could only be used on bounded polyhedra. We present an extension of the "wrapping" method to unbounded polyhedra. (Received February 14, 2009)

1049-52-84 **Iskander Aliev** (alievi@cf.ac.uk), School of Mathematics and Wales Institute of, Mathematical and Computational Sciences, Senghennydd Road, Cardiff, Wales, and **Martin Henk*** (henk@math.uni-magdeburg.de), Institut fuer Algebra und Geometrie, Universitaetsplatz 2, 39106 Magdeburg, Germany. *Average Behavior of the Frobenius Numbers.*

Given a primitive positive integer vector $a \in \mathbb{Z}^n_{>0}$, the largest integer that can not be represented as a non-negative integer combination of the coefficients of a is called the Frobenius number of a. We show that the asymptotic growth of the Frobenius number on average is significantly slower than the growth of the maximum Frobenius number. More precisely, we prove that it does not essentially exceed $||a||_\infty^{1+1/(n-1)}$, where $||\cdot||_\infty$ denotes the maximum norm. (Received February 23, 2009)

1049-52-88 **Nikos Dafnis** (nikdafnis@googlemail.com), Department of Mathematics, University of Athens, 157 84 Athens, Greece, and **Grigorios Paouris*** (grigoris@math.tamu.edu), Department of Mathematics, Texas A & M University, College Station, TX TX 77843. *Small ball probability estimates, ψ_2-behavior and the hyperplane conjecture.*

We introduce a method which leads to upper bounds for the isotropic constant. We prove that a positive answer to the hyperplane conjecture is equivalent to some very strong small probability estimates for the Euclidean norm on isotropic convex bodies. As a consequence of our method, we obtain an alternative proof of the result of J. Bourgain that every ψ_2-body has bounded isotropic constant, with a slightly better estimate. (Received February 23, 2009)

1049-52-108 **Joseph Gubeladze*** (soso@math.sfsu.edu), Mathematics Department, San Francisco State University, San Francsico, CA 94132. *Hom, tenzor, Ker, and Coker constructions for polytopes.*

The set of affine maps between any two convex polytopes is a convex polytope in a natural way; i. e., the category of convex polytopes and affine maps is a closed category. Employing ideas from category theory – such as adjoint functors, representable functors, Yoneda lemma, we will propose universal polytopal constructions as in the title. Actual computation of these objects, as opposed to the existence claims, is a hard problem. In the second half of the talk I will present results obtained jointly with T. Bogart on the 6-dimensional polytope of affine maps between regular n- and m-gons. Already there one faces a number of combinatorial, arithmetic and algorithmic challenges. (Received February 26, 2009)

1049-52-143 **Alexander M. Kasprzyk**, **Maximilian Kreuzer** and **Benjamin Nill*** (nill@math.fu-berlin.de), Arnimallee 3, 14195 Berlin, Germany. *Bounds on lattice polygons and the classification of toric log Del Pezzo surfaces.*

We study lattice polygons containing the origin in their interiors. Astonishingly, even for these simple objects elementary questions are still open. In this talk, we give an upper bound on the area that depends cubically on the maximal lattice distance of the origin from the facets. The most interesting case occurs when all the vertices are primitive lattice points. In this situation there is a one-to-one correspondence to toric log Del Pezzo surfaces, which was used to give a complete classification of these varieties up to Gorenstein index < 17. (Received March 02, 2009)

1049-52-152 **Sinai Robins*** (rsinai@ntu.edu.sg) and **James Propp** (jpropp@cs.uml.edu). *TILING LATTICES WITH TRANSLATES OF SUBLATTICES.* Preliminary report.

We study the problem of tiling (that is, exactly covering) an n-dimensional lattice by finitely many translates of sublattices. This problem extends the 1-dimensional case studied by Morris Newman and others. If we assume that each tiling sublattice is a Cartesian product of arithmetic progressions, we can prove that two of the sublattices must be translates of one another. In the absence of the assumption of special structure, it can happen (for $n > 2$) that no two of the sublattices are translates of one another. We use theta functions to give an (almost) equivalent description in terms of multidimensional Gauss Sums. The case $n = 2$ remains open. (Received March 02, 2009)

1049-52-164 **Jan Verschelde*** (jan@math.uic.edu), University of Illinois at Chicago, Dept. of Math., Stat., and CS, 851 S. Morgan St. (M/C 249), Chicago, IL 60607-7045. *Searching for Solution Curves of Polynomial Systems.*

A polynomial system with as many equations as unknowns is expected to have only isolated solutions. In the exceptional case of a solution curve we propose to develop the solution curve starting at infinity. A tropism defines the leading powers of this Puiseux series development of a solution curve. Computing these tropisms

along with the coefficients of the Puiseux series leads to a polyhedral method for solution curves of polynomial systems. (Received March 02, 2009)

1049-52-202 **Jesus A De Loera*** (deloera@math.ucdavis.edu), Davis, CA 95616. *Subgraph Isomorphism through Polynomial Ideals and their relaxations.*

Given two graphs G and H, the *subgraph isomorphism problem* asks whether there is a subgraph of G isomorphic to H. Instances of this question include a wide range of famous questions in Graph Theory (e.g. graph isomorphism, existence of hamiltonian cycles or cliques, etc).

We investigate the convex-algebraic-geometric nature of such questions. Starting with a non-linear encoding of the problem using polynomial ideals we present a hierarchy of relaxations each yielding relevant computational information. In particular, we derived some results on the estimation the number of distinct isomorphic subgraph inside G and connections to the multiplicity of eigenvalues of the adjacency matrices of G and H.

This is joint work with C. Hillar (MSRI-Berkeley), P. Malkin (UC Davis), and M. Omar (UC Davis). (Received March 03, 2009)

1049-52-209 **Francisco Santos*** (francisco.santos@unican.es), Dept. Matemáticas, Estadística y Computación, Universidad de Cantabria, 39005 Santander, Spain. *52 years of the Hirsch conjecture.*

The Hirsch conjecture, stated in 1957 a letter by Warren M. Hirsch (1920–2007) to George Dantzig (1914–2005) says that the graph of a d-polytope with n facets cannot have diameter bigger than $n - d$.

Despite being one of the most fundamental open problems in polytope theory, both from a theoretical and applied point of view, our knowledge about it is shamefully scarce. Suffice it to say that no polynomial upper bound is known for the diameters of polytopes, when the conjecture says they are linear.

In contrast, very few polytopes where the bound $n - d$ is achieved are known. In fact, only one such example is known, leaving aside "trivial cases" and polytopes that can be derived from it by more or less standard constructions.

In this talk I will briefly revise the history of the conjecture, focusing on the side of constructions and "partial counterexamples". (Received March 04, 2009)

53 ► Differential geometry

1049-53-40 **Ovidiu Munteanu*** (omuntean@math.columbia.edu), Mathematics Department, Columbia University, Room 509, MC 4406, 2990 Broadway, New York, NY 10027. *The Structure of Complete Manifolds with Positive Spectrum.*

We discuss complete noncompact manifolds with Ricci curvature bounded from below by a negative constant and with positive bottom of spectrum. Our talk will cover some recent progress in the study of such manifolds that have maximal bottom of spectrum relative to the lower bound of the Ricci curvature. (Received February 10, 2009)

1049-53-51 **Yuguang Shi*** (ygshi@math.pku.edu.cn), School Of Mathematics, Peking University, Beijing, 100871, Peoples Rep of China. *Geometric problems relates with positivity of quasilocal mass.*

A couple years ago, Tam and presenter proved positivity of Riemannian version of the quasi-local mass which was introduced by Brown-York. Later, Liu and Yau introduced a quasi-local mass in spacetime, and proved its positivity. However, all the results mentioned above has to assume Gauss curvature of the boundary of domain is positive, this is quite restrictive. So, can we remove this assumption? Wang and Yau has several interesting works on this. In this talk, we will discuss these results and some related geometric inequalities obtained by Miao and authors. (Received February 15, 2009)

1049-53-54 **Richard Schoen*** (schoen@math.stanford.edu), Mathematics Department, Stanford University, Stanford, CA 94305. *The geometry of static and stationary spacetimes.*

In this talk we will describe some differential geometric problems which arise from consideration of static and stationary matter models in general relativity. We will give some relevant background from Newtonian physics and describe analogous questions for the Einstein equations. The main new theorem imposes restrictions on the geometry of static n-body configurations for arbitrary matter fields with positive mass density. (Received February 16, 2009)

1049-53-55 **William D. Dunbar*** (wdunbar@simons-rock.edu), Bard College at Simon's Rock, 84 Alford Road, Great Barrington, MA 01230, and **Sarah J. Greenwald**, **Jill McGowan** and **Catherine Searle**. *Diameters of spherical 3-orbifolds.*

In joint work with S.J. Greenwald, J. McGowan, and C. Searle, we have calculated a lower bound for the diameter of any quotient space of the form S^3/G, where G is a closed subgroup of $O(4)$ acting nontransitively on the unit three-sphere S^3. I will concentrate on the case when G is a finite group, so that the quotient has the structure of a 3-orbifold. Many such orbifolds are Seifert-fibered (more precisely, G leaves a Hopf fibration invariant), and when the fiber is short, the diameter is well-approximated by that of the base 2-orbifold. Indeed, that is one way to approach our lower bound of $\arccos(\tan(3\pi/10)/\sqrt{3})/2$. The remaining orbifolds were analyzed case-by-case, with emphasis of course on those which did not cover another orbifold (i.e., those for which G was maximal among finite subgroups). I will sketch our approach, give some illustrations, and pose a question which I believe is still open. (Received February 16, 2009)

1049-53-56 **Mu-Tao Wang*** (mtwang@math.columbia.edu). *Mean curvature flows of Lagrangian graphs and isotopy problems.* Preliminary report.

We discuss two types of Lagrangian graphs: graphs of symplecto-morphisms of symplectic manifolds and graphs of one-forms in cotangent bundles. In each case, we present global existence and convergence results of the mean curvature flow and applications to isotopy problems. (Received February 17, 2009)

1049-53-58 **Jenny Harrison*** (harrison@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, Berkeley, CA 94705. *Introduction to Operator Calculus and New Geometric Methods in Analysis and Topology.*

Axioms of calculus are presented in which continuum and discrete geometries are unified. The theory make use of a new integral and derivative, and treats highly singular domains of integration. We present new fundamental theorems underlying the generalized theorems of Stokes and Gauss. The ansatz is the existence of topological coalgebras of 'differential chains' that dualize to exterior algebras of differential forms, as opposed to distributions and currents, which are dual spaces of forms. A new homology theory emerges that is not equivalent to singular homology theory. The new theory is able to distinguish the sine circle from the smooth circle. Both dualize to de Rham cohomology on smooth manifolds, but our theory is equipped with a coproduct whose dual is cup product. Homology becomes primary, for cohomology can be built from it. This work marks a fundamental change in the point of view from the contravariant back to the covariant. Analytical methods are greatly simplified.

> *It is possible that we have in these researches the dim outlines of an operational calculus, destined to become in one or two centuries as powerful an instrument as the differential calculus has been for our predecessors and for ourselves.*

Andre Weil, 1950. (Received March 03, 2009)

1049-53-60 **Nolan R Wallach*** (nwallach@ucsd.edu), Department of Mathematics, University of California, San Diego, La Jolla, CA 92093. *Exceptional compact simply connected spaces with positive pinching.* Preliminary report.

Before the work of Berger on the classification of compact homogeneous with positive pinching the only known examples of spaces in the title had the underlying topology of a sphere or a renk one symmetric space of compact type. Berger introduced two new spaces of dimension 7 and 13 respectively. In the early seventies the speaker introduced 3 new spaces of dimension 6,12, and 24 as an outgrowth of his classification of even dimensional positively pinched homogeneous spaces. Also, with Aloff he introduced the first examples of an infinite number of homotopy types of simply connected homogeneous spaces in one dimension (dimension 7) each admitting positive pinching. In the ensuing years new spaces that are not homeomorphic with homogeneous spaces have been introduced by Eschenberg and Bazaikin in, respectively, dimensions 7 and 13. This lecture will touch on these subjects and more recent developments. (Received February 17, 2009)

1049-53-65 **Brett L Kotschwar*** (kotschwar@math.mit.edu), Massachusetts Institute of Technology, Department of Mathematics, 2-304, 77 Massachusetts Ave., Cambridge, MA 02139-4307. *Geometric applications of monotone entropy quantities for parabolic PDE.*

I will discuss monotonic entropy quantities for solutions to a number of parabolic PDE, drawn from the work of Perelman, Hamilton, Chow, Ni, and others, and their (in cases, spectacularly successful!) application to geometric problems. I will also describe the fundamental relationship of these quantities to Li-Yau-type pointwise differential Harnack inequalities, and further explore this connection in the development of a new entropy formula for a nonlinear analog of the heat equation in joint work with Lei Ni. (Received February 17, 2009)

1049-53-69 **Zhongmin Shen*** (zshen@math.iupui.edu), Math Dept, IUPUI, 402 N Blackford Street, Indianapolis, IN 46202. *Geometric Meanings of Curvatures in Finsler Geometry.*

Finsler metrics are just Riemannian metrics without quadratic restriction. In Finsler geometry, there are several notions of curvatures. It is an important problem to understand their geometric meanings. In this talk, I will discuss some important curvatures and their relationship. I will also show some global rigidity theorems for Finsler metrics under certain curvature conditions. (Received February 20, 2009)

1049-53-72 **Chuu-Lian Terng*** (cternng@math.uci.edu), Department of Mathematics, University of California at Irvine, Irvine, CA. *Soliton equations and Gauss-Codazzi equations.*

We explain a general method for constructing soliton equations from symmetric spaces, how Gauss-Codazzi equations of submanifolds arise as soliton equations, and the geometry of the moduli spaces of these classes of submanifolds. (Received February 20, 2009)

1049-53-74 **Carla Farsi** and **Christopher Seaton*** (seatonc@rhodes.edu), Mathematics and Computer Science Department, 2000 N. Parkway, Memphis, TN 38112. *Generalized twisted sectors and applications.*

Given an orbifold Q, the inertia orbifold is a disconnected orbifold consisting of Q itself as well as other connected components, called twisted sectors. In this talk, we discuss a generalization of this construction assigning a collection of twisted sectors to any finitely generated discrete group Γ; the inertia orbifold corresponds to the case where Γ is the integers. We discuss the properties of these orbifolds, showing that they generalize several constructions for global quotient orbifolds. We discuss several different equivalent approaches to this construction and the corresponding applications. (Received February 20, 2009)

1049-53-97 **J. McGowan*** (jmcgowan@howard.edu), Howard University, Department of Mathematics, Washington, DC 20059, and **C. Searle**. *Cohomogeneity 3 Actions on the Sphere.*

In their classic paper, Hsiang and Lawson gave a nearly complete list of all cohomogeneity 1 and 2 irreducible maximal linear actions on the standard sphere [HL]. Their classification was later completed by Straume in his comprehensive work on the subject [S1] and [S2]. With C.Searle, we have begun the classification of irreducible maximal linear actions of cohomogeneity 3, as well as a study of the associated spherical orbit spaces. This outstanding problem is interesting and useful for the same reasons that the 1- and 2-dimensional problems were: we gain greater understanding of the sphere, a basic model space for any space of constant curvature; the exploration of these actions can lead to the discovery of new structures and new descriptions of existing structures; and we can learn more about the properties of symmetric spaces.

[HL] Hsiang, W.-Y. and Lawson, Minimal Submanifolds of Low Cohomogeneity, J. Diff. Geometry, Vol. 5, (1971) pp. 1-38.

[S1]Straume, E., Compact Connected Lie Transformation Groups on Spheres with Low Cohomogeneity, I, Memoirs of the AMS, Vol. 119, No. 569 (1996).

[S2]Straume, E., Compact Connected Lie Transformation Groups on Spheres with Low Cohomogeneity, II, Memoirs of the AMS, Vol. 125, No. 595 (1997). (Received February 25, 2009)

1049-53-103 **Emily B. Proctor*** (eproctor@middlebury.edu), Department of Mathematics, Warner Hall, Middlebury College, Middlebury, VT 05753, and **Elizabeth A. Stanhope** (stanhope@lclark.edu), Lewis & Clark College, Department of Mathematical Sciences, 0615 SW Palatine Hill Rd., MSC 110, Portland, OR 97219. *Bounds on 2-orbifold diffeomorphism type.*

The familiar geometric notions of curvature, diameter, volume, and the Laplace spectrum generalize from Riemannian manifolds to Riemannian orbifolds. One can also generalize the topological notion of a diffeomorphism to the orbifold category. An orbifold diffeomorphism represents an equivalence of the smooth orbifold structure as well as of the underlying topological space. We show that any collection of 2-orbifolds with lower bounds on sectional curvature and volume, and an upper bound on diameter, can contain only finitely many orbifold diffeomorphism types. As a consequence we also show that any collection of Laplace isospectral 2-orbifolds sharing a lower bound on sectional curvature can contain only finitely many orbifold diffeomorphism types. (Received February 26, 2009)

1049-53-140 **Charles Frances*** (Charles.Frances@math.u-psud.fr), Laboratoire de Mathématiques, Bat 425, Université Paris-Sud, 91405 Orsay, France. *Dynamical properties of automorphisms of Cartan geometries.*

The notion of Cartan geometries gives a unified framework for the study of classical geometric structures, such as pseudo-Riemannian metrics, conformal structures, CR and projective structures.... The aim of the talk is to

show that Cartan geometries are also useful to understand the dynamics of automorphisms of such structures. As an illustration, we will recover, and generalize classical results of J.Ferrand, M.Obata and R.Schoen about the automorphism group of conformal and CR structures. (Received March 01, 2009)

1049-53-158 **Catherine E Searle*** (csearle@matcuer.unam.mx), Av. Universidad s/n, Apartado Postal 273. Admon. de Correos #3, Colonia Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico, and **Fernando Galaz-Garcia**, Department of Mathematics, Mathematics Building, University of Maryland, College Park, MD 20742-4015. *Non-negatively curved manifolds with maximal symmetry rank in low dimensions.*

We show that closed, simply-connected, non-negatively curved 5 manifolds admitting an (almost) effective, isometric T^3 action are equivariantly diffeomorphic to one of $S^5, S^3 \times S^2$ or $S^3 \tilde{\times} S^2$. If we allow only T^2 symmetry, the Wu manifold may also occur and we have a classification up to homeomorphism. As a direct consequence we can show that the maximal symmetry rank for manifolds under the same hypotheses of dimension up to and including 9 is equal to $[\frac{2n}{3}]$. (Received March 02, 2009)

1049-53-178 **Sarah J Greenwald*** (greenwaldsj@appstate.edu), 121 Bodenheimer Drive, 326 Walker Hall, Boone, NC 28608, and **Emily Dryden**, **Carolyn Gordon** and **David Webb**. *Applications of heat invariants to 2-orbifolds.*

We study the relationship between the geometry and the Laplace spectrum of a Riemannian orbifold via its heat kernel; as in the manifold case, the time-zero asymptotic expansion of the heat kernel furnishes geometric information about the orbifold. H. Donnelly studied the heat expansion and computed the first few heat invariants of quotients of Riemannian manifolds by properly discontinuous group actions, in particular, good orbifolds. In joint work with E. Dryden, C. Gordon, and D. Webb, we extended the work of Donnelly to show the existence of the heat expansion on arbitrary compact orbifolds and we found the first few heat invariants. In this talk we will use these invariants to explore what classes of 2-orbifolds are spectrally determined. (Received March 03, 2009)

54 ► General topology

1049-54-83 **Alexander Y Grosberg*** (ayg1@nyu.edu), Department of Physics, New York University, 4 Washington Place, New York, NY 10003. *Self-avoiding knots.*

The root-mean-squared gyration radius of a non-phantom loop of zero thickness and fixed knot topology is believed to scale as N^ν, where N is the number of segments and ν is the critical exponent which describes the self-avoiding random walk. What happens if self avoidance and topological constraints are presented simultaneously? The zero thickness model has no unitless parameters apart from N, while the self-avoiding model has parameter d/a, where d and a are the segment thickness and length, respectively. There are several numerical studies of the concurrent effect of self-avoidance (chain thickness or ionic strength in case of DNA). In this work, and attempt of a simple minded scaling estimate is presented. (Received February 23, 2009)

1049-54-125 **R Varela*** (rocco.varela@gmail.com), Department of Computer Science, 1600 Holloway Ave., TH 906, San Francisco, CA 94132, **K Hinson** (kehinson@uncc.edu), Mathematics and Statistics Fretwell 376, 9201 University City Blvd., Charlotte, NC 28223, **J Arsuaga** (jarsuaga@math.sfsu.edu), Department of Mathematics, 1600 Holloway Ave., TH937, San Francisco, CA 94132, and **Y Diao** (YuananDiao@uncc.edu), Mathematics and Statistics Fretwell 376, 9201 University City Blvd., Charlotte, NC 28223. *A fast ergodic algorithm for generating ensembles of equilateral random polygons.*

Knotted structures are commonly found in circular DNA and along the backbone of certain proteins. In order to properly estimate properties of these three-dimensional structures it is often necessary to generate large ensembles of simulated closed chains (i.e. polygons) of equal edge lengths (such polygons are called equilateral random polygons). Finding efficient algorithms that properly sample the space of equilateral random polygons is a difficult problem. We have developed a method that generates equilateral random polygons in a 'step-wise uniform' way. We have proven that this method is ergodic in the sense that any given equilateral random polygon can be generated by this method and we can demonstrate the time needed to generate an equilateral random polygon of length n is linear in terms of n. These two properties provide very significant improvements over existing generating methods. (Received February 28, 2009)

1049-54-192 **Teresita Ramirez-Rosas*** (teresita@math.ucsb.edu), 734 Elkus Walk, Apt 106, Goleta, CA 93117-4170. *Upper Bound for the Ropelength of a Trefoil Knot.*

The ropelength of a knot K is defined as the shortest length of unit radius rope needed to tie the knot K. The principal goal is to find an upper bound for its ropelength. In 2005, Justyna Baranska, Piotr Pieranski and Eric Rawdon found a polygonal knot with 1920 edges and unit normal injectivity radius that has length 32.7431. This is the last upper bound for a trefoil knot. We improved this upper bound by finding a trefoil knot with normal injectivity radius one and length 32.6039. Since the current lower bound is 32.31, we know that the ropelength of a trefoil knot lie between 31.32 and 32.6039. The construction suggests that the ropelength is likely to be very close to our upper bound. (Received March 03, 2009)

55 ► Algebraic topology

1049-55-66 **Andres Angel*** (aangel79@math.uni-bonn.de), Beringstrasse 1, Raum 21, 53115 Bonn, Germany. *Cobordisms of Orbifolds.* Preliminary report.

In this talk I will present a framework to study cobordism groups of orbifolds. As application, I will show decompositions of these groups in terms of usual bordism theory. These decompositions involve information around the singular sets and provide a way to define new invariants for orbifolds. (Received February 18, 2009)

1049-55-78 **Hellen Colman*** (hcolman@ccc.edu). *Lusternik-Schnirelmann category for orbifolds as Lie groupoids.*

We propose a new numerical invariant for Lie groupoids which generalizes the Lusternik-Schnirelmann category of topological spaces. This number is invariant under Morita equivalence, then yields a well defined LS-category for orbifolds.

An orbifold map is given by an equivalence class of generalized maps between Lie groupoids. These generalized maps are obtained by formally inverting essential equivalences. We develop a notion of Morita homotopy between generalized maps and prove that our LS-category of a Lie groupoid is a Morita homotopy invariant.

Estimates for the LS-category of an orbifold relate to other numerical invariants such as Euler characteristic of a category, groupoid cardinality and the stringy Euler characteristic of an orbifold. (Received February 21, 2009)

57 ► Manifolds and cell complexes

1049-57-52 **Eric J Rawdon*** (ejrawdon@stthomas.edu), Department of Mathematics, University of St. Thomas, 2115 Summit Ave, OSS201, Saint Paul, MN 55105. *Size and Shape of Knotted Polymers.*

We use numerical simulations to investigate how the chain length and topology of freely fluctuating knotted polymer rings affect their size and shape. In particular, we analyze ellipsoids describing the inertial properties of the simulated polymers and minimal ellipsoids and rectangular boxes enveloping the simulated polymers. We measure the size and shape of these geometric containers using the radius of gyration, asphericity, and prolateness and use these quantities to characterize the mean size and shape of the polymers. This work was done in collaborations with Akos Dobay, John Kern, Kenneth Millett, Michael Piatek, Patrick Plunkett, and Andrzej Stasiak. (Received February 16, 2009)

1049-57-53 **Isabel K. Darcy*** (idarcy@math.uiowa.edu), Mathematics Department, 14 MLH, University of Iowa, Iowa City, IA 52242. *Tangle analysis of protein-DNA complexes.* Preliminary report.

Protein-DNA complexes have been modeled using tangles. A tangle consists of arcs properly embedded in a 3-dimensional ball. The protein is modeled by the 3D ball while the segments of DNA bound by the protein can be thought of as arcs embedded within the protein ball. This is a very simple model of protein-DNA binding, but from this simple model, much information can be gained. The main idea is that when modeling protein-DNA reactions, one would like to know how to draw the DNA. For example, are there any crossings trapped by the protein complex? How do the DNA strands exit the complex? Is there significant bending? Tangle analysis cannot determine the exact geometry of the protein-bound DNA, but it can determine the overall entanglement of this DNA, after which other techniques may be used to more precisely determine the geometry. (Received February 16, 2009)

1049-57-62 **Kenneth C Millett*** (millett@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, Santa Barbara, CA 93106. *Knots, Ephmeral Knots and Slipknots in Random Walks and Equilateral Polygons.*

Diao, Pippenger, Sumners, and Whittington proved the Delbruck-Frisch-Wasserman conjecture that the probability that a self-avoiding random walk or equilateral polygon contains a knot goes to one as the number of edges goes to infinity. An ephemeral knot is defined to be a knotted segment of a walk or polygon that is contained in a larger unknotted segment, called the associated slipknot. Millett, Dobay, and Stasiak showed that the statistics of random closures, to the sphere at infinity, of a polygonal segment provide an effective definition of knotting of the segment. We prove that the probability that a self-avoiding random walk or equilateral polygon, in 3-space or the simple cubic lattice, contains a slipknot goes to one as the number of edges goes to infinity and confirm it with a Markov Chain Monte Carlo of random walks in three space. (Received February 17, 2009)

1049-57-63 **Sophy Huck**, **Alexandra Appel**, **Miguel-Angel Manrique** and **Thomas W Mattman*** (TMattman@CSUChico.edu), Department of Mathematics, California State University, Chico, Chico, CA 95929-0525. *A sufficient condition for intrinsic knotting of bipartite graphs.*

We present evidence in support of a conjecture that a bipartite graph with at least five vertices in each part and $|E(G)| \geq 4|V(G)| - 17$ is intrinsically knotted. We prove the conjecture for graphs that have exactly five or exactly six vertices in one part. We also show that there is a constant C_n such that a bipartite graph with exactly $n \geq 5$ vertices in one part and $|E(G)| \geq 4|V(G)| + C_n$ is intrinsically knotted. Finally, we classify bipartite graphs with ten or fewer vertices with respect to intrinsic knotting. (Received February 17, 2009)

1049-57-64 **Ilesanmi Adeboye*** (adeboye@math.ucsb.edu), Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 93106. *On Volumes of Hyperbolic 4-Orbifolds.*

We will discuss progress in developing an explicit lower bound for the volume of a hyperbolic orbifold in dimension 4. (Received February 17, 2009)

1049-57-67 **Joseph E Borzellino** and **Victor W Brunsden*** (vwb2@psu.edu), Penn State Altoona, 3000 Ivyside Drive, Altoona, PA 16601. *The Stratified Structure of Spaces of Smooth Orbifold Mappings.*

4 different notions of orbifold map are presented for maps betweeen smooth, closed orbifolds $\mathcal{O}_1$ and $\mathcal{O}_2$. The spaces of orbifold mappings corresponding to each of these are either a) a manifold, b) a stratified space, c) an orbifold or d) a space stratified with orbifold strata for each of these distinct notions. The model spaces are Banach spaces for C^r maps where r is finite and Fréchet spaces for C^∞ maps in all cases. Corresponding to each possible notion of orbifold map is a category of orbifolds. (Received February 18, 2009)

1049-57-76 **Yuanan Diao*** (ydiao@uncc.edu), Department of Mathematics and Statistics, UNC Charlotte, 9201 University City Blvd, Charlotte, NC 28223, and **Ernst Claus**, **Attila Por** and **Uta Ziegler**. *The Ropelengths of Knots Are Almost Linear in Terms of Their Crossing Numbers: Part 1.*

For a knot or link $\mathcal{K}$, let $L(\mathcal{K})$ be the ropelength of $\mathcal{K}$ and $Cr(\mathcal{K})$ be the crossing number of $\mathcal{K}$. Here we show that there exists a constant $a > 0$ such that $L(\mathcal{K}) \leq aCr(\mathcal{K}) \ln^5(Cr(\mathcal{K}))$ for any $\mathcal{K}$, that is, the ropelength upper bound of any knot is almost linear in terms of its minimum crossing number and is a significant improvement over the best known upper bound established previously, where it was shown that $L(\mathcal{K}) \leq O((Cr(\mathcal{K})^{\frac{3}{2}}))$.

In this part, we lay out some basic graph theoretical results on subdividing a plane graph into sub plane graphs which are needed for constructing lattice knots of the given knot type with a length at most of order $O(n \ln^5(n))$ where n is the minimum crossing number of the given knot. (Received February 20, 2009)

1049-57-77 **Yuanan Diao** and **Ernst Claus*** (claus.ernst@wku.edu), Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101, and **Attila Por** and **Uta Ziegler**. *The Ropelengths of Knots Are Almost Linear in Terms of Their Crossing Numbers: Part 2.* Preliminary report.

For a knot or link $\mathcal{K}$, let $L(\mathcal{K})$ be the ropelength of $\mathcal{K}$ and $Cr(\mathcal{K})$ be the crossing number of $\mathcal{K}$. Here we show that there exists a constant $a > 0$ such that $L(\mathcal{K}) \leq aCr(\mathcal{K}) \ln^5(Cr(\mathcal{K}))$ for any $\mathcal{K}$, that is, the ropelength upper bound of any knot is almost linear in terms of its minimum crossing number and is a significant improvement over the best known upper bound established previously, where it was shown that $L(\mathcal{K}) \leq O((Cr(\mathcal{K})^{\frac{3}{2}}))$.

In this part, we outline the reconstruction process of a plane graph (namely our original minimum knot projection) from the pieces of sub plane graphs obtained by subdividing the original graph repeatedly. An

analysis of the volume the reconstructed graph occupies will yield the desired ropelength bound. (Received February 20, 2009)

1049-57-85 **Isabel Darcy** and **John Luecke*** (luecke@math.utexas.edu), University of Texas at Austin, Mathematics Department, 1 University Station C1200, Austin, TX 78712-0257, and **Mariel Vazquez**. *Knot Theoretic Analysis of Difference Topology Experiments on a Protein-DNA complex.*

Biologists Pathania, Jayaram, and Harshey developed an experimental technique, difference topology, for analyzing the structure of a protein-DNA complex, the mu transpososome. Deducing the shape of the complex from the experimental results presents an interesting knot-theoretic problem. In particular, the three strands of DNA in the complex are thought of as a 3-string tangle in a ball, and we seek those tangles consistent with the experimental results. We characterize such "solution tangles" by certain knotted graphs. By investigating planarity conditions on these graphs, we show that the only rational tangle solution, and the only solution with small crossing number, is that deduced by Pathania, Jayaram, and Harshey. That is, though there are other possible solutions, there is a unique one that is biologically relevant. (Received February 23, 2009)

1049-57-121 **Christian Laing** and **De Witt Sumners*** (sumners@math.fsu.edu), Department of Mathematics, Tallahassee, FL 32306. *The Writhe of Oriented Polygonal Graphs.*

The directional writhe of a simple closed curve is the sum of the signed crossings in the projection of the curve in the given direction. The writhe of a simple closed curve in 3-space is the average over all directions of directional writhe. We extend [1] this definition to apply to edge-oriented (each edge has an arrow on it) finite spatial graphs. This definition of writhe covers spatial polygonal arcs and non-connected graphs, and does not require the ad hoc closing of arcs to eliminate the problems posed by endpoints. This talk will discuss the properties of writhe of graphs, the proof of writhe additivity for connected sums, and applications to DNA and RNA.

[1] C. Laing and D.W.Sumners. The Writhe of Oriented Polygonal Graphs, Journal of Knot Theory and Its Ramifications 17 (2008), 1575-1594. (Received February 28, 2009)

1049-57-153 **Jianyuan Kathy Zhong*** (kzhong@csus.edu), Department of Mathematics and Statistics, California State University Sacramento, 6000 J Street, Sacramento, CA 95819, and **Bin Lu**, Department of Mathematics and Statistics, California State University Sacramento, 6000 J street, Sacramento, CA 95819. *The Kauffman Polynomials of Pretzel Knots and Rational Knots.* Preliminary report.

Let $\mathbb{Q}(\alpha, s)$ be the field of rational functions in α, s. We compute the Kauffman polynomial of a given pretzel knot [**?**] [**?**] or rational knot using the Kauffman skein theory and linear algebra tools. Our calculation can be implemented in Mathematica, Maple, Mathcad, etc. such that for a pretzel knot, after inputting the sequence notation, the output is its Kauffman polynomial. (Received March 02, 2009)

1049-57-208 **soojeong kim***, 14 mlh, iowa city, IA 52242, and **isabel darcy**, 14 mlh, iowa city, IA 52242. *'4-string tangle analysis of DNA-protein complexes'.* Preliminary report.

Kim, Darcy

An n-string tangle is a three dimensional ball with n-strings properly embedded in it. Protein-DNA complexes have been modeled by tangles. In this model, the protein is represented by the three dimensional ball and the protein-bound DNA is represented by the strings embedded in the ball. Recently, Darcy, Luecke and Vazquez used a 3-string tangle model to analyze the topological structure of DNA bound by Mu proteins. Their analysis is based on Pathania,Jayaram, and Harshey's experimental data of the Mu protein-DNA complex that consists of three DNA segments containing five nodes. Motivated by 3-string tangle analysis, we address a possible model of a protein binding DNA at four sites. The latest results of the topological 4-string tangle model for this case will be discussed. (Received March 04, 2009)

58 ► Global analysis, analysis on manifolds

1049-58-30 **Jiaping Wang*** (jiaping@math.umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455, and **Peter Li**. *Weighted Poincare inequality and Ricci curvature lower bound.*

We will describe an optimal upper bound estimate for the weight function in the weighted Poincare inequality on a complete manifold in terms of its Ricci curvature lower bound. The result provides an extension of Cheng's result concerning the upper bound of the bottom spectrum on a complete manifold. Some rigidity results for the equality case will also be mentioned. (Received February 02, 2009)

1049-58-59 **Markus J Pflaum*** (markus.pflaum@colorado.edu), Department of Mathematics UCB 395, University of Colorado, Boulder, CO 80309, and **Hessel Posthuma** and **Xiang Tang**. *Higher Index Theorems For Orbifolds.*

Given a symplectic orbifold and a deformation quantization on it, we prove an algebraic higher index theorem on orbifolds by computing the pairing between cyclic cocycles and the K-theory of the formal deformation quantization. As an application, we obtain the analytic higher index theorem of Connes–Moscovici and its extension to orbifolds. (Received February 17, 2009)

1049-58-75 **Carla Farsi*** (carla.farsi@colorado.edu), Department of mathematics, University of Colorado, Boulder, CO , and **Christopher Seaton**. *Generating Functions for Orbifold Wreath Products.*

In this talk, we will discuss a generating series approach for multiplicative functions on wreath products of a general orbifold in terms of orbifold sector decompositions. Particular instances of these product formulas occur for the Euler and the Euler–Satake charactersitics. This generalizes results known for global quotient orbifolds. (Received February 20, 2009)

1049-58-105 **Mary R Sandoval*** (mary.sandoval@trincoll.edu), 300 Summit Street, Department of Mathematics, Trinity College, Hartford, CT 06106. *Connections between singular spaces: leaf spaces of Riemannian manifolds and orbifolds.*

Given a Riemannian foliation on a compact boundaryless manifold, recall that the space of leaf closures is a singular stratified space. In fact, under certain circumstances the leaf closure space has the structure of an orbifold. More generally, the leaf closure space is a connected union of orbifolds whose dimensions vary. This talk will consist of a brief survey of the connections between leaf spaces and orbifolds, via the underlying groupoids. Connections to problems in spectral theory may also be discussed, as time permits. (Received February 26, 2009)

1049-58-135 **Victor Guillemin**, **Alejandro Uribe** and **Zuoqin Wang*** (zwang@math.jhu.edu), Department of Mathematics, Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD 21218. *Geodesics on weighted projective spaces.*

We study the inverse spectral problem for weighted projective spaces using wave-trace methods. We show that in many cases one can "hear" the weights of a weighted projective space. (Received March 01, 2009)

1049-58-189 **Emily B. Dryden*** (emily.dryden@bucknell.edu), Department of Mathematics, Bucknell University, Lewisburg, PA 17837. *Orbifolds and blowing up.* Preliminary report.

The process of blowing up can be useful when doing analysis on singular spaces. We discuss the role of orbifolds in this framework. (Received March 03, 2009)

60 ► Probability theory and stochastic processes

1049-60-2 **Roman Vershynin*** (romanv@umich.edu), University of Michigan, Department of Mathematics, 530 Church St, Ann Arbor, MI 48105. *Concentration of measure, convex geometry and random matrices.*

Concentration of measure provided us with a new look at independence in probability theory. In this talk will survey some recent developments in concentration of measure and applications in convex geometry and random matrix theory. (Received March 02, 2009)

1049-60-14 **Djalil Chafai*** (djalil@chafai.net), , France, and **Florent Malrieu**. *On fine properties of mixtures with respect to concentration of measure and Sobolev type inequalities.*

Mixtures of probability distributions are ubiquitous in Stochastic Analysis, Modelling, Simulation, and Statistics. A mixture can be far more subtle than its mixed components. For instance, mixing Gaussian laws may produce a potential with multiple deep wells. Also, the fine control of concentration of measure and functional inequalities for mixtures is not an easy task. We present in this talk some recent results, examples, and open questions. (Received January 11, 2009)

1049-60-19 **Steven N Evans** and **Bernd Sturmfels*** (bernd@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720, and **Caroline Uhler**. *Commuting birth-and-death processes.*

We use methods from combinatorics and algebraic statistics to study analogues of birth-and-death processes that have as their state space a finite subset of the m-dimensional lattice and for which the m matrices that

record the transition probabilities in each of the lattice directions commute pairwise. One reason such processes are of interest is that the transition matrix is straightforward to diagonalize, and hence it is easy to compute n step transition probabilities. The set of commuting birth-and-death processes decomposes as a union of toric varieties, with the main component being the closure of all processes whose nearest neighbor transition probabilities are positive. We exhibit an explicit monomial parametrization for this main component, and we explore the boundary components using primary decomposition. (Received January 19, 2009)

1049-60-33 **Katalin Marton*** (marton@renyi.hu), Reáltanoda u. 13-15, Budapest, 1053, Hungary.
Bounding relative entropy between measures on product spaces by the relative entropy between local specifications.

Let $q^n(x^n)$ be the density function of a random vector X^n in R^n. Under the conditions that its local specifications satisfy transportation-cost inequalities, and the dependence of coordinates is weak, we prove a bound for relative entropy in terms of single phase conditional entropies:

$$Ent(p^n||q^n)$$
$$\leq const. \cdot \sum_{i=1}^{n} Ent(P_i(\cdot|Y_1, Y_2, \ldots, Y_{i-1}, Y_{i-1}, \ldots, Y^n)||Q_i(\cdot|Y_1, Y_2, \ldots, Y_{i-1}, Y_{i-1}, \ldots, Y^n)).$$

(Here Y^n is a random vector with density p^n, and P_i and Q_i are the local specifications of p^n resp. q^n.)

Since single phase conditional entropies measure how different the local specifications of p^n and q^n are, this inequality allows to conclude from closeness of local specifications to closeness of p^n and q^n. Moreover, it yields logarithmic Sobolev inequalities in R^n, under conditions, similar to, but weaker than, those in a recent paper by Otto and Reznikoff. It gives a worse constant, but of the same order of magnitude as by Otto and Reznikoff.

The proof exploits and demonstrates the close connection between entropy and quadratic Wasserstein distance. (Received February 03, 2009)

1049-60-37 **Michel LEDOUX*** (ledoux@math.univ-toulouse.fr), Institut de Mathématiques de Toulouse, Université de Toulouse, F-31062 Toulouse, France. *Concentration inequalities for eigenvalues of random matrices.*

We survey recent developments on concentration and deviation inequalities for spectral measures and extremal eigenvalues of classes of random matrices. Concentration inequalities for spectral measures develop at the correct large deviation rate. The study of concentration and deviation inequalities, as well as variance bounds, for extremal eigenvalues at the fluctuation regime towards the Tracy-Widom distribution is more delicate. We present several approaches developed recently towards this goal, moment recurrence equations for the classical orthogonal polynomial ensembles, combinatorial estimates on families of Wigner matrices, and analysis of (Hermite and Laguerre) tridiagonal models (that leads to the best known estimates so far). (Received February 06, 2009)

1049-60-96 **Jean-René Chazottes*** (jeanrene@cpht.polytechnique.fr), CPHT, CNRS-Ecole Polytechnique, 91128 Palaiseau, France. *Concentration via coupling and some applications.*

We will describe some concentration inequalities for Markov processes, dynamical systems, Gibbs random fields and interacting particle systems. Our approach is via coupling. We get not only gaussian but also moment inequalities. Some applications will be mentioned. This is joint work with P. Collet and F. Redig. (Received February 25, 2009)

1049-60-130 **Malwina J Luczak*** (m.j.luczak@lse.ac.uk), Department of Mathematics, London School of Economics, Houghton Street, London, WC2A 2AE, England. *Concentration of measure, laws of large numbers and mixing for Markov chains.*

We consider Markovian models on graphs with local dynamics. We show that, under suitable conditions, well-behaved functions of the state of such a Markov chain at time t exhibit strong concentration of measure. We discuss how this can be used to prove a law of large numbers for a sequence of Markov chains. Also, we consider chains that exhibit both rapid convergence to equilibrium and strong concentration of measure in the stationary distribution.

We illustrate our results with applications to some known chains from computer science and statistical mechanics. (Received March 01, 2009)

1049-60-169 **Charlie Brubaker** and **Santosh S Vempala*** (vempala@cc.gatech.edu), Georgia Tech, Atlanta, GA 30332. *Random Tensors and Planted Cliques.* Preliminary report.

A random graph on n vertices where each edge is chosen with probability $1/2$ has a clique of size nearly $2\log n$ with high probability. What if a larger clique were planted in a random graph? Could we find it in polynomial

time? For general graphs, approximating the maximum clique is an intractable problem. Does the situation get better with random graphs? The current best algorithm can find a planted clique of size roughly $\sqrt{n}$. However, any planted clique of size greater than $2 \log n$ is unique with high probability, so there is large gap here. In a recent remarkable paper, Frieze and Kannan introduced a tensor-based method that could reduce the size of the planted clique to as small as roughly $n^{1/3}$. Their method relies on finding the spectral norm of a 3-dimensional tensor, a problem whose complexity is open. Moreover, their combinatorial proof does not seem to extend beyond this threshold. We show how to recover the Frieze-Kannan result using a purely probabilistic argument which generalizes naturally to r-dimensional tensors and lets us recover cliques of size as small as $poly(r).n^{1/r}$ provided we can find the spectral norm of r-dimensional tensors. (Received March 02, 2009)

1049-60-170 **Christian Houdre*** (houdre@math.gatech.edu), Georgia Institute of Technology, Department of Mathematics, Atlanta, GA 30332, and **Trevis Litherland** (trevisl@math.gatech.edu), Georgia Institute of Technology, Department of Mathematics, Atlanta, GA 30332. *On the Limiting Shape of Random Young Tableaux for Markovian Words.*

In this talk, I will describe some work of Trevis Litherland and myself on the limiting shape of random Young tableaux. More precisely: Let $(X_n)_{n\geq 0}$ be an irreducible, aperiodic, homogeneous Markov chain, with state space an ordered finite alphabet of size m. Using combinatorial constructions and weak invariance principles, we obtain the limiting shape of the associated Young tableau as a multidimensional Brownian functional. Since the length of the top row of the Young tableau is also the length of the longest (weakly) increasing subsequence of $(X_k)_{1\leq k\leq n}$ the corresponding limiting law follows. We relate our results to a conjecture of Kuperberg by showing that, under a cyclic condition, a spectral characterization of the Markov transition matrix delineates precisely when the limiting shape is the spectrum of the traceless GUE. For $m = 3$, all cyclic Markov chains have such a limiting shape, a fact previously known for $m = 2$. However, this is no longer true for $m \geq 4$. (Received March 02, 2009)

1049-60-176 **Sourav Chatterjee** and **Partha S Dey*** (partha@stat.berkeley.edu). *Stein's Method for concentration inequalities - some applications.*

Stein's method is a semi-classical tool for establishing distributional convergence, particularly effective in problems involving complex dependencies. A general way of deriving concentration inequalities using Stein's method was introduced by Sourav Chatterjee in his PhD thesis. In this talk we present extension and some applications of Stein's method for concentration inequalities. We prove a concentration inequality for the magnetization in the Curie-Weiss model at critical temperature where it obeys a non-standard normalization and super-Gaussian concentration. We also show how this method can be used to derive exact large deviation asymptotics for the number of triangles in the Erdős-Rényi random graph $G(n, p)$ when $p \geq 0.31$. Finally we provide some interesting concentration inequalities for the Ising model on lattices that hold at all temperatures. This talk is based on joint work with Sourav Chatterjee. (Received March 03, 2009)

1049-60-186 **Mark Meckes*** (mark.meckes@case.edu), 10900 Euclid Ave., Cleveland, OH 44106. *Concentration of functionals of random matrices.*

We discuss some concentration results for Hermitian and non-Hermitian random matrices with independent entries. (Received March 03, 2009)

62 ► Statistics

1049-62-34 **Hisayuki Hara**, Department of Technology Management for Innov, University of Tokyo, Tokyo, Japan, **Akimichi Takemura**, Graduate School of Information Science and Te, University of Tokyo, Tokyo, Japan, and **Ruriko Yoshida***, 805A Patterson Office Tower, Lexington, KY 40506. *On connectivity of fibers with positive marginals in multiple logistic regression.*

In this talk we consider exact tests of a multiple logistic regression, where the levels of covariates are equally spaced, via Markov beses. In usual application of multiple logistic regression, the sample size is positive for each combination of levels of the covariates. In this case we do not need a whole Markov basis, which guarantees connectivity of all fibers. We first give an explicit Markov basis for multiple Poisson regression. By the Lawrence lifting of this basis, in the case of bivariate logistic regression, we show a simple subset of the Markov basis which connects all fibers with a positive sample size for each combination of levels of covariates. (Received February 04, 2009)

68 ► Computer science

1049-68-204 **Thomas J Emerson*** (tj_emerson@yahoo.com), Mountain View, CA 94041. *Cell Discovery in Networks with Transient Links.* Preliminary report.

A considerable amount of recent research has been devoted to the study of communities within networks, that is, sets of nodes which are highly interconnected but only sparsely connected to the rest of the network. It is typically assumed that the network is static - that is, the links between nodes are permanent, or at least that their duration is relatively long in comparison to the timescale of data collection. In this talk we present an algorithm for finding cells in networks defined by transient links, where by a cell we mean a set of nodes that have exhibited a temporally correlated pattern of link instantiation; in networks where the nodes represent agents which can instantiate links (e.g., computers in a local area network, or callers in a telephone system), the existence of a cell signifies dependence between the stochastic actions of the agents that comprise the cell. We illustrate the performance of the algorithm on a telephone call graph based on data collected from cell phone users in the MIT Media Lab's Reality Mining project. (Received March 03, 2009)

76 ► Fluid mechanics

1049-76-45 **Peter Constantin** and **Gautam Iyer*** (gi1242@stanford.edu), Mathematics Bldg. 380, 450 Serra Mall, Stanford, CA 94305, and **Jonathan C. Mattingly** and **Alexei Novikov**. *Stochastic Lagrangian Particle systems for the Navier-Stokes and Burgers equations.*

I will introduce an exact stochastic representation for certain non-linear transport equations (e.g. 3D-Navier-Stokes, Burgers) based on noisy Lagrangian paths, and use this to construct a (stochastic) particle system for the Navier-Stokes equations. On any fixed time interval, this particle system converges to the Navier-Stokes equations as the number of particles goes to infinity.

Curiously, a similar system for the (viscous) Burgers equations shocks in finite time, and solutions can not be continued past these shocks using classical methods. I will describe a resetting procedure by which these shocks can (surprisingly!) be avoided, and thus obtain convergence to the viscous Burgers equations on long time intervals. (Received February 13, 2009)

1049-76-122 **Moe Ebrahimi**, **Michael Holst**, **Evelyn M. Lunasin*** (elunasin@math.ucsd.edu) and **Edriss S. Titi**. *The 2D Navier-Stokes-Voight and 2D damped Navier-Stokes equations for image inpainting.*

In 2001, Bertalmio, et. al. have built an analogy between the image intensity function for the inpainting problem and the stream function in 2D incompressible fluid. The solution to the inpainting problem is obtained by solving the steady state solution of the 2D NSE vorticity transport equation, and simultaneously solving the Poisson problem between the vorticity and the stream function, in the region to be inpainted. From this analogy one can investigate the quality and efficiency of a sub-grid scale turbulence model in the context of image inpainting. For small regularization parameter $\alpha > 0$, our numerical results show that the 2D Navier-Stokes-Voight equation gives a solution to the inpainting problem which is comparable with NSE (both in using subjective and objective measures) but requires reduced computational resources. A similar result holds true for the 2D damped NSE for a small damping coefficient. (Received February 28, 2009)

1049-76-124 **Joel Avrin*** (jdavrin@uncc.edu), Department of Mathematics and Statistics, Universty of North Carolina at Charlotte, 9201 University City Blvd, Charlotte, NC 28223-0001. *Attractor and inertial-manifold results for the 3-D spectrally-hyperviscous Navier-Stokes equations.*

Let P_m project onto the first m eigenmodes of $A = -\Delta$, and let $Q_m = I - P_m$, then we add to the 3-D incompressible Navier-Stokes equations the term $\mu A_\varphi u$ where the operator A_φ satisfies $A_\varphi \geq Q_m A^\alpha$ $(\alpha \geq 2)$ in the sense of quadratic forms. A distinguished class of A_φ is zero on the first m_0 eigenmodes for $m_0 \leq m$. We obtain global regularity and a compact global attractor $\mathcal{A}$ with Hausdorff and fractal dimensions bounded by $Km^a\kappa^b$ where κ is the Kolmogorov wavenumber, K is generally within an order of magnitude of unity, a is a fractional power, and $b < 3$. In particular $m^a\kappa^b \leq \kappa^3$ for $m \leq \kappa^3$, i.e. for m so large as to suggest machine-indistinguishability from NSE solutions. This robust conformance with the Landau-Lifschitz estimates appears to be unique among NSE closure models, and b is significantly lower for more realistic choices of m. We also obtain the existence of inertial manifolds which imply in the distinguished-class case that for m large enough eigenmodes free of hyperviscosity control the essential dynamics. (Received February 28, 2009)

1049-76-161 **James P Kelliher*** (kelliher@math.ucr.edu), University of California, Riverside, Department of Mathematics, Surge 253, 900 University Avenue, Riverside, CA 92521.
Vanishing viscosity and the accumulation of vorticity on the boundary.

We say that the vanishing viscosity limit holds in the classical sense if the velocity for a solution to the Navier-Stokes equations converges in the energy norm uniformly in time to the velocity for a solution to the Euler equations as the viscosity vanishes. I will show that, for a bounded domain in dimension 2 or higher, the vanishing viscosity limit holds in the classical sense if and only if a vortex sheet forms on the boundary. (Received March 02, 2009)

1049-76-182 **Gung-Min Gie** (gugie@umail.iu.edu), ISCAM, Indiana University, Room SE 315, Rawles Hall, 831 E. Third St., Bloomington, IN 47405, **Makram Hamouda*** (mahamoud@indiana.edu), ISCAM, Indiana University, Room SE 315, Rawles Hall, 831 E. Third St., Bloomington, IN IN 47405, and **Roger Temam** (temam@indiana.edu), ISCAM, Indiana University, Room SE 315, Rawles Hall, 831 E. Third St., Bloomington, IN IN 47405.
Remarks on the boundary layers for the Navier-Stokes equations in bounded domains.

We present in this lecture some convergence results related to the Linearized Navier-Stokes equations as the viscosity goes to zero. In this case and when the Dirichlet boundary conditions are considered, it is well known that some boundary layers occur at the boundary for bounded domains (at least in one direction). However, depending on the prescribed boundary conditions we distinguish two cases: the non-characteristic and the characteristic boundaries. Here, we mainly deal with the characteristic case when the boundary is flat (flow in a channel) and we end by giving some (necessary) results on the case of general bounded domains with curved boundary. These results should be useful, in particular, for the study of the asymptotic analysis of the linear and nonlinear Navier-Stokes problems when the viscosity goes to zero. (Received March 03, 2009)

82 ► Statistical mechanics, structure of matter

1049-82-82 **Tetsuo Deguchi*** (deguchi@phys.ocha.ac.jp), 2-1-1 Ohtsuka, Bunkyo-ku, Tokyo, 112-8610, Japan, and **Naoko Kanaeda** (kanaeda@degway.phys.ocha.ac.jp), 2-1-1 Ohtsuka, Bunkyo-ku, Tokyo, 112-8610, Japan. *A chain of linked ring polymers in solution via Brownian dynamics.* Preliminary report.

We discuss statistical and dynamical properties of a chain of linked ring polymers in solution through Brownian dynamics under hydrodynamic interaction. Here bond crossing is prohibited due to the FENE and the Lenard-Jones potentials. The chain consists of n ring polymers where each ring polymer is entangled to two adjacent ones. We have evaluated the mean-square radius of gyration and the diffusion constant of the chain. We also briefly review universality in the diffusion of knotted ring polymers in solution through Brownian dynamics. (Received February 23, 2009)

90 ► Operations research, mathematical programming

1049-90-24 **Jon Lee***, IBM TJ Watson Research Center, PO Box 218, Yorktown Heights, NY 10598.
Parametric Nonlinear Discrete Optimization.

I will discuss algorithms for solving max f(Wx), over x in F, where f is nonlinear, the rows of the matrix W can be thought of as describing several linear objectives, and F is a finite set of points. The function f can be though of as balancing the various linear objectives. We look at various combinatorial choices of F. So our work fits somewhere on the landscape between multi-criteria optimization and nonlinear discrete optimization.

In full generality the model is intractable, so we look at cases that yield poly-time algorithms and approximation schemes. Our results involve broad special cases. E.g., regarding F, we consider multi-knapsacks, matchings and (poly)matroids. Regarding f, we consider optimization of concave and convex functions, etc. Regarding W, we usually assume that it has a fixed number of rows and the entries are small in some sense.

Most of our algorithms were mainly designed for theoretical efficiency. Nonetheless, there is a good argument for trying to implement some of these methods on modern high-performance platforms. We describe such an effort, using ultra-high precision solution of linear systems on the BlueGene supercomputer.

Joint work, different parts with Berstein, Gunnels, Margulies, Maruri-Aguilar, Onn, Riccomagno, Weismantel, Wynn. (Received January 21, 2009)

1049-90-28 **Gabor Pataki*** (gabor@unc.edu), Dept of Statistics and Operations Research, Hanes Hall, UNC Chapel Hill, Chapel Hill, NC 27599, and **Mustafa Tural** (tural@email.unc.edu), Dept of Statistics and Operations Research, Hanes Hall, UNC Chapel Hill, Chapel Hill, NC 27599. *Basis reduction, and the complexity of branch-and-bound.*

Branch-and-bound is a classical method to solve integer programming feasibility problems. On the theoretical side, it is considered inefficient: it can provably take an exponential number of nodes to prove the infeasibility of a simple integer program.

In this work we show that branch-and-bound is theoretically efficient, if we apply a simple transformation in advance to the constraint matrix of the problem which makes the columns short and near orthogonal. We analyze two such reformulation methods, called the rangespace- and the nullspace methods. We prove that if the coefficients of the problem are drawn from $\{1, ..., M\}$ for a sufficiently large M, then for almost all such instances the number of subproblems that need to be enumerated by branch-and-bound is at most one.

Besides giving an analysis of branch-and-bound, our main result generalizes a result of Furst and Kannan on the solvability of subset sum problems to bounded integer programs.

We give some numerical values of M which make sure that 99 percent of the reformulated problems solve at the rootnode. These values turned out to be surprisingly small for moderate values of n (the number of variables), and m (the number of constraints). (Received January 25, 2009)

1049-90-32 **Alper Atamturk*** (atamturk@berkeley.edu), Berkeley, CA 94720, and **Vishnu Narayanan** (vishnu@iitb.ac.in), Mumbai, 400076, India. *Conic lifting.*

Lifting is a procedure for deriving valid inequalities for mixed-integer sets from valid inequalities for suitable restrictions of those sets. Lifting has been shown to be very effective in developing strong valid inequalities for linear integer programming and it has been successfully used to solve such problems with branch-and-cut algorithms. Here we generalize the theory of lifting to conic integer programming, i.e., integer programs with conic constraints. We show how to derive conic valid inequalities for a conic integer program from conic inequalities valid for its lower-dimensional restrictions. In order to simplify computations, we also discuss sequence-independent lifting for conic integer programs. When the cones are restricted to nonnegative orthants, conic lifting reduces to the lifting for linear integer programming. (Received February 03, 2009)

1049-90-38 **Joao Gouveia*** (jgouveia@math.washington.edu), **Monique Laurent**, **Pablo A Parrilo** and **Rekha R Thomas**. *A new SDP approach to the Max-Cut problem.* Preliminary report.

Using sums-of-squares techniques we develop a new hierarchy of SDP relaxations for the Max-Cut problem, solving an open question by Laszlo Lovasz. (Received February 09, 2009)

1049-90-39 **Edwin O'Shea***, edwin@math.cinvestav.mx. *On Large Gaps in Small Hierarchical Models.* Preliminary report.

Examples of contingency tables on binary random variables with large integer programming gaps on the lower bounds of cell entries were constructed by Sullivant. We show here that the marginals for which these constructed large gaps occur are "exceptionally rare", thus reopening the question, as Sullivant put it, of "whether linear programming is an effective heuristic for detecting disclosures when releasing margins of multi-way tables". This notion of "exceptionally rare" is made precise through the language of standard pairs. (Received February 10, 2009)

1049-90-50 **Carol Meyers*** (meyers14@llnl.gov), 7000 East Ave., L-153, Livermore, CA 94550, and **Andreas S. Schulz** (schulz@mit.edu), 77 Massachusetts Ave., E53-357, Cambridge, ME 02139. *Complexity and Equilibria in Congestion Games.*

Congestion games are games in which the cost of a resource depends solely on the number of players using that resource. In a network setting, player strategies correspond to simple $s_i - t_i$ paths and the cost of each arc varies according to the amount of flow traversing the arc. In this talk, we examine the complexity of finding system optimal solutions to such games, which are ones in which the overall cost is minimized. We also address the existence and price of anarchy of Nash equilibria in k-splittable congestion games, a varient of network congestion games in which a player may send flow on at most k different paths. (Received February 20, 2009)

1049-90-68 **Bala Krishnamoorthy*** (bkrishna@math.wsu.edu), PO Box 643113 WSU, Pullman, WA 99164, and **William Webb** (webb@math.wsu.edu) and **Nathan Moyer** (nmoyer@math.wsu.edu). *Lattice-based Approaches to Number Partitioning in the Hard Phase.*

The number partitioning problem (NPP) is to divide a set of integers $a_1, ..., a_n > 0$ into two disjoint subsets so that we minimize the difference of the subset sums, the discrepancy D. NPP is NP-complete, has a well-characterized phase transition, and finds many applications. When $a_j \in [1, R]$ (chosen uniformly), the expected optimal discrepancy is $O(\sqrt{n}2^{-n}R)$. The best known polynomial time approximation algorithm, due to Karmarkar and Karp, gives discrepancies that are $O(n^{-0.72 \log n}R)$. When $R > 2^n$, the optimal discrepancy is bigger than zero (no perfect partition), and the optimal partition is unique. Such instances with large R constitute the hard phase of NPP. We propose transformations of NPP in the hard phase to the shortest vector problem (SVP). We propose algorithms that tackle the NPP by solving SVP instances using basis reduction. We also propose a mixed integer program (MIP) model for NPP, and use a basis reduction-based reformulation of the MIP to handle the typically huge a_j's found in the hard phase. Finally, we propose a heuristic called truncated NPP, where we solve an equivalent NPP instance with $a'_j = a_j/T$ for $T > 0$. We show that the expected discrepancy given by this method is $O(D^* + nT)$, where D^* is the optimal discrepancy. (Received February 19, 2009)

1049-90-101 **Ellis L. Johnson*** (ejohnson@isye.gatech.edu), Georgia Tech, School of ISyE, Atlanta, GA 30332-0205. *Facets of the Mixed Integer Cut.* Preliminary report.

Gomory's mixed integer cut (MIC) has received attention as being important both from the shooting experiment and from strengthening the LP before branch-and-bound. The shooting experiment is discussed and its results explained. MIC is known to be a facet for every cyclic group master problem. We show that the facets of this face are closely related to knapsack facets and are in fact what are called MIC tilting facets in [J. Aráoz, L. Evans, R.E. Gomory, E.L. Johnson, "Cyclic Group and Knapsack Facets", Mathematical Programming Series B 96, 377-408, 2003]. (Received February 25, 2009)

1049-90-115 **Jiawang Nie*** (njw@math.ucsd.edu), UCSD Mathematics Department, 9500 Gilman Drive, La Jolla, CA 92122, and **J. William Helton**. *SDP representation of convex sets.*

This talk will present some new results on representing convex set by semidefinit programming (SDP). A set is SDP representable if it can be expressed by some linear matrix inequality (LMI) with lifting variables. The necessary conditions for SDP representation are convexity and being semialgebraic. This talk will show a general sufficient condition: if the boundary of a convex set has positive curvature, then it is SDP representable. This is joint work with Bill Helton. (Received February 27, 2009)

1049-90-139 **Egon Balas*** (eb17@andrew.cmu.edu), Carnegie Mellon University, Tepper School of Business and, Department of Mthematical Sciences, Pittsburgh, PR 15213. *Intersection cuts from maximal lattice-free convex sets and lift-and-project cuts from multiple-term disjunctions.*

Intersection cuts from maximal lattice-free convex sets have recently been investigated with a view of deriving cuts simultaneously from multiple rows of a simplex tableau. We examine the relationship of these cuts to disjunctive cuts and lift-and-project cuts from multiple-term disjunctions. In the case of 0-1 mixed-integer programs, the cuts from maximal q-dimensional lattice-free convex sets are dominated by cuts from q-term disjunctions, which in turn are rank q split cuts. For a general mixed integer program with feasible set PI and its linear programming relaxation P, we define the disjunctive relaxation PD(v) at a fractional vertex v of P as the set of points satisfying all disjunctions that exclude v but no integer point, and the disjunctive hull at v as conv(PD(v)). We examine the relation between the disjunctive hull, the corner polyhedron and the integer hull, and give conditions for a facet defining inequality for the disjunctive hull to be facet defining for the integer hull. (Received March 01, 2009)

1049-90-203 **Jesus A De Loera*** (deloera@math.ucdavis.edu), Dept of Mathematics, University of California, Davis, CA 95616. *Gauging feasibility of integer linear programs.*

Given an integer linear programming problem, $Ax = b$, $x \geq 0$, $x \in \mathbb{Z}^d$, we are interested on exploring new ideas for estimating the number of feasible solutions to the problem. This a well-known NP-hard problem, so we cannot expect positive results in all instances, but we aim to develop practical strategies that allows to discard infeasible problems in a large proportion of instances.

In this talk I report on the practical computational behavior of estimators arising from the solution of simple convex optimization problems recently introduced by Barvinok and Hartigan and from some reformulation techniques. Our numerical tests include knapsack problems, transportation problems. We also report on the

binary feasibility problem case (i.e. x is a binary vector) through the study of market-split problems and other packing problems.

This is joint work, in progress, with A. Barvinok (U. Michigan). (Received March 03, 2009)

91 ► Game theory, economics, social and behavioral sciences

1049-91-57 **Christopher Thomas Ryan*** (chris.ryan@sauder.ubc.ca), 2053 Main Mall, Vancouver, BC V6T 1Z2, Canada, and **Matthias Koeppe**, **Albert Xin Jiang**, **Kevin Leyton-Brown** and **Maurice Queyranne**. *Computing pure Nash equilibria in games with piecewise linear utilities.*

We explore the computational complexity of computing pure Nash equilibria and related concepts for two classes of games. The first is a new class of strategic games called integer programming games, where players' action sets are integer points inside of polytopes. The other is a class of symmetric games with fixed-size action sets. In both setting we consider piecewise linear utilities. Using recent results from the algorithmic study of short rational generating functions for encoding sets of integer points, we present efficient algorithms (taking some parameters to be fixed) for deciding the existence of pure Nash equilibria in these games, and as well as other related computations. (Received February 17, 2009)

92 ► Biology and other natural sciences

1049-92-150 **Stephen D Levene*** (sdlevene@utdallas.edu), Dept. of Molecular and Cell Biology, 800 West Campbell Road, Richardson, TX 75080. *New Mechanistic Insights into Flp and Cre Recombination from DNA Loop-closure Kinetics.*

The Flp and Cre recombination systems have become important tools for the genetic manipulation of higher organisms and paradigms for site-specific DNA-recombination mechanisms employed by the λ-int superfamily of recombinases. A hallmark of the int superfamily is that recombination takes place via a four-stranded, Holliday-junction DNA intermediate. High-resolution crystal structures of Flp and Cre synaptic complexes formed with duplex and junction DNAs suggest that the key mechanistic steps can be explained in terms of DNA strand exchanges taking place within an approximate square-planar arrangement of DNA duplexes. It is difficult, however, to reconcile the square-planar exchange mechanism observed in the co-crystal structures with evidence for a chiral recombination intermediate, which derives from the topological handedness of recombination products generated with circular DNA substrates. A rigorous kinetic analysis of intramolecular site-specific recombination as a function of target-site spacing, in concert with numerical analysis of loop-closure probabilities, shows that the rate-determining step in this mechanism involves a non-planar DNA intermediate. Implications of this finding regarding int-superfamily recombination pathways will be discussed. (Received March 02, 2009)

94 ► Information and communication, circuits

1049-94-26 **Friedrich Eisenbrand*** (friedrich.eisenbrand@epfl.ch), EPFL IMA, Station 8, 1015 Lausanne, Switzerland, and **Gennady Shmonin**, EPFL SB IMA Station 8, 1015 Lausanne, Switzerland. *Parametric integer programming in fixed dimension.*

A parametric integer program consists of an integral matrix $A \in Z^{m \times n}$ and a polyhedron $Q \subseteq R^m$. The problem is to determine, whether there exists a right-hand-side $b \in Q$ such that $Ax \leq b$ is an integer infeasible inequality system. Kannan showed that this problem can be solved in polynomial time, if the number of columns n of A and the affine dimension of Q are fixed. In this talk we show that there exists an extension of this algorithm which runs in polynomial time under the only requirement that the number of columns of A is fixed. (Received January 24, 2009)

00 ► General

1050-00-65 **Paul A O'Gorman*** (pog@mit.edu), Massachusetts Institute of Technology, Cambridge, MA 02139. *Understanding the relative humidity distribution of the atmosphere using a simple model.*

The distribution of water vapor in the atmosphere is crucial for the maintenance of the Earth's climate. The amount of water vapor that the atmosphere can hold at saturation is very sensitive to changes in temperature. The extent to which atmospheric water vapor content responds to changes in temperature depends on whether the relative humidity remains constant. Observations and climate model simulations suggest that relative humidity will remain approximately constant when averaged over very large regions. But climate model simulations of global warming do indicate local changes in relative humidity. We discuss a stochastic model for the relative humidity distribution based on Lagrangian trajectories driven by Ornstein-Uhlenbeck processes. The stochastic model is reduced to a partial differential equation for the mean relative humidity, and is shown to reproduce the major features of the observed relative humidity distribution in the extratropics. Further work is needed to understand how solutions of the stochastic model relate to the relative humidity distributions found in climate model simulations. (Received February 23, 2009)

1050-00-114 **Young-Oh Kwon*** (yokwon@whoi.edu), Woods Hole Oceanographic Institution, Physical Oceanography Department, MS #21, Woods Hole, MA 02543, and **Claude Frankignoul**, LOCEAN, Université Pierre et Marie Curie, Paris, France. *Multi-decadal Variability of Atlantic Meridional Overturning Circulation in the Community Climate System Model Version 3.* Preliminary report.

Multi-decadal variability of Atlantic meridional overturning circulation (AMOC) is examined from a 700-year present-day control integration of the Community Climate System Model version 3 (CCSM3). AMOC variability in CCSM3 exhibit two distinct regimes, i.e. periods with very regular and strong decadal (20-years) variability versus irregular and weak multi-decadal (50-years) variability. The focus of the presentation is the mechanism of the weak multi-decadal AMOC variability during the last 250 years of the integration. AMOC variability in this regime is primarily driven by the stochastic atmospheric buoyancy and wind stress curl forcing associated with NAO. During the NAO positive phase, most of the upper ocean in the subpolar North Atlantic becomes anomalously denser due to the surface heat flux as well as fresh water flux. Deepest mixed layer of 1000 1200m is found in the interior of the Labrador Sea. On the other hand, the cyclonic subpolar gyre circulation becomes stronger in response to NAO wind stress curl forcing. Advection of anomalous density by the cyclonic circulation acts as a positive feedback to render the multi-decadal persistence to the circulation. (Received March 02, 2009)

1050-00-145 **Sudeep Samanta*** (ssamanta@whrc.org), 149 Woods Hole Road, Falmouth, MA 02540, and **Richard A. Houghton**, 149 Woods Hole Road, Falmouth, MA 02540. *A component-based framework for semi-empirical, process-based modeling of carbon flux from terrestrial ecosystems.*

Complex process models integrate multiple interacting components, each representing a simpler process. Often multiple alternatives for modeling one such component are available. However, such alternatives can only be tested within the context of a larger model, which is usually complex and not very transparent. Therefore, the results of testing a component within one specific complex model cannot be easily transferred to a more general context. To address this issue, we are developing a modeling framework to provide a transparent, and easily modifiable, structural context. At its core is a data structure where process functions are represented by function pointers. The data structure takes care of data handling tasks during a simulation, and the computational structure associated with these tasks remain unchanged regardless of the process descriptions. A complete model for a certain system response can be created by putting together various plausible process components through the corresponding function pointers at the initialization stage. This technique provides the ability to test model components by choosing to activate or deactivate them individually for such tests, while retaining transparency in the overall model structural context for the component being tested. (Received March 03, 2009)

1050-00-155 **Steven E Gaurin*** (sgaurin@geo.umass.edu). *North Atlantic Climate Variability: Preliminary Analysis of Historical Weather Data and Stable Isotope Time Series from Cave Dripwater and a Holocene-Age Stalagmite from Bermuda.*

Bermuda, located in the subtropical North Atlantic, is a unique laboratory for analyzing Holocene climate change. This area lacks a strong seasonal cycle, making it an ideal place to look for low-frequency cycles identified in observational records of climate parameters. A preliminary statistical analysis of historical climate data, spanning a period from 1852 to 2006, is presented. Emphasis is placed on the identification of cycles in the data which might correspond to such climate modes as the North Atlantic Oscillation (NAO) and the Atlantic Multidecadal Oscillation (AMO).

Carbonate caves abound on the island of Bermuda and contain numerous speleothems with the potential to serve as extremely high-resolution (sub-decadal) recorders of climate change. Time series of stable isotope data from a Bermuda stalagmite covering 4700-2700 years ago are presented and briefly analyzed. Stalagmite stable isotope data are reflective of changes in stable isotopes of the cave dripwater feeding the stalagmite. Approximately bi-weekly to monthly samples of dripwater from three sites in each of two Bermuda caves have been collected from April 2006 to present; time series of stable oxygen isotope data are presented, including a signal from the passage of Hurricane Florence in September 2006. (Received March 03, 2009)

01 ► History and biography

1050-01-22 **Willem J Wallinga*** (wjl3@unh.edu), 12 Maplewood Ave., Rochester, NH 03867. *The Historical and Educational Origins of Probability Theory.*

The invention of probability theory in the 16th and 17th centuries has been a subject of recurring interest for historical researchers in mathematics. The earliest efforts arose from attempts to analyze simple games of chance involving randomizers such as coins and dice, objects that have existed worldwide for several millennia. This developmental delay is a source of great debate and speculation among historians, and has been described as one of the greatest enigmas of modern science. Students in the 21st century face a similar delay in learning the basics of mathematical probability. Despite being familiar with a wide range of randomizers and games of chance at an early age, children have not been traditionally introduced to concepts in probability until at least adolescence. This presentation will elaborate on these common themes. (Received January 05, 2009)

05 ► Combinatorics

1050-05-20 **Ji-A Yeum*** (yeum@math.ohio-state.edu), Ohio State University, Department of mathematics, 231 W 18th Avenue, Columbus, OH 43210. *Probability of solvability of random systems of 2-linear equations over $GF(2)$.*

We consider the random system of 2-linear equations over the finite field $GF(2)$ whose left hand side corresponds to the random graph $G(n,p)$ and whose right hand side consists of independent Bernoulli random variables with success probability $1/2$, assuming that the right hand side is independent of the left hand side.
$G(n,p)$ is the random graph with n labeled vertices such that each of the $\binom{n}{2}$ possible edges is present in the graph independently of all others, with probability p.
We prove that when $G(n,p)$ is at the subcritical phase and $|\lambda| \gg n^{1/39}, |\lambda| = O(n^{1/12-\epsilon})$ with a fixed $0 < \epsilon < 1/12 - 1/39$, the probability of solvability of the random system corresponding to $G(n,p)$ is asymptotic to $e^{3/8}|\lambda|^{1/4}n^{-1/12}$ as $n \to \infty$. Also, we prove that when $G(n,p)$ is at the critical phase, the probability of solvability of the random system corresponding to $G(n,p)$ is asymptotic to $c_\lambda n^{-1/12}$ as $n \to \infty$, where the constant c_λ is expressed as a convergent double series depending on λ. (Received January 05, 2009)

1050-05-37 **Sebastian M. Cioabă*** (cioaba@math.udel.edu), Department of Mathematical Sciences, 501 Ewing Hall, University of Delaware, Newark, DE 19711. *Eigenvalues and connectivity of regular graphs.* Preliminary report.

I will present some new results relating the connectivity of a regular graph to its eigenvalues. (Received January 29, 2009)

1050-05-51 **Jack E Graver*** (jegraver@syr.edu), Department of Mathematics, Syracuse University, Syracuse, NY 13244, and **Elizabeth J Hartung** (ejhartun@syr.edu), Department of mathematics, Syracuse University, Syracuse, NY 13244. *A catalog of self-dual plane graphs with maximum degree 4.*

Self-dual plane graphs have been studied extensively. In 1992, Archdeacon and Richter [*Construction and Classification of Self-Dual Spherical Polyhedral*, J. Comb. Theo. **B 54**, 37-63 (1992)] described a method for constructing all self-dual plane graphs; a second construction was produced by Servatius and Servatius [*Self-dual graphs*, Disc. Math. **149**, 223-232, (1996)]. In both cases the construction is inductive. In this paper, we construct a catalog of self-dual plane graphs with maximum degree 4 (self-dual spherical grids). Self-dual spherical grids fall into a finite number of parameterized, infinite families. The individual self-dual spherical grids in a family have the same basic shape, differing only in size. A catalog, as opposed to a method of construction, yields direct access to individual self-dual spherical grids without constructing all smaller self-dual spherical grids first. (Received February 21, 2009)

1050-05-53 **Brigitte Servatius*** (bservat@wpi.edu), Mathematical Sciences, WPI, 100 Institute Rd, Worcester, MA 01609. *Polarity and rigidity in the plane.*

If the edges of a graph, G, are interpreted as rigid bodies and vertices of G are interpreted as pin joints, then the rigidity of a generic realization is a combinatorial property, which is well studied. We examine the behavior of the rigidity properties under the polar construction in the plane, which takes lines to points and points to lines. To every graph in the plane we get a corresponding line arrangement and we can now view the lines as rigid bodies, which are pinned at certain intersection points, namely those, which are polar images of the edges of G. We give a formula for the degrees of freedom of this line arrangement derived from the rigidity properties of the graph G. (Received February 21, 2009)

1050-05-54 **Servatius Herman*** (hservat@wpi.edu), Mathematical Sciences, WPI, Worcester, MA 01609. *Equivalent Mechanisms and Configuration Spaces.*

A theorem of Kempe states that every algebraic plane curve can be traced by a vertex of a pinned mechanism of rigid rods and revolute joints. We consider two mechanisms to be locally point equivalent if there is a curve in the plane, other than a circle, which is traced by the vertices of both mechanisms. Given two locally point equivalent mechanisms, one cane superimpose them to create a larger mechanism which is necessarily dependent. We examine ways to reverse this process. (Received February 21, 2009)

1050-05-55 **Sandra Kingan*** (skingan@brooklyn.cuny.edu), Department of Mathematics, Brooklyn College, CUNY, Brooklyn, NY 11210. *On Representable Matroids With Large Planes.*

Two $GF(q)$-representable matroids $M(A)$ and $M(B)$ may be representable as matroids, but there may be no way of obtaining matrix A from matrix B using elementary row operations, column scaling, column permutations, or field automorphisms. In this case we say A and B are inequivalent representations of the same matroid. The study of $GF(q)$-representable matroids is complicated by the presence of inequivalent representations. It may be one reason why Rota's conjecture that $GF(q)$-representable matroids have a finite list of minimal excluded minors is not yet resolved. We prove that inequivalence is not an issue for 3-connected $GF(q)$-representable matroids with large planes (planes with at least $2q$ elements) because they are stabilized by their rank 3 minors. This is joint work with Robert Kingan. (Received February 21, 2009)

1050-05-57 **Edwin R. van Dam*** (Edwin.vanDam@uvt.nl), Dept. Econometrics & OR, Tilburg University, PO Box 90153, 5000 LE Tilburg, Netherlands. *Almost distance-regular graphs.*

Motivated by spectral characterizations of distance-regular graphs, we discuss some concepts of almost distance-regularity of graphs, such as partial distance-regularity and walk-regularity. (Received March 02, 2009)

1050-05-58 **Mikhail H Klin**, **Dale M Mesner** and **Andrew J Woldar*** (andrew.woldar@villanova.edu), Department of Mathematical Sciences, Villanova University, Villanova, PA 19085. *The Combinatorics of Transitive Extensions.*

If (H, Ω) is a permutation group then H admits natural actions on the sets Ω^k, $\Omega^{\{k\}}$ of ordered and unordered k-tuples, respectively. Hence these sets partition into H-orbits. We propose an algebraic calculus for partitions of Ω^k, $\Omega^{\{k\}}$ which serves to approximate H-orbit partitions in pure combinatorial terms. In this sense we attempt to formulate combinatorially what it means for a structure to be highly symmetric without saying that its symmetry groups have the property of being highly transitive. Our motivation stems from the way in which association schemes analogously approximate 2-orbits of transitive permutation groups (this is the case $k = 2$). New combinatorial structures are defined, and results which apply these structures to the problem of transitive extension are provided. (Received February 22, 2009)

1050-05-63 **Miklos Bona*** (bona@math.ufl.edu) and **Ryan T Flynn**. *The Average Number of Block Interchanges Needed to Sort A Permutation.*

We use an interesting result of probabilistic flavor concerning the product of two permutations consisting of one cycle each to find an explicit formula for the average number of block interchanges needed to sort a permutation of length n. That is, a question from the theory of algorithms is shown to have its roots in group theory and probability. Even more interestingly, a crucial step of the proof is a lemma of algebraic flavor which may have far-reaching generalizations using tools related to association schemes. (Received February 23, 2009)

1050-05-68 **Tim Penttila*** (penttila@math.colostate.edu), Department of Mathematics, Colorado State University, Fort Collins, CO 80523. *Hemisystems of unitary spaces.*

A hemisystem H is a set of maximal totally isotropic subspaces of a finite nondegenerate unitary space of even dimension such that, for every totally isotropic point P, exactly half of the maximals on P are in H. Hemisystems were introduced by Beniamino Segre in 1965. He constructed one in the four-dimensional unitary space over the field with 9 elements, and raised the question of their existence for other spaces (necessarily over fields of odd order). In 2005, Cossidente and Penttila constructed hemisystems in all of the four-dimensional unitary spaces in odd characteristic, with the resulting hemisystems admitting four-dimensional orthogonal groups of minus type. In work to appear in J. Algebraic Combinatorics, the same authors constructed hemisystems in all the six-dimensional unitary spaces in odd characteristic. Here, in joint work with Bayens, these constructions are generalized to all even-dimensional unitary spaces in odd characteristic. Recently, van Dam, Martin and Muzychuk constructed new Q-polynomial associations schemes (that are not distance-regular graphs) from hemisystems in the four-dimensional unitary spaces and, more generally, from hemisystems of generalized quadrangles meeting the Higman bound. (Received February 23, 2009)

1050-05-69 **M. E. Muzychuk*** (misha.muzychuk@gmail.com), Dept. of Comp Science ans Mathematics, Netanya Academic College, University st. 1, 42365, Netanya, Israel, and **I. N. Ponomarenko** (inp@pdmi.ras.ru), Petersburg Dept. of Institute of Mathematics, 27, Fontanka,191023, St. Petersburg, Russia. *On pseudocyclic association schemes.* Preliminary report.

A pseudocyclic association schemes were introduced by D.H.L. Hollman in 1982. We extended this notion for non-commutative schemes. In our talk we present recent result about pseudocyclic non-commutative schemes. We will show their relationship with block designs and permutation groups. We also will formulate some open problems. (Received February 24, 2009)

1050-05-70 **Andre Schulz*** (aschulz@email.smith.edu), Smith College, Computer Science Department, Northampton, MA 01060, and **Kevin Buchin** (buchin@cs.uu.nl). *On the Number of Spanning Trees a Planar Graph Can Have.*

The maximum number of spanning trees of a planar graph grows exponentially with the size of the graph. We prove a new upper bound for this exponentiell growth. The improved bound relies on a careful probabilistic analysis of the so called "outgoing edge" approach. We analyze the occurrence of directed cycles if one selects one outgoing edge for every vertex. As novelty we introduce a technique that is capable to analyze dependent events in this scenario easily. Our method might find applications on similar problems with sparse dependency graphs.

By Kirchoff's Matrix-Tree Theorem the determinant of the Laplace matrix of a graph equals the number of its spanning trees. As a consequence the improved upper bound implies also a new upper bound for grid embedding of 3-polytopes. For this application the maximal growth is determined by planar graphs which contain no triangular and quadrilateral faces. We therefore analyze this special situation separately and obtain an improved upper bound for this setting too. (Received February 24, 2009)

1050-05-76 **Stephen S. Graves** (sgraves@syr.edu), Syracuse University, Mathematics Department, 215 Carnegie, Syracuse, NY 13244-1150, and **Mark E. Watkins*** (mewatkin@syr.edu), Syracuse University, Mathematics Department, 215 Carnegie, Syracuse, NY 13244-1150. *Growth of Homogeneous Planar Tessellations.*

A (planar) tessellation T is an embedding in the plane without accumulation points of a 3-connected, one-ended, locally finite simple graph. With a single vertex or face as the root (0th corona), each (new) face in the $(n+1)$st corona shares a common incident vertex with a face in the nth corona. Let f_n denote the number of faces in the nth corona of T, and define $\varphi_T(z) = \sum_{n=0}^{\infty} f_n z^n$. Define growth rate $\gamma(T)$ to be the reciprocal of the radius of convergence of $\varphi_T(z)$. This generalizes J. Moran's definition of growth rate as $\lim_{n\to\infty}[\sum_{k=0}^{n+1} f_k / \sum_{k=0}^{n} f_k]$, which sometimes does not exist.

For normal tessellations T in the Euclidean plane, $\gamma(T) = 1$. They grow quadratically, while in the hyperbolic plane, $\gamma(T) > 1$ and growth is exponential. As every growth rate > 1 is realizable by some hyperbolic tessellation, it is more interesting to investigate those having edge-, vertex-, or face-homogeneity, where accretion rules make possible exact computation of $\gamma(T)$. These growth rates are bounded away from 1, and minimum values are found in all cases. In the case of edge-homogeneity, the authors' work is joint with T. Pisanski. (Received February 25, 2009)

1050-05-79 **David Feldman** and **James Propp*** (JamesPropp@gmail.com), Department of Mathematical Sciences, University of Massachusetts Lowell, One University Avenue, Lowell, MA 01854, and **Sinai Robins**. *Tiling lattices with translates of sublattices.* Preliminary report.

We study the problem of tiling (exactly covering) an n-dimensional lattice by finitely many translates of sublattices. If we make the assumption that each tiling sublattice is a Cartesian product of arithmetic progressions, we can use Fourier methods to prove that two of the sublattices must be translates of one another. In the absence of this assumption, it can happen (for $n > 2$) that no two of the sublattices are translates of one another. The case $n = 2$ remains open, and we are exploring the use of theta functions to illuminate the question. (Received March 04, 2009)

1050-05-80 **Etsuko Bannai*** (etsuko@math.kyushu-u.ac.jp), 2-8-21 Misakigaoka, Maebaru-shi, Fukuoka 819-1136, Japan. *Euclidean designs and coherent configurations.*

Euclidean designs are introduced by Neumaier-Seidel (1988) as a generalization of spherical designs. As is well known by Delsarte-Goethals-Seidel (1977), association schemes play important roles in the study of spherical designs. Through the study of Euclidean designs, we found out that even if it is not tight, a Euclidean design satisfying some good conditions has a structure of the coherent configuration. Coherent configuration is a purely combinatorial concept defined by D. G. Higman. It is obtained by abstracting the properties of general, not necessarily transitive, permutation groups in the same way as association scheme was obtained by abstracting the properties of transitive permutation groups. As an application of this general theory, we discuss the current status of our research to try to classify Euclidean 4-designs (X,w) on two concentric spheres $S = S_1 \cup S_2$ whose weight function is constant on each $X \cap S_i (i = 1, 2)$ and $X \cap S_i (i = 1, 2)$ is at most 2-distance set. We will also give a series of feasible parameters for coherent configurations, if they exist then we will have Euclidean tight 4-designs on two concentric spheres. This talk is base on a joint work with Eiichi Bannai. (Received February 26, 2009)

1050-05-88 **Hasan Alnajjar** (h.najjar@ju.edu.jo), Department of Mathematics, University of Jordan, Jordan, and **Brian W Curtin*** (bcurtin@math.usf.edu), Department of Mathematics and Statistics, University of South Florida, 4202 E. Fowler Ave. PHY 114, Tampa, FL 33620. *Leonard pairs associated with sl_2.*

The equitable basis x,y, z of the Lie algebra sl_2 satisfies $[x, y] = 2x + 2y$, $[y, z] = 2y + 2z$, $[z, x] = 2z + 2x$. We show that every Leonard pair A, A^* of classical type (Racah, Hahn, dual Hahn, or Krawtchouk) acts as a linear combination of I, x, y, xy and I, y, z, yz, respectively. We then discuss extending these Leonard pairs to Leonard triples from this perspective. (Received February 26, 2009)

1050-05-93 **Hiroshi Suzuki*** (hsuzuki@icu.ac.jp), Dept. of Mathematics and Computer Science, International Christian University, 3-10-2, Osawa, Mitaka, Tokyo, 181-8585. *Distance-Regular Graphs Having Certain Completely Regular Subgraphs.*

Let $\Gamma = (X, R)$ be a distance-regular graph of diameter d. A subset Y of X is said to be *completely regular* if the numbers

$$\pi_{i,j} = |\Gamma_j(x) \cap Y| \quad (i, j \in \{0, 1, \ldots, d\})$$

depend only on $i = \partial(x, Y)$ and j.

Many distance-regular graphs have distance-regular subgraphs whose vertex set is completely regular. In this presentation, we discuss characterizations of distance-regular graphs by their completely regular distance-regular subgraphs.

We start from the case when the induced subgraph is a quadrangle and give characterizations of Hamming graphs and dual polar graphs.

We also discuss its connection to D-bounded distance-regular graphs. (Received February 28, 2009)

1050-05-97 **Jianmin Ma*** (jianmin.ma@emory.edu), Oxford College of Emory University, Oxford, GA 30054. *Nonexistence of Certain Amorphous Association Schemes.* Preliminary report.

An association scheme is said to be skew symmetric if it has no non-diagonal symmetric relations. In this talk, we will show that there is no amorphous skew symmetric association scheme of class at least 4. The we will examine the parameters of three-class and four-class nonsymmetric schemes of Latin square type. (Received February 28, 2009)

1050-05-101 **Gargi Bhattacharyya** (gbhattacharyya@ubalt.edu), Liberal Studies, University of Baltimore, Baltimore, MD 21201, **Sung Y Song*** (sysong@iastate.edu), Department of Mathematics, Iowa State University, Ames, IA 50011-2064, and **Rie Tanaka** (hrie@webmail.tohoku.ac.jp), Graduate School of Information Sciences, Tohoku University, Sendai, 980-8579, Japan. *Terwilliger algebras of wreath products of one-class association schemes.*

We discuss the wreath product of one-class association schemes $K_n = H(1,n)$ for $n \geq 2$. We show that the d-class association scheme $K_{n_1} \wr K_{n_2} \wr \cdots \wr K_{n_d}$ formed by taking the wreath product of K_{n_i} (for $n_i \geq 2$) has the triple-regularity property. Then based on this fact, we determine the structure of the Terwilliger algebra of $K_{n_1} \wr K_{n_2} \wr \cdots \wr K_{n_d}$ by studying its irreducible modules. In particular, we show that every non-primary module of this algebra is 1-dimensional. (Received February 28, 2009)

1050-05-102 **Aleksandar Jurisic*** (aj@fri.uni-lj.si), Faculty of Computer and Information Science, LKRV, Jadranska 21, 1000 Ljubljana, Slovenia, and **Paul Terwilliger** (terwilli@math.wisc.edu), Department of Mathematics, Van Vleck Hall, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706. *Distance-regular graphs with tails.* Preliminary report.

Let Γ be a distance-regular graph with valency $k \geq 3$ and diameter $d \geq 2$. It is well-known that the Schur product $E \circ F$ of any two minimal idempotents of Γ is a linear combination of minimal idempotents of Γ. Situations where there is a small number of minimal idempotents in the above linear combination can be very interesting. In the case when $E = F$, the rank one minimal idempotent E_0 is always present in this linear combination and can be the only one only if $E = E_0$ or $E = E_d$ and Γ is bipartite. We study the case when $E \circ E \in \mathrm{span}\{E_0, E, H\}$ for some minimal idempotent H of Γ. We call a minimal idempotent E with this property a *tail*. If Γ is Q-polynomial wrt E, then E is a tail. Let θ be an eigenvalue of Γ with multiplicity $m > 1$. We show that

$$m(a_1 - k - k\,\omega)\left(\omega - \frac{k\,\omega^2 - a_1\,\omega - 1}{k - a_1 - 1}\right) \;\leq\; k(a_1^* - m - m\,\omega)\left(\omega - \frac{m\,\omega^2 - a_1^*\,\omega - 1}{m - a_1^* - 1}\right),$$

where $\omega = \theta/k$ and $a_1^* = q_{ii}^i$ if $\theta = \theta_i$. Let E be the minimal idempotent corresponding to θ. The equality case is equivalent to E being a tail. Further characterizations of the case when E is a tail are given. (Received February 28, 2009)

1050-05-103 **Jason Williford*** (jason.williford@ucdenver.edu), University of Colorado Denver, Campus Box 170, P.O. Box 173364, Denver, CO 80217-3364. *Q-polynomial association schemes which are not generated by a distance-regular graph.*

In this talk we will discuss Q-polynomial schemes which are neither P-polynomial nor duals of P-polynomial schemes. Few families of such schemes are known, and only finitely many primitive examples are known. In this talk we will give a description of these schemes, including some new examples. Feasible parameter sets with three classes for which existence has yet to be determined will also be discussed. (Received February 28, 2009)

1050-05-105 **V. Nikiforov*** (vnikifrv@memphis.edu). *The spectral radius of monotone graph properties.* Preliminary report.

A graph property is a class of graphs closed under isomorphisms. A property P is said to be monotone if $G \in \mathcal{P}$ and $H \subset G$ imply that $H \in \mathcal{P}$.

Write $|G|$ for the order of a graph G and $\mu(G)$ for the spectral radius of its adjacency matrix. Given a property $\mathcal{P}$, define the function

$$f_{\mathcal{P}}(n) = \max\{\mu(G) : G \in \mathcal{P},\ |G| = n\}.$$

In the recent years $f_{\mathcal{P}}(n)$ has been determined or approximated for a vast number of graph properties. This talk will present some general new results related to $f_{\mathcal{P}}(n)$ for a monotone graph property $\mathcal{P}$. (Received March 01, 2009)

1050-05-108 **Leif K Jorgensen*** (leif@math.aau.dk), Department of Mathematical Sciences, Aalborg University, Fr. Bajers Vej 7G, 9220 Aalborg, Denmark. *Directed quotient graphs of bipartite graphs.*

We consider two cases of bipartite graphs with a partition such that the quotient graph is a normally regular digraph, i.e., a directed graph with adjacency matrix A satisfying $AA^{\mathrm{t}} = kI + \lambda(A + A^{\mathrm{t}}) + \mu(J - I - A - A^{\mathrm{t}})$. It is necessary that two vertices that are in the same cell of the partition and also in the same bipartition class have the same number of neighbours in each of the cells.

The first case is an $(r + 1)$-regular bipartite graph with $2(r^2 + r)$ vertices, diameter 3 and a partition in 4-cycles. This is the largest possible bipartite graph with diameter 3 if a projective plane of order r does not exist. This is joint work with Delorme, Miller and Pineda-Villavicencio.

In the second case we consider partitions of (incidence graphs of) projective planes in subplanes. Such "ordinary" partitions have also been considered by Fossorier, Ježek, Nation and Pogel. They used this idea in an attempt to construct new projective planes. I will consider construction of new normally regular digraphs from known projective planes. (Received March 01, 2009)

1050-05-110 **Chris D Godsil*** (cgodsil@uwaterloo.ca). *Cocliques and Polytopes.* Preliminary report.

A d-dimensional eigenspace of the adjacency matrix of a graph determines a convex polytope in $\mathbb{R}^d$. I will outline how this polytope can be used to prove analogs of the Erdős-Ko-Rado theorem for some graphs associated to the symmetric group. (Received March 01, 2009)

1050-05-116 **Sho Suda** and **Hajime Tanaka*** (htanaka@math.is.tohoku.ac.jp), Graduate School of Information Sciences, Tohoku University, Sendai, 980-8579, Japan, and **Rie Tanaka**. *Dual-tight cometric association schemes.* Preliminary report.

The concept of a *tight* distance-regular graph was introduced by Jurišić, Koolen and Terwilliger. Such graphs (or metric association schemes) have a number of interesting algebraic, combinatorial and geometric properties. Motivated largely by the recent developments in the study of cometric association schemes, we introduce and discuss *dual-tight* cometric association schemes. We present several examples and characterizations, one of which involves dual-thin irreducible modules for the Terwilliger algebra. (Received March 02, 2009)

1050-05-138 **Mike Newman*** (mnewman@uottawa.ca), Department of Mathematics and Statistics, 585 King Edwards Ave, Ottawa, Ontario K1N 6N5, Canada. *Partition Graphs.* Preliminary report.

Partition graphs are graphs whose vertices are partitions of an n-set, and where adjacency means that each class of one partition intersects each class of the other. These graphs are natural candidates for eigenspace techniques. Surprisingly few exact results have been established on these graphs. We will describe some of the important results, as well as recent work and indicate some strategies for better understanding these graphs. (Received March 02, 2009)

1050-05-139 **S. Bang*** (sjbang3@pusan.ac.kr), Department of Mathematics, Pusan National University, Geumjeong Gu, Busan, 609-735, South Korea, **J H Koolen** (koolen@postech.ac.kr), Department of Mathematics, POSTECH Hyoja-dong, Namgu, Pohang, 790-784, South Korea, and **V. Moulton** (vincent.moulton@cmp.uea.ac.uk), School of Computing Sciences, University of East Anglia, Norwich, NR4 7TJ, England. *The Bannai-Ito Conjecture.*

In their 1984 book "Algebraic Combinatorics I: Association Schemes", E.Bannai and T.Ito conjectured that there are only finitely many distance-regular graphs with fixed valency $k \geq 3$. In the series of papers, they showed that their conjecture holds for $k = 3, 4$, and for the class of bipartite distance-regular graphs. J.H.Koolen and V.Moulton also show that there are only finitely many distance-regular graphs with $k = 5, 6$, or 7, and there are only finitely many triangle-free distance-regular graphs with $k = 8, 9$ or 10. In this talk, we show that the Bannai-Ito conjecture holds for any integer $k > 2$ (i.e., for fixed integer $k > 2$, there are only finitely many distance-regular graphs with valency k). This is a joint work with J.H.Koolen and V.Moulton. (Received March 02, 2009)

1050-05-142 **Ada Chan*** (ssachan@yorku.ca), Department of Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *Small Four Weight Spin Models.*

Given a four-weight spin models $(W_1, W_2, W_3, W_4; d)$, we construct the type-II matrix

$$W = \begin{pmatrix} \frac{1}{d}W_1^T & -\frac{1}{d}W_1^T \\ W_2 & W_2 \end{pmatrix}.$$

Using the structure of the Nomura algebra of W, we search for small four-weight spin models. (Received March 02, 2009)

1050-05-161 **Junhua Wu*** (wuj@wpi.edu), Worcester, MA 01606. *A binary linear code and its combinatorial properties.*

Let $PG(2,q)$ be the classical projective plane, where q is an odd prime power. An oval in $PG(2,q)$ is a set of $q+1$ points, no three of which are collinear. A binary linear code L was constructed based on point-line incidence structures related to an oval in $PG(2,q)$. We study several geometric structures associated with L and give an algebraic description of L in terms of certain module structures, which also gives a proof of the conjecture on the dimension of L. We also related this code with a commutative association scheme. (Received March 03, 2009)

1050-05-162 **Paul Terwilliger*** (terwilli@math.wisc.edu), Math Department, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706. *Towards a classification of the tridiagonal pairs.*

Let K denote a field and let V denote a vector space over K with finite positive dimension. We consider a pair of linear transformations $A : V \to V$ and $A^* : V \to V$ that satisfy the following conditions: (i) each of A, A^* is diagonalizable; (ii) there exists an ordering $\{V_i\}_{i=0}^d$ of the eigenspaces of A such that $A^*V_i \subseteq V_{i-1} + V_i + V_{i+1}$ for $0 \leq i \leq d$, where $V_{-1} = 0$ and $V_{d+1} = 0$; (iii) there exists an ordering $\{V_i^*\}_{i=0}^\delta$ of the eigenspaces of A^* such that $AV_i^* \subseteq V_{i-1}^* + V_i^* + V_{i+1}^*$ for $0 \leq i \leq \delta$, where $V_{-1}^* = 0$ and $V_{\delta+1}^* = 0$; (iv) there is no subspace W of V such that $AW \subseteq W$, $A^*W \subseteq W$, $W \neq 0$, $W \neq V$. We call such a pair a *tridiagonal pair* on V. It is an open problem to classify up to isomorphism the tridiagonal pairs. We will discuss our recent progress on this problem. This is joint work with Tatsuro Ito and Kazumasa Nomura. (Received March 03, 2009)

1050-05-170 **John Caughman*** (caughman@pdx.edu), 3532 SE Long St, Portland, OR 97202. *An Inequality for Leonard Systems.* Preliminary report.

Let $\Phi = (A; A^*; \{E_i\}_{i=0}^d; \{E_i^*\}_{i=0}^d)$ be a Leonard system over the real numbers $\mathbb{R}$ with eigenvalue sequence $\theta_0, \theta_1, \ldots, \theta_d$. Let $a_i = \mathrm{tr}(\mathrm{E_i^*AE_i^*A})$ for $0 \leq i \leq d$ and $x_i = \mathrm{tr}(\mathrm{E_i^*AE_{i-1}^*A})$ for $0 \leq i \leq d$. Define polynomials $p_0, p_1, \ldots, p_{d+1}$ by the three-term recurrence $\lambda p_i = p_{i+1} + a_i p_i + x_i p_{i-1}$ for $0 \leq i \leq d$, where $p_0 = 1$ and $x_0 = p_{-1} = 0$. We consider conditions on Φ that imply the absolute value

$$\left| \frac{p_i(\theta_j)}{p_i(\theta_0)} \right| \leq 1$$

for all $0 \leq i, j \leq d$. An application of these results could resolve a conjecture concerning the arithmetic Grassmanian $G(2, N)$. (Received March 03, 2009)

11 ► Number theory

1050-11-7 **Byungchul Cha*** (cha@muhlenberg.edu), 2400 Chew Street, Allentown, PA 18104. *Linear independence of zeta zeros in function fields.* Preliminary report.

The Linear Independence (LI) assumption, sometimes called Grand Simplicity Hypothesis, is the assumption that the ordinates of nontrivial zeros of the Riemann zeta function are linearly independent over the rationals. LI has been used in the past by many authors in analytic number theory, including Rubinstein and Sarnak in their work on prime number races and Ng in his work on the growth of the summatory function of the Moebius function. We give some applications of LI in the function field case, exhibiting a strong resemblance to the number field case. In particular, we prove certain function field analogs of the aforementioned works of Rubinstein and Sarnak, and Ng. (Received November 20, 2008)

1050-11-29 **Michael P. Knapp*** (mpknapp@loyola.edu), Loyola College, 4501 North Charles Street, Baltimore, MD 21210-2699. *Simultaneous diagonal equations of odd degrees.* Preliminary report.

In this talk, we will consider a system of two diagonal equations

$$a_1 x_1^k + \cdots + a_s x_s^k = 0$$
$$b_1 x_1^n + \cdots + b_s x_s^n = 0$$

where the coefficients are ordinary integers and the degrees k and n are odd. We will show that if $\{k, n\} \neq \{5, 3\}$ and the number of variables is at least $k^2 + n^2 + 1$, then this system must have a nontrivial solution in p-adic integers for every prime p. (Received January 06, 2009)

1050-11-32 **Steven J Miller*** (Steven.J.Miller@williams.edu), Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. *Benford's Law, Values of L-Functions and the 3x+1 Problem.*

Many systems exhibit a digit bias. For example, the first digit (base 10) of the Fibonacci numbers or of 2^n equals 1 about 30% of the time; the IRS uses this digit bias to detect fraudulent corporate tax returns. This phenomenon, known as Benford's Law, was first noticed by observing which pages of log tables were most worn from age – it's a good thing there were no calculators 100 years ago! The first digit of values of L-functions near the critical line also exhibit this bias. A similar bias exists (in a certain sense) for the first digit of terms in the $3x+1$ problem, provided the base is not a power of two. For L-functions the main tool is the Log-Normal law; for $3x+1$ it is the rate of equidistribution of $n \log_B 2 \bmod 1$ and understanding the irrationality measure of $\log_B 2$. (Received January 16, 2009)

1050-11-34 **Florian Luca*** (fluca@matmor.unam.mx), Mathematical Institute, UNAM, 58089 Morelia, Michoacan, Mexico. *Variants of a problem of Erdos and Romanov.* Preliminary report.

Romanov proved that there is a positive proportion of odd positive integers of the form $2^n + p$ for some positive integer n and prime p. Erdős proved that the odd integers not representable in this way also account for a positive proportion of all the integers. Note that if m is a positive integer of the latter kind, then $m-1$ is even and not representable under the form $2^n + (p-1) = 2^n + \phi(p)$ for any positive integer n and prime p, where ϕ is the Euler function. Similarly, $m+1$ is even and not representable under the form $2^n + (p+1) = 2^n + \sigma(p)$ for any positive integer n and prime p, where σ is the sum of divisors function. It makes sense to ask if we can remove the assumption that p is prime in the above statements and prove that there are infinitely many positive integers not of the form $2^n + \phi(m)$, or not of the form $2^n + \sigma(m)$ for any positive integers n and m, respectively. In my talk, I will prove that the answer to the above questions is yes. In fact, each of the above two sets of positive integers has a positive lower density. We shall also discuss some related problems and pose some open questions.

This talk is based on joint work with V. J. Mejía Huguet (Mexico) and F. Nicolae (Germany). (Received January 21, 2009)

1050-11-35 **David E. Rohrlich*** (rohrlich@math.bu.edu), Department of Mathematics and Statistics, Boston University, 111 Cummington Street, Boston, MA 02215. *Galois invariance of local root numbers.*

Let M be a motive over a number field, pure of odd weight. A conjecture of Deligne and Gross (Proc. Symp. Pure Math. Vol. 33 – Part 2, p. 323, Conjecture 2.7, part (ii)) predicts that the order of vanishing of $L(s, M)$ at the center of the critical strip is independent of the complex embedding ι of the coefficient field of the motive. It follows that the global root number $W(M)$ should likewise be independent of ι. We give a result on local root numbers which supports this conclusion. (Received January 24, 2009)

1050-11-85 **Álvaro Lozano-Robledo*** (alozano@math.uconn.edu), 196 Auditorium Rd., Dept. of Math., U-3009, University of Connecticut, Storrs, MA 06269. *Bernoulli-Hurwitz numbers, Wieferich primes and Galois representations.*

Let K be a quadratic imaginary number field with discriminant $D_K \neq -3, -4$ and class number one. Fix a prime $p \geq 7$ which is unramified in K. Given an elliptic curve $A/\mathbb{Q}$ with complex multiplication by K, let $\overline{\rho_A}\colon \mathrm{Gal}(\overline{K}/K(\mu_{p^\infty})) \to \mathrm{SL}(2, \mathbb{Z}_p)$ be the representation which arises from the action of Galois on the Tate module. We will show that, for all but finitely many inert primes p, the image of a certain deformation $\rho_A\colon \mathrm{Gal}(\overline{K}/K(\mu_{p^\infty})) \to \mathrm{SL}(2, \mathbb{Z}_p[[X]])$ of $\overline{\rho_A}$ is "as large as possible", that is, it is the full inverse image of a Cartan subgroup of $\mathrm{SL}(2, \mathbb{Z}_p)$. If p splits in K, then the same result holds as long as certain Bernoulli-Hurwitz number is a p-adic unit which, in turn, is equivalent to a prime ideal not being a Wieferich place. The proof rests on the theory of elliptic units of Robert and Kubert-Lang, and on the two-variable main conjecture of Iwasawa theory for quadratic imaginary fields. (Received February 26, 2009)

1050-11-121 **Andrew Knightly*** (knightly@math.umaine.edu), Department of Mathematics & Statistics, Neville Hall, Room 333, University of Maine, Orono, ME 04469, and **Charles Li**. *Average values of L-functions via relative trace formula.*

Using a relative trace formula on GL(2), we derive an expression for the average (over cusp forms of a given level and weight) of L-values in the critical strip. When the weight or the level is large, this average is nonzero. (Received March 02, 2009)

1050-11-129 **Rafe Jones***, College of the Holy Cross, Department of Math and CS, Worcester, MA 01610. *Prime Divisors in Arithmetic Dynamics.*

Certain non-linear integer recurrence sequences, such as the Fermat numbers $F_n = 2^{2^n} + 1$, can be described as an orbit of an arithmetic dynamical system. In this talk, I'll discuss the case when the dynamical system is given by iteration of a quadratic polynomial f. For orbits of such a system, the set of primes dividing at least one term is a natural object of study: it loosely gives a measure of how close the terms in the sequence are to being prime. The density of this set can be measured in terms of arithmetic properties of the orbit of the critical point of f. I'll discuss some families of f where this leads to a proof that all orbits have a density zero set of prime divisors. (Received March 02, 2009)

1050-11-140 **Farshid Hajir*** (hajir@math.umass.edu), Dept of Mathematics & Statistics, University of Massachusetts, Amherst, Amherst, MA 01003, and **John Cullinan** (cullinan@bard.edu), Dept of Mathematics, Bard College, Annandale-on-Hudson, NY 12504. *Specializations of finitely ramified towers of self-maps of the projective line.*

For a rational function $\varphi(x)$ over a number field K, we give a formula for the discriminant of the numerator of $\varphi(x) - t$ where t is a parameter and examine how the terms in the formula change under iteration of φ. (Received March 02, 2009)

1050-11-141 **David Pollack*** (dpollack@wesleyan.edu), 265 Church Street, Middletown, CT 06459, and **Robert Pollack**, 111 Cummington Street, Boston, MA 02215. *Computations with Overconvergent Modular Symbols.*

We will discuss some computations of explicit lifts of classical modular symbols to overconvergent modular symbols. (Received March 02, 2009)

1050-11-143 **Caleb McKinley Shor*** (cshor@wnec.edu), WNEC Math Dept, Box H5156, 1215 Wilbraham Rd, Springfield, MA 01119. *Codes over $\mathbb{F}_{p^2}$ and $\mathbb{F}_p \times \mathbb{F}_p$, lattices, and theta functions.*

Let $\ell > 0$ be a square-free integer congruent to 3 mod 4 and $\mathcal{O}_K$ the ring of integers of the imaginary quadratic field $K = \mathbb{Q}(\sqrt{-\ell})$. Let p be a prime. If $p \nmid \ell$ then the ring $\mathcal{R} := \mathcal{O}_K/p\mathcal{O}_K$ is isomorphic to $\mathbb{F}_{p^2}$ or $\mathbb{F}_p \times \mathbb{F}_p$. Let C be a code over $\mathcal{R}$. Given such a code, one can create a lattice $\Lambda_\ell(C)$ over K. One can then construct the corresponding theta function of such a lattice.

In 2005, working with $p = 2$, K. S. Chua found an example of two non-equivalent codes that have the same theta function for $\ell = 7$ and different theta functions for larger values of ℓ. In this talk, motivated by Chua's example, we will consider the situation for general primes p. In particular, we will see how to represent these theta functions in terms of some basic theta series, see connections between these theta functions and weight enumerator polynomials, and consider the question of whether two non-equivalent codes can have the same theta function for some or all values of ℓ. (Received March 02, 2009)

1050-11-144 **Russell Prime*** (prime@math.uconn.edu), Department of Mathematics, University of Connecticut, 196 Auditorium Rd, U-3009, Storrs, CT 06269. *Averages of L-functions over Quadratic Function Fields.*

The problem of averaging quadratic L-functions dates back to Gauss, who (essentially) conjectured an average value for the class numbers of quadratic fields, which is connected to the the average of certain quadratic L-functions at $s = 1$. We will discuss a formula for the average value of L-functions associated to a set of quadratic function fields ramified at one finite place and infinity, which are analogous to the imaginary quadratic fields $\mathbf{Q}(\sqrt{-p})$ for a prime number p. (Received March 02, 2009)

1050-11-150 **Jennifer Beineke** (jbeineke@wnec.edu), **Ben Brubaker** (brubaker@math.mit.edu) and **Sharon Frechette*** (sfrechet@mathcs.holycross.edu). *Weyl group multiple Dirichlet series, and GT patterns: Part II.* Preliminary report.

We construct Weyl group multiple Dirichlet series associated to root systems of Type C, through a combinatorial recipe involving Gelfand-Tsetlin patterns. These Dirichlet series are associated with an n-fold metaplectic cover of $\mathrm{So}(2r + 1)$, and we prove functional equations for them when $n = 1$, via the Casselman-Shalika formula. We also prove that our description matches the so-called "stable case," as described for general root systems by Brubaker, Bump and Friedberg. This is joint work with Jennifer Beineke and Ben Brubaker. (Received March 03, 2009)

1050-11-163 **Jennifer Beineke*** (jbeineke@wnec.edu), Department of Mathematics, Western New England College, 1215 Wilbraham Road, Springfield, MA 01119, and **Ben Brubaker** and **Sharon Frechette**. *Weyl Group Multiple Dirichlet Series and GT-Patterns: Part I.*

In this talk, we provide an introduction to *Weyl group multiple Dirichlet series for type C*, Dirichlet series in several complex variables associated to the root system $\Phi = C_r$. We will describe background and motivational material, explaining how these Dirichlet series relate to Kubota's rank one Dirichlet series. Current results will be stated, along with giving a general sense of how patterns from algebraic combinatorics are used in the proofs. These patterns are a variant of Gelfand-Tsetlin patterns. Specifics will be addressed in Part II. (Received March 03, 2009)

20 ► Group theory and generalizations

1050-20-4 **Kevin Whyte***, University of Illinois at Chicago. *A rapid survey of coarse geometry.*

Coarse geometry is the study of non-compact metric spaces from a large scale perspective, ignoring the local structure. For instance, we consider the Euclidean plane and its integer lattice to be coarsely equivalent. Coarse geometry is closely connected to the study of infinite groups and to the topology of non simply-connected spaces. In this talk I will describe some of the basic motivations and examples in the subject, and how techniques from classical topology, geometry, and analysis appear. In particular, I will try to explain "coarse differentiation", developed in some recent work on the coarse geometry of solvable groups, joint with Alex Eskin and David Fisher. (Received May 15, 2008)

1050-20-59 **Paul-Hermann Zieschang*** (zieschang@utb.edu), Department of Mathematics, University of Texas at Brownsville, Brownsville, TX 78520. *On association schemes with thin thin residue.*

Let S be an association scheme. The smallest closed subset of S with thin quotient scheme is called the thin residue of S and is denoted by $O^\vartheta(S)$; cf. [2]. We shall look at schemes the thin residue of which is thin. If $O^\vartheta(S)$ is thin, $O^\vartheta(S)$ can be viewed as a group. In [1] it was shown that S is schurian if the set of all normal subgroups of $O^\vartheta(S)$ is linearly ordered. As a consequence, one obtains that S is schurian if $O^\vartheta(S)$ is a finite simple group. In [3], it is shown that S is schurian if $O^\vartheta(S)$ the direct product of two simple groups of different order. In my talk, I will discuss the main idea of the proof of this latter result. The emphasis will be on ideas how to generalize this result.

[1] Hirasaka, M. and Zieschang, P.-H.: Sufficient conditions for a scheme to originate from a group, *J. Combin. Theory Ser. A* **104**, 17-27 (2003)

[2] Zieschang, P.-H.: *Theory of Association Schemes*. Springer Monographs in Mathematics, Berlin Heidelberg New York (2005)

[3] Zieschang, P.-H.: On association schemes with thin thin residue, *J. Algebra*, to appear (Received February 22, 2009)

22 ► Topological groups, Lie groups

1050-22-168 **Piotr Hajlasz*** (hajlasz@pitt.edu), University of Pittsburgh, Department of Mathemtics, 301 Thackeray Hall, Pittsburgh, PA 15260, and **Jeremy T. Tyson**. *Highly regular surjections between Carnot groups.* Preliminary report.

In the talk I will discuss results concerning sufficient conditions for the existence of highly regular Peano cubes which are surjective mappings from a cube onto a metric space. By high regularity we mean Holder continuity, Sobolev regularity, Lipschitz continuity or even higher order smoothness. In particular it will be shown that there is a C^1 horizontal surjective mapping from R^5 onto the Heisenberg group. The result generalizes also to the case of smooth surjective mappings between general Carnot groups. (Received March 03, 2009)

26 ► Real functions

1050-26-18 **shoshana - abramovich*** (abramos@math.haifa.ac.il), Shoshana Abramovich, Department of Mathematics, University of Haifa, Haifa, Israel. *On Superquadracity.*

The definition of a superquadratic function which is widely used is as follows:

A function $\varphi : [0.\infty) \to \mathbb{R}$ is superquadratic provided that for all $x \geq 0$ there is a constant $C(x) \in \mathbb{R}$ such that

$$\varphi(y) \geq \varphi(x) + C(x)(y - x) + \varphi(|y - x|)$$

for all $y \geq 0$.

A different definition of superquadracity, for functions defined on $\mathbb{R}$ is as follows:

The function $\varphi : \mathbb{R} \to \mathbb{R}$ is superquadratic if

$$\varphi(x + y) + \varphi(x - y) \geq 2\varphi(x) + 2\varphi(y),$$

is satisfied for all $x, y \in \mathbb{R}$.

After discussing the differences and similarities of these definitions, we show that the first class of superquadratic functions, leads to many applications. Some of these applications we show here. (Received January 04, 2009)

1050-26-120 **Hoai-Minh Nguyen*** (hoaiminh@ias.edu), Institute for Advanced Study, School of Mathematics, Einstein Drive, Princeton, NJ 08540. *Characterizations of Sobolev spaces and related inequalities.*

In this talk I will present some recent characterizations of Sobolev spaces and new inequalities appearing naturally in this context. I will also discuss some improvements of classical properties of Sobolev spaces such as Sobolev inequality, Poincare inequality, and Rellich-Kondrachov theorem which follow from these inequalities. (Received March 02, 2009)

30 ► Functions of a complex variable

1050-30-126 **Cristina Ballantine*** (cballant@holycross.edu), Department of Mathematics and Comp. Science, College of the Holy Cross, Worcester, MA 01610, and **Dorin Ghisa**. *Blaschke Product Mappings: Visualization and Automorphic Properties.*

Blaschke products are obtained by multiplying particular Möbius transformations. A visualization of Blaschke product mappings can be obtained by treating them as canonical projections of covering Riemann surfaces and finding fundamental domains and covering transformations corresponding to these surfaces. The mappings are automorphic with respect to the group of covering transformations. We use a technique similar to domain coloring to display the fundamental domains and mapping properties of Blaschke products. If time permits, we will discuss similar properties for general rational functions. (Received March 02, 2009)

1050-30-128 **Tadeusz Iwaniec**, **Leonid V Kovalev** and **Jani Onninen*** (jkonnine@syr.edu), Department of Mathematics, Syracuse University, 215 Carnegie Building, Syracuse, NY 13244. *Harmonic mappings between doubly connected domains.* Preliminary report.

By the Riemann Mapping Theorem, simply connected domains are conformally equivalent. Annuli are the first place one meets obstructions to the existence of conformal mappings. The famous theorem, due to Schottky (1877), tells us that an annulus $\mathbb{A} = A(r, R)$ can be mapped conformally onto the annulus $\mathbb{A}^* = A(r_*, R_*)$ if and only if $R/r = R_*/r_*$. In this talk we discuss the 1962 conjecture of Nitsche which asserts that a harmonic homeomorphism $h \colon \mathbb{A} \to \mathbb{A}^*$ exists only if

$$\frac{R_*}{r_*} \geq \frac{1}{2}\left(\frac{R}{r} + \frac{r}{R}\right).$$

(Received March 02, 2009)

34 ► Ordinary differential equations

1050-34-92 **Tadeusz Iwaniec** and **Leonid V. Kovalev*** (lvkovale@syr.edu), Department of Mathematics, 215 Carnegie Building, Syracuse University, Syracuse, NY 13244-1150, and **Jani Onninen**. *Uniqueness for ordinary differential equations associated with quasiconformal mappings.*

We address the question: does the ODE $\dot{x} = f(x)$, where $f \colon \mathbb{R}^n \to \mathbb{R}^n$ is a quasiconformal mapping, have unique solutions outside of $f^{-1}(0)$? In this generality the problem remains unsolved, but we give an affirmative answer under additional assumptions on f. For example, uniqueness holds when f is a δ-monotone mapping or, in the planar case, when f is a solution of the reduced Beltrami equation. (Received February 27, 2009)

35 ► Partial differential equations

1050-35-2 **Umberto Mosco***, Worcester Polytechnic Institute. *Fractal spectra between Scylla and Charybdis.*

In our talk we shall approach fractals from a very limited . although basic – point of view: as objects of physical nature that exhibit peculiar static and dynamical features. Intrinsically, fractals are manifolds of a new kind, which display unusual spectral properties. We will describe some implication of this fundamental feature and make a comparison with simple sub-Riemannian models. Fractals occur also as "large" boundaries of "small" Euclidean domains. This is a setting with unusual volume vs surface relation. We will describe simple examples of this kind and some related boundary value problems. (Received May 15, 2008)

1050-35-14 **Abdelkader Y Boucherif*** (aboucher@kfupm.edu.sa), Department of Mathematics and Statistics, KFUPM- Box 5046, Dhahran, Eastern 31261, Saudi Arabia. *Parabolic problems with nonlocal conditions.* Preliminary report.

Let Ω be an open bounded domain in $\mathbb{R}^N$, and $T > 0$. We are concerned with the existence of solutions of the following parabolic problem $u_t + Lu = F(x,t,u),\ (x,t) \in \Omega \times (0,T),\ u(x,t) = 0,\ (x,t) \in \partial\Omega \times [0,T]$ subjected to the nonlocal condition $u(x,0) = \int_0^T g(x,t,u(x,t))dt,\ \ x \in \Omega$.

We provide sufficient conditions on L, F, g that guarantee the existence of at least one solution. (Received January 02, 2009)

1050-35-38 **Fridolin Ting*** (fting@lakeheadu.ca), Department of Mathematical Sciences, Lakehead University, 955 Oliver Road, Thunder Bay, Ontario P7B 5E1, Canada. *Effective Dynamics of multi-vortices in an external potential for Ginzburg-Landau Gradient flow.* Preliminary report.

We study the dynamics of widely spaced multi-vortex configurations to the Ginzburg-Landau dissipative/gradient flow evolution equations with external potential in $\mathbb{R}^2$. We show that for initial data close to the widely spaced multi-vortex configurations, the effective dynamics of the vortex centers are governed by the inter-vortex forces and by forces due to external potential for "weak" and "strong" external potentials, respectively. (Received February 04, 2009)

1050-35-39 **Panayotis Kevrekidis*** (kevrekid@math.umass.edu), Lederle Graduate Research Tower, Department of Mathematics & Statistics, University of Massachusetts, Amherst, MA 01003. *Dark Solitons in Bose-Einstein Condensates: Experimental Findings, Numerical Computations and Theoretical Directions.*

In this talk, we plan to summarize some of the experimental activity on the dynamics of dark solitons that has been enabled by the very controllable atomic physics setting of Bose-Einstein condensates, focusing especially on some of the most recent developments in quasi-1d settings. We will then illustrate how to connect these findings to numerical computations of one- and multi-soliton solutions and their linearization in appropriately tailored variants of the nonlinear Schrodinger equation which account for the transverse dimensions of the atomic clouds. Finally, we will motivate and compare to numerics and experiments simple particle-based theoretical models which capture the essential physics of the system. (Received February 07, 2009)

1050-35-73 **Yujin Guo***, 127 Vincent Hall, 206 Church St. S.E., Minneapolis, MN 55455. *Partial Differential Equations Arising from Electrostatic MEMS.*

We introduce a nonlinear evolution equation with an inverse-square type nonlinearity, which describes the dynamical deflection of a simple electrostatic Micro-Electromechanical System (MEMS) device. In the second-order parabolic case, various qualitative properties of solutions are discussed. (Received February 25, 2009)

1050-35-83 **Robert Hardt*** (hardt@rice.edu), Mathematics Department, Rice University, PO Box 1892, Houston, TX 77251-1892, and **Rolf Ryham** (ryham@rice.edu). *Some Remarks on Total Variation Flow.* Preliminary report.

In 1994, R.Hardt and X.Zhou studied the heat equation $u_t = div_x[F_p(Du)]$ corresponding to a convex function F with linear growth at oo. For an initial, Dirichlet boundary-value problem, they established existence in $L^2([0,T], BV)$, a comparison principle, continuity in time, and minimality of the unique time asymptotic limit. Earlier in 1992, E.Fatemi, S.Osher, and L.Rudin had numerical results for the special case of TV flow where $F(p) = |p|$. The last 10 years has seen numerous applications to imaging of the TV flow and its relatives. Here, we examine carefully specific examples and look for further regularity properties and associated constrained problems. (Received February 26, 2009)

1050-35-90 **Changfeng Gui*** (gui@math.uconn.edu), 196 Auditorium road, U-9, University of Connecticut, Storrs, CT 06250. *Hamiltonian identities for PDEs and their applications.*

In this talk I will present hamiltonian identities for PDEs and systems of PDEs. I will also show some interesting applications of these identities to problems in phase transition, such as the proof of Young's law in triple junction configuration for a vector-valued Allen Cahn model and the derivation of a necessary condition for the existence of saddle solutions for Allen-Cahn equation with asymmetric double well potential. (Received March 04, 2009)

1050-35-100 **Yanyan Li*** (yyli@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854, and **Ellen ShiTing Bao** and **Biao Yin**. *Gradient Estimates for the Perfect Conductivity Problem.*

I will describe some joint works with Ellen ShiTing Bao and Biao Yin on the gradient estimates for the perfect conductivity problem. Some open problems will also be mentioned. (Received February 28, 2009)

1050-35-104 **Robert Pertsch Gilbert*** (gilbert@math.udel.edu), 112 Briar Lane, Newark, DE 19711, and **Ana Vasilic**. *Acoustic Propagation in a Random Saturated Medium: The Monophasic Case.*

We extend our study of acoustic wave propagation for an elastic medium from the deterministic case to a randomly fissured medium. Moreover, the fissures are assumed to be statistically homogeneous. Although the underlying stochastic process does not necessarily have to be ergodic, we assume for simplicity of exposition that it is. This allows us to obtain an explicit and computationaly easier auxillary problem in a Representative Elementary Volume. In a later work we intend to study the more general case. (Received February 28, 2009)

1050-35-111 **Benoit Pausader*** (benoit.pausader@math.brown.edu), Mathematics department, Box 1917, Providence, RI 02912. *The cubic fourth-order Schrodinger equation.*

We prove that the cubic defocusing fourth-order Schrodinger equation is globally wellposed in the energy space for all dimensions below or equal to 8. For dimensions larger the equation is no longer locally wellposed. We focus mainly on the critical case n=8. (Received March 01, 2009)

1050-35-112 **Gideon Simpson*** (simpson@math.toronto.edu), Department of Mathematics, 40 St. George Street, Room 6290, Toronto, ON M4Y 2P8, Canada, and **Michael I Weinstein**. *Solitary Waves in the Earth's Interior and their Stability.*

Solitary waves can be found in models and analog experiments of the Earth's interior. Their stability is a natural property warranting investigation. Unfortunately, the equations in this geophysical setting lack tools such as an inverse scattering transform or a variational formulation. This necessitates less elegant analysis, exposing the limits of known techniques. We prove asymptotic stability of the solitary waves and extend global well-posedness results. Open problems on well-posedness and stability will also be discussed. (Received March 01, 2009)

1050-35-118 **Walid Abou Salem*** (walid@math.utoronto.ca), Department of Mathematics, University of Toronto, 40 St. George Street, Toronto, ON M5S2E4, Canada. *Tunneling of solitons through potential barriers.*

I discuss recent rigorous results on the resonance tunneling of solitons through potential barriers for the generalized nonlinear Schrodinger equation in one spatial dimension. (Received March 02, 2009)

1050-35-122 **Robin Ming Chen*** (chenm@math.umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455, **Yujin Guo** (yjguo@math.umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455, **Daniel Spirn** (spirn@math.umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455, and **Yisong Yang** (yyang@math.poly.edu), Department of Mathematics, Yeshiva University, New York, NY 10033. *Charged vortices of finite energy in the Chern-Simons-Higgs theorey.*

The existence is shown of charged vortices of finite energy in the (2+1)-dimensional Higgs model with Chern-Simons term. The electric charge and magnetic charge of the vortices are both quantized. The solutions are constructed via a constrained minimization method applied on an indefinite action functional. (Received March 02, 2009)

1050-35-125 **Walter A Strauss*** (wstrauss@math.brown.edu), Department of Mathematics, Brown University, Providence, RI 02912. *Pressure Beneath a Stokes Wave.*

A Stokes wave is a irrotational incompressible periodic 2D steady water wave under the influence of gravity. It is well-known that there is a one-parameter family of such waves. I will prove that the pressure in the fluid strictly decreases horizontally away from the crest line. Numerical evidence shows that this is not true in the

presence of vorticity. Furthermore, the pressure strictly increases with depth provided the maximum slope of the free surface is less than 1. (Received March 02, 2009)

1050-35-127 **Matthias Kurzke**, **Christof Melcher**, **Roger Moser** and **Daniel Spirn*** (spirn@math.umn.edu), 206 Church St SE, Minneapolis, MN 55455. *Dynamics of vortices in a damped Gross-Pitaevskii equation.*

We consider the dynamics of a Gross-Pitaevskii type equation of mixed type with both parabolic and Schrodinger terms. This equation serves as a model for both micromagnetic dots and superconductivity. Under the limit of a large coupling constant, vortices condense down to points and satisfy a first order ODE. This is joint work with M. Kurzke, C. Melcher, and R. Moser. (Received March 02, 2009)

1050-35-130 **A Bathi Kasturiarachi*** (akasturi@kent.edu), Department of Mathematics, 6000 Frank Ave, NW, North Canton, OH 44720. *Exp-function method for solving nonlinear dispersive equations.*

In this paper, we will use the Exp-function method to obtain solitary and periodic solutions for the KdV and gKdV equations. The results will be illustrated numerically and compared to existing solutions. (Received March 02, 2009)

1050-35-151 **Michael I Weinstein*** (miw2103@columbia.edu), Dept. Applied Physics and Applied Mathematics, Columbia University, New York, NY 10027. *Dynamics of solitons of the nonlinear Schroedinger / Gross Pitaevskii equation.*

We discuss the dynamics of soliton-like solutions of the nonlinear Schroedinger - Gross Pitaevskii equation. In particular, we present recent results (with Z. Gang) on large time energy distribution in multimoded systems and results (with B. Ilan and Y. Sivan) on solitons with frequencies near a spectral band edge associated with background periodic potential. (Received March 03, 2009)

1050-35-157 **Leonid Berlyand*** (berlyand@math.psu.edu), 337 McAllister Bld, Department of Mathematics, University Park,, PA 16802, and **Houman Owhadi**. *Homogenization of elasticity equations without scale separation.*

In this joint work with H. Owhadi (Caltech), we investigate the homogenization of divergence form elliptic (scalar and vectorial) equations with arbitrary bounded coefficients (in particular, in situations where assumptions of scale separation and/or ergodicity are not satisfied). We prove the existence of an h- basis that is superior to standard piecewise polynomial bases with the same number of degrees of freedom. We obtain an explicit error constant for h-basis approximations, which is independent of the contrast of the material and geometry of its microstructure. We also discuss minimization of the number of "cell" (precomputed) problems for homogenization with arbitrary bounded coefficients and show that this issue is related to a new class of elliptic inequalities. Finally, we will discuss potential applications of this work ranging from brain damage and virtual liver surgery to reservoir modeling and upscaling of atomistic models. (Received March 03, 2009)

1050-35-167 **Avy Soffer*** (soffer@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Rd, Piscataway, NJ 08854-8019. *Realistic Models of NLS-Large time behavior and Applications to Physics.*

The NLS Equation appears naturally in nonlinear optics and BEC theory. I will describe models of NLS with interaction terms that correspond to real physical systems. I will describe some theoretical results and conjectures, as well as numerical and very recent experiments based on the theoretical predictions. (Received March 03, 2009)

1050-35-169 **Slim Ibrahim*** (ibrahim@math.uvic.ca), Department of Mathematics and Statistics, Victoria, BC V8W3R4, Canada, **Nader Masmoudi**, New York, NY , and **Kenji Nakanishi**, Kyoto, Japan. *Sharp scattering and blow up regimes for focusing nonlinear Klein-Gordon equation.*

We consider a semilinear Klein-Gordon equation with a focusing and at most energy critical nonlinearity. Below the energy of the ground state, we show that the energy space can be split into two complements sets leading to two opposite dynamics: the finite time blow up in one side and the global existence and scattering in the other side. This result relay on various characterizations of the ground state, and on the use of a compactness argument for the scattering. (Received March 03, 2009)

1050-35-172 **Konstantin A Lurie*** (klurie@wpi.edu), Department of Mathematical Sciences, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609. *Discontinuities in the Wave Propagation Through Dynamic Materials.*

The wave propagation through the dynamic materials assembled in space-time from conventional constituents is governed by linear hyperbolic equations with discontinuous coefficients. Such waves remain smooth only if the characteristics do not collide. If they do (for example, on the material interfaces),then the solutions become discontinuous; in the absence of takeover, the elementary masses cling together and form the delta-singularities with finite mass (clots).With the traveling clots, the problem loses its originally linear character because the clots move at velocities that depend on the dynamic disturbances and are no longer controllable by the local material property pattern that specifies the velocities of small disturbances.The motion of clots becomes well defined as we postulate the conservation of mass and momentum maintained through their formation. We also postulate irreversibility of such formation: the once created clot cannot disintegrate. This scheme is applied to the study of the optimal traffic flow without takeover governed by the continuity equation in 1D; particularly, solutions with concentrated traveling masses are introduced as participants in the transportation policies formulated for this type of traffic. (Received March 03, 2009)

1050-35-175 **Daniel Faraco*** (daniel.faraco@uam.es), Universidad Autonoma de Madrid, Campus de Cantoblanco, Departamento de Matemáticas, Ciencias, 28049 Madrid, Spain. *Gamma quasiregular mappings and nonlinear planar eliptic systems.*

A weakly differentiable map $f : \Omega \to \mathbb{R}^n$ is called quasiregular if it satisfies almost everywhere the pointwise constraint,

$$\|Df(x)\|^n \leq K \det(Df(x)) \tag{1}$$

The theory of quasiregular mappings has been extensively developed in the last century and prove to be a useful tool in partial differential equations, geometry, complex dinamics and more recently in the Calculus of Variations. It is well known that equation (1) yields fascinating analitical and topological properties to the mapping f.

In the study of the compactness of approximate solutions to diferential inclusions with Székelyhidi we discovered a new class of quasiregular mappings. Given a Jordan curve in matrix space, called Γ we say that f is Γ-quasiregular if for every $p \in \Gamma$ $f - p$ is quasiregular.

In the plane these mappings are naturally related to a broad class of nonlinear elliptic systems. I will discuss this connection together with the relation between the injectivity properties of this class of maps and the range of the differential.

This is a joint work with Alber Clop (Barcelona) and Kari Astala and Jarmo Jaskelainen (Helsinki). (Received March 04, 2009)

1050-35-177 **Irina Mitrea*** (im3p@cms.mail.virginia.edu), Department of Mathematics, 225 Kerchof Hall, Charlottesville, VA. *On the Mixed Problem for Second Order Elliptic Systems*

In this talk I will discuss wellposedness results for boundary value problems for second order elliptic operators with mixed Dirichlet and Neumann type boundary conditions in irregular domains.
(Received March 09, 2009)

1050-35-179 **Louis Nirenberg*** (nirenberg@cims.nyu.edu), 251 Mercer St., New York, NY 10012. *Remarks on nonlinear elliptic equations*

Property of solutions with singularities will be presented, with applications. (Received March 09, 2009)

1050-35-180 **Emily J. Evans*** (montu@wpi.edu), Department of Mathematical Sciences, 100 Institute Rd., Worcester, MA. *A Novel Finite Element Meshing Technique Driven by Fractal Koch Curves* Preliminary report.

We present a novel new way of discretizing a square domain based on a fractal Koch curve. This discretization is unusual, in that the shape, quantities, and size of the elements are determined by the Koch generating function. Thus we have a finite element mesh generated by a continuous function. We describe the family of Koch curves this technique is valid for and detail the necessary methodology to create the mesh. We then consider the triangles and quadrilaterals created in the process and provide shape regularity parameters for these elements. Using this information we show that the constant in the error estimate $\|u - u_I\|_{H^1(K)} \leq Ch\|u - u_I\|_{H^2(K)}$, is *independent* of the choice of n. Finally we will consider the case of singularities and introduce a weighted space. We will then calculate the constant in that case. (Received March 09, 2009)

37 ► Dynamical systems and ergodic theory

1050-37-49 **Esther R. Widiasih*** (widiasih@math.umn.edu), 127 Vincent Hall, 206 Church St. S.E., Minneapolis, MN 55455. *How Ice Line Moves: Revisiting Budyko's Energy Balance Model.*

An Energy Balance Model (EBM) is an example of a conceptual climate model, constructed to build an understanding of the ice albedo feedback mechanism. In this talk, I will start with an EBM, originated by Mihail Budyko in 1969, and formulated by Ka Kit Tung in 2007. Then I will propose a new formulation which includes a mechanism admitting the movement of the ice line and which leads to new results. (Received February 21, 2009)

1050-37-50 **James A Yorke*** (yorke@umd.edu), 5465 Mystic Ct, Columbia, MD 21044. *Weather prediction and Chaos.*

Weather prediction and climate prediction are closely tied to chaos and positive Lyapunov exponents. (Received February 21, 2009)

39 ► Difference and functional equations

1050-39-44 **M R.S. Kulenovic*** (mkulenovic@mail.uri.edu), Lippitt Hall 200A, Kingston, RI 02881, and **Orlando Merino** (merino@math.uri.edu), Lippitt Hall, Kingston, RI 02881. *Global Bifurcation for Competitive Systems in the Plane.*

A global bifurcation result is obtained for families of competitive systems of difference equations

$$\begin{cases} x_{n+1} &= f_\alpha(x_n, y_n) \\ y_{n+1} &= g_\alpha(x_n, y_n) \end{cases}$$

where α is a parameter, f_α and g_α are continuous real valued functions on a rectangular domain $\mathcal{R}_\alpha \subset \mathbb{R}^2$ such that $f_\alpha(x, y)$ is non-decreasing in x and non-increasing in y, and $g_\alpha(x, y)$ is non-increasing in x and non-decreasing in y. A unique interior fixed point is assumed for all values of the parameter α. (Received February 10, 2009)

1050-39-48 **Orlando Merino*** (merino@math.uri.edu), Department of Mathematics, Room 200, Lippitt Hall, 5 Lippitt Road, Kingston, RI 02881. *A Solution to the Y2K Problem.*

In a 1995 publication, G. Ladas conjectured the global attractivity of the equilibrium of the difference equation $x_{n+1} = \frac{p+q\,x_n}{1+x_{n-1}}$, $n = 0, 1, 2, \ldots$, $x_{-1} > 0$, $x_0 > 0$, where p and q are positive constants. This is the well known Y2K conjecture of rational difference equations. The case $q \geq p$ was proved in 1993 by Kocic and Ladas. A proof for the remaining case with $q < p$ will be presented here, thus completing the proof of the conjecture for all positive values of the parameters. (Received February 20, 2009)

1050-39-64 **Ann Brett*** (ambrett@verizon.net), Department of Mathematics, University of Rhode Island, 5 Lippitt Road, Kingston, RI 02881, and **Mustafa Kulenovic** (kulenm@math.uri.edu), Department of Mathematics, University of Rhode Island, 5 Lippitt Road, Kingston, RI 02881. *Two Species Competitive Model with Allee's Effect.*

We consider the following system of difference equations:

$$\begin{aligned} x_{n+1} &= \frac{ax_n^2}{1+x_n^2+cy_n} \\ y_{n+1} &= \frac{by_n}{1+y_n^2+dx_n}, \quad n = 0, 1, \ldots, \end{aligned}$$

where a, b, c, d are positive constants and $x_0, y_0 \geq 0$ are initial conditions. System (1) has interesting dynamics and it can have up to nine equilibrium points. The most complex and perhaps interesting case is one where (1) has nine equilibrium points, four of which are local attractors, four are saddle points and one is repeller. Using recent results of Kulenović and Merino we are able to characterize the basins of attractions of all local attractors and thus describe the global dynamics of (1). This case can be considered as a two-dimensional version of the Allee's effect for competitive systems. (Received February 23, 2009)

1050-39-87 **S W Schultz*** (sschultz@providence.edu), Providence College, Providence,R.I., RI 02918, and **E A Grove**, **G Ladas** and **E Camouzis**. *Periodicites which Preserve and Periodicies which Destroy Boundedness.*

It is known that every positive solution of the difference equation with positive b>0
x(n+1)=b +x(n-2)/x(n), n=0,1,...
is bounded. In this note we study the difference equation

x(n+1)=b(n) +x(n-2)/x(n) , n=0,1,... .

We show that every positive solution of this equation is bounded when b(n) is a period-2 sequence of positive real numbers.

We also show that there exists prime period-3m,sequences b(n) of positive real numbers such that the equation has unbounded solutions. (Received February 26, 2009)

1050-39-89 **Gabriel Lugo** and **Frank J Palladino*** (fpalladino@math.sunysb.edu), 350 Circle Rd., Schomburg B103C, Stony Brook, NY 11794. *Unboundedness for some classes of rational difference equations.* Preliminary report.

We study the rational difference equation

$$x_n = \frac{\alpha + x_{n-1}}{Cx_{n-2} + x_{n-3}}, n \in \mathbb{N}.$$

Particularly, we show that for non-negative α and C, whenever $C\alpha = 0$ and $C + \alpha > 0$, unbounded solutions exist for some choice of non-negative initial conditions. Moreover, we study the rational difference equation

$$x_n = \frac{\alpha + \beta x_{n-1} + x_{n-2}}{x_{n-3}}, n \in \mathbb{N}.$$

Particularly, we show that whenever $0 < \beta < \frac{1}{3}$ and $\alpha \in [0, 1]$, unbounded solutions exist for some choice of non-negative initial conditions. (Received February 27, 2009)

1050-39-98 **Vlajko L Kocic*** (vkocic@xula.edu), Department of Mathematics, Xavier University of Louisiana, 1 Drexel Dr., New Orleans, LA 70125. *Dynamics of certain classes of periodic rational difference equations.*

Boundedness, extreme stability, and existence of periodic orbits of certain periodic rational difference equations is studied. In addition the question of attenuance of periodic cycles is discussed. (Received February 28, 2009)

1050-39-106 **Ladas Gerry*** (geladas@mail.uri.edu), Department of Mathematics, University of Rhode Island, Kingston, RI 02881. *Open Problems and Conjectures in Rational Difference Equations and Systems.* Preliminary report.

We present some open problems and conjectures about some interesting types of rational difference equations and systems. We are mainly interested in the boundedness nature of solutions, the periodic character of the equation, the global stability behavior of the equilibrium points. (Received March 01, 2009)

1050-39-117 **Mihaela Predescu*** (mpredescu@bentley.edu), Bentley University, Department of Mathematical Sciences, 175 Forest St., Waltham, MA 02452. *Global Behavior of a Nonlinear Equation.*

In this talk we will discuss the global behavior of solutions of a nonlinear rational map. The initial conditions as well as the parameters involved are assumed to be non-negative real numbers. (Received March 02, 2009)

1050-39-136 **Y. Kostrov*** (ekostrov@yahoo.com), 25 brookway rd, providence, RI 02906, and **E Grove**, **S Schultz** and **M Radin**. *On the Character of the System*

$$x_{n+1} = \frac{\alpha_1}{x_n + y_n} \quad , \quad y_{n+1} = \frac{\alpha_2 + y_n}{B_2 x_n + y_n}$$

.

We investigate the boundedness character of the system

$$x_{n+1} = \frac{\alpha_1}{x_n + y_n} \quad , \quad y_{n+1} = \frac{\alpha_2 + y_n}{B_2 x_n + y_n}$$

. We also present some global results for this system. (Received March 02, 2009)

41 ► Approximations and expansions

1050-41-42 **Dmitry Pelinovsky*** (dmpeli@math.mcmaster.ca), Dmitry Pelinovsky, Department of Mathematics, McMaster University, Hamilton, Ontario L8S 4K1, Canada. *On the Thomas-Fermi ground state in a parabolic trap.*

We study the nonlinear ground state of the Gross–Pitaevskii equation with a parabolic potential. The Thomas–Fermi approximation of the ground state was recently justified on various spatial scales using the variational method. We justify here the Thomas–Fermi approximation on an uniform spatial scale using the Painlevé-II equation. These results allow us to characterize the distribution of eigenvalues in the point spectrum of the Schrödinger operator associated with the nonlinear ground state. This is the joint work with Clement Gallo. (Received February 09, 2009)

46 ► Functional analysis

1050-46-113 **Marta Lewicka*** (lewicka@math.umn.edu), University of Minnesota, School of Mathematics, Minneapolis, MN , and **Reza Pakzad**. *A scaling law for* $3d$ *nonlinear elastic energies of thin plates with strain at free equilibria.*

A Riemannian metric $G = [g_{ij}]$ on a simply connected domain $\Omega \subset \mathbb{R}^n$ can be realized as the pull-back metric of an orientation preserving deformation $u \in W^{1,1}(\Omega, \mathbb{R}^n)$ if and only if the associated Riemann curvature tensor R vanishes identically. When this condition does not hold, one may seek a mapping u as above, yielding the closest metric realization. We set up a variational formulation of this problem by introducing the energy functional:

$$E(u) = \int_\Omega \operatorname{dist}^2 \left(\nabla u(x), SO(n)\sqrt{G(x)} \right) \, \mathrm{d}x.$$

It can be shown that when $R \not\equiv 0$, the infimum of E over $W^{1,2}(\Omega, \mathbb{R}^n)$ is positive. We shall discuss the scaling behavior of the infimum energy for thin plates $\Omega = \Omega^h$, in the limit of their vanishing thickness h, as well as the Γ-limit of the scaled energy functionals. This work is motivated by studying elastic materials which show non-zero strain at free equilibria. (Received March 01, 2009)

1050-46-132 **Marta Lewicka**, **Maria Giovanna Mora** and **Reza Pakzad***, Department of Mathematics, Univeristy of Pittsburgh, Pittsburgh, PA 15232. *Rigidity and density of smooth mappings in Sobolev spaces of isometries.*

The Sobolev spaces of isometries and infinitesimal isometries on surfaces arise in the context of nonlinear elasticity. In this talk, we will discuss the space of $W^{2,n}$ isometries of a flat domain $\Omega \subset \mathbb{R}^n$ into $\mathbb{R}^{n+1}$ and the space of $W^{2,2}$ first order infinitesimal isometries on a convex shell in $\mathbb{R}^3$. Our recent results show that the rigidity results known for smooth isometries still hold true for these classes of mappings. Also, we are able to show that smooth mappings are dense in the above spaces of Sobolev isometries. These questions remain unanswered in various other situations. (Received March 02, 2009)

49 ► Calculus of variations and optimal control; optimization

1050-49-156 **Pavel Grinfeld*** (pg@freeboundaries.com), Department of Mathematics, Drexel University, Philadelphia, PA, PA 19105, and **Gilbert Strang** (gs@math.mit.edu), Department of Mathematics, MIT, Cambridge, MA 02139. *Moving Interfaces in Sectral Problems: Laplace Eigenvalues on Polygons and Deformed Manifolds.*

The three essential elements of a boundary-value problem are the differential operator, the shape of the domain, and the boundary conditions. Our primary interest is shape. We discuss the change in Laplace eigenvalues induced by the perturbation of the boundary. We concentrate on regular polygons with N sides and present the first few terms in a series for the eigenvalues in powers of 1/N. The series involves the Riemann zeta function and has other interesting properties. We also discuss out-of-plane deformations of manifolds and draw a connection to the dynamics of fluid films. (Received March 03, 2009)

51 ► Geometry

1050-51-19 **Olguta Buse***, LD-270 IUPUI, 402 N. Blackford St., Indianapolis, IN 46202. *Topological properties of symplectomorphism groups.* Preliminary report.

We will discuss new results regarding the topology of symplectomorphism groups of ruled four-manifolds. (Received January 05, 2009)

1050-51-25 **Richard K Hind*** (hind.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Symplectic embeddings of domains in Euclidean space.*

We describe sharp new estimates related to embeddings of ellipses into cylinders. (Received January 06, 2009)

1050-51-43 **Yaron Ostrover***, 2 Lamson place, Cambridge, MA 02139. *A Symplectic Brunn-Minkowski Inequality.*

The Brunn-Minkowski inequality for volumes of bodies is a fundamental result which has numerous applications in geometry and analysis. In this talk we discuss an analogue of this inequality in the context of symplectic geometry. (This is a joint work with Shiri Artstein-Avidan). (Received February 10, 2009)

1050-51-45 **Barry Monson***, Department of Mathematics and Statistics, University of New Brunswick, P.O. Box 4400, Fredericton, NB E3B 5A3, Canada, and **Egon Schulte** and **Daniel Hay**. *More on the* 11*-cell.* Preliminary report.

Codiscovered by Coxeter and Grünbaum in the 1970's, the 11-cell is a very beautiful abstract regular 4-polytope, with automorphism group $PSL_2(11)$. Here we give what is perhaps the most natural construction (via orthogonal groups over the ring $\mathbb{Z}[\tau]$; work with Egon Schulte), then try to sensibly visualize the thing (work with UNB student Danny Hay). (Received February 16, 2009)

1050-51-56 **Michael F Thorpe*** (mft@asu.edu), Department of Physics, Arizona State University, Tempe, AZ 85287-1504. *What makes Materials Flexible or Rigid?*

Have you ever wondered why some materials are more flexible than others? Many interesting phenomena occur in material structures that are poised between rigid and flexible. In this talk, we describe the modern theory of rigidity and show how it can be used to analyze networks of constraints. These results can be used as input to geometrical simulation, where the various rigid parts of a system are moved, while maintaining all the constraints; both equalities and inequalities. These concepts can be introduced in high school by using popsicle sticks and cotter pins to construct frameworks in an interesting new approach involving hands-on self discovery. On a research level, this approach has led to important insights in both in zeolites that are important for cracking petroleum, manganites that exhibit colossal magnetoresistance, and proteins and protein complexes (like viruses) where flexibility is often associated with function. (Received February 22, 2009)

1050-51-81 **Egon Schulte*** (schulte@neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115, and **Daniel Pellicer** (dpellicer@math.unam.mx), Department of Mathematics and Statistics, University of New Brunswick, Fredericton, NB E3B5A3, Canada. *Polygonal Complexes and Symmetry.*

The talk reviews the enumeration of the complete set of forty-eight regular polyhedra in 3-space (known as the Grünbaum-Dress polyhedra), following a classification scheme obtained years ago in joint work by Peter McMullen and the speaker. We also describe work in progress on the full classification of regular polygonal complexes in 3-space. Polygonal complexes are more general than polyhedra, in that they usually have more than two faces meeting at an edge, but otherwise share many of their properties. (Received February 26, 2009)

1050-51-82 **Kirk Haller** and **Audrey Lee-St.John*** (astjohn@mtholyoke.edu), Computer Science Department, Mount Holyoke College, South Hadley, MA 01075, and **Meera Sitharam**, **Ileana Streinu** and **Neil White**. *Body-and-cad geometric constraint systems.*

Motivated by constraint-based CAD software, such as SolidWorks, we develop the foundation for the rigidity theory of a new model: the *body-and-cad structure*, composed of rigid bodies in 3D constrained by pairwise **c**oincidence, **a**ngle and **d**istance constraints. We identify 21 relevant geometric constraints and develop the corresponding infinitesimal rigidity theory for these structures. As a consequence, we identify a necessary, but not sufficient, combinatorial counting condition called *nested sparsity*. Note that the classical body-and-bar rigidity model can be viewed as a body-and-cad structure that uses only one constraint from this new class. (Received February 26, 2009)

1050-51-95 **Robert J. MacG. Dawson*** (rdawson@cs.stmarys.ca), Department of Mathematics and CS, Saint Mary's University, Halifax, NS B3H 3C3. *Some new Čebyšev sets in hyperspaces.*

A set in a metric space is said to have the *Čebyšev property* if every point of the space has a unique nearest neighbour in the set. This purely metric property is equivalent to convexity for (closed, nonempty) sets in Euclidean spaces; but even in other finite-dimensional Banach spaces it need not be.

We define a *hyperspace* to be a metric space, the points of which are compact sets of an underlying space. We will consider in particular the space $\mathcal{K}^n$ of compact convex sets in $\mathbf{R}^n$ with the Hausdorff metric

$$\varrho(A,B) := \max\{\max_{a\in A}\min_{b\in B} d(a,b), \max_{b\in B}\min_{a\in A} d(a,b)\}\ ,$$

and the space $\mathcal{O}^n$ of compact strictly convex sets with the same metric.

Various different examples of Čebyšev sets are known in these hyperspaces, but we have no unifying classification. In this paper we will present constructions that unify some previously known classes, although a general characterization remains elusive. (Received February 28, 2009)

52 ► Convex and discrete geometry

1050-52-8 **David Richter*** (david.richter@wmich.edu), Department of Mathematics, MS 5248, Western Michigan University, Kalamazoo, MI 49008-5248. *Theory and examples of ghost symmetry.*

Ghost symmetry describes a circumstance when a finite configuration of points in a vector space lacks certain symmetries but displays them upon projection to various subspaces. In many instances, one may recover the entire symmetry group of a configuration using only ghost symmetries of a proper projection of the configuration. (Received December 01, 2008)

1050-52-40 **Robert Connelly*** (connelly@math.cornell.edu), Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853, and **Walter J Whiteley** (whiteley@mathstat.yorku.ca), Department of Mathematics and Statistics, York University, Toronto, Ontario M3J 1P3, Canada. *Global Rigidity.*

Given a configuration of points and some of the pairwise distances between them in Euclidean space, when does this determine the configuration uniquely? Thinking of the configuration as joints of a bar framework, when the configuration is determined uniquely, we say it is globally rigid. We show how the process of coning in the next higher dimension preserves the property of generic global rigidity. (Received February 08, 2009)

1050-52-47 **Daniel Pellicer*** (dpellicer@math.unam.mx), Department of Mathematics and Statistics, University of New Brunswick, Box 4400, Fredericton, NB E3B5A3, Canada, and **Asia I. Weiss**. *Cobinatorial structure of chiral polyhedra in the Euclidean space.* Preliminary report.

In 2005, Schulte classified all (geometrically) chiral polyhedra in the Euclidean space in six families. The polyhedra in three of these families have finite faces whereas the polyhedra in the other three families have infinite faces. We shall discuss which of these polyhedra are combinatorially chiral and which are combinatorially regular. Furthermore, we shall show a geometric argument that proves the existence of a combinatorial isomorphism between any two chiral polyhedra in each of the classes consisting of polyhedra with infinite faces. (Received February 19, 2009)

1050-52-52 **Bernd Schulze*** (bschulze@mathstat.yorku.ca), Department of Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario M3J1P3, Canada. *Symmetry as a sufficient condition for a finite flex.* Preliminary report.

A finite flex of a (bar-and-joint) framework (G, p) moves the joints of (G, p) on differentiable displacement paths while holding the lengths of all bars fixed and changing the distance between two unconnected joints. In this talk, we consider finite flexes of *symmetric* frameworks. We prove that if a framework (G, p) is 'generic' within a given symmetry class and there exists a 'fully-symmetric' infinitesimal flex of (G, p) (i.e., the velocity vectors of the infinitesimal flex remain unaltered under all symmetry operations of (G, p)), then (G, p) also possesses a 'symmetry-preserving' finite flex, i.e., a flex which displaces the joints of (G, p) in such a way that all the resulting frameworks have the same symmetry as (G, p) (or possibly higher symmetry). This and other related results are obtained by symmetrizing techniques described by L. Asimov and B. Roth in their paper 'The Rigidity Of Graphs' from 1978 and by using the fact that the rigidity matrix of a symmetric framework can be transformed into a block-diagonalized form by means of group representation theory. The finite flexes that can be detected with these symmetry-based methods can in general not be found with the analogous non-symmetric methods. (Received February 21, 2009)

1050-52-66 **Leah Wrenn Berman*** (lberman@ursinus.edu), Department of Mathematics & Computer Science, Ursinus College, P.O. Box 1000, Collegeville, PA 19426. *Highly Incident Configurations.* Preliminary report.

A k-configuration is a collection of points and straight lines in the plane where every point lies on k lines and every line passes through k points. There has been considerable work in the last few years on finding and classifying 3- and 4-configurations, but little is known about k-configurations for $k > 4$. This talk will discuss recently discovered classes of highly symmetric $5-$ and $6-$configurations. (Received February 23, 2009)

1050-52-71 **Elissa Ross*** (elissa@mathstat.yorku.ca), Department of Mathematics, York University, N520 Ross Building, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *Periodic Rigidity.* Preliminary report.

Zeolites are a type of molecule with a sieve-like structure where the "holes" of the sieve expand and contract. Using this as motivation, we study the rigidity properties of infinite periodic frameworks. We can think of such

a framework in n dimensions as a multigraph embedded on an n-dimensional torus, where the torus may be of fixed or variable dimensions. In this talk we describe a characterization of infinitesimal rigidity for 2-dimensional frameworks on a fixed torus, and outline what is known for periodic frameworks in higher dimensions. (Received February 24, 2009)

1050-52-74 **Norman W. Johnson*** (njohnson@wheatonma.edu), Department of Mathematics, Wheaton College, Norton, MA 02766. *Torohedral groups.*

Of the seventeen discrete Euclidean "wallpaper patterns," nine are *lattice patterns* having no rotations other than half-turns. The other eight are *apeirohedral patterns* having rotations of periods 3, 4, or 6. The symmetry group of such a pattern has for its fundamental region the closure of a triangle (3 3 3), (4 4 2), or (6 3 2) whose interior angles are submultiples of π. Each of these infinite groups operating in the Euclidean plane has families of finite quotient groups operating on a torus. Three of the corresponding *torohedral patterns* are of particular interest, providing Euclidean models for finite affine planes over the fields with 2, 3, or 5 elements. (Received February 25, 2009)

1050-52-75 **Marjorie Senechal*** (senechal@smith.edu), Department of Mathematics, Smith College, Northampton, MA 01060. *Another Look at Matching Rules.*

In the late 20th century, the study of shapes which, juxtaposed by matching rules, tile space only non-periodically became a mini-growth industry. But today the mathematical literature on "aperiodic order" relegates matching rules to the background. In this new era of nanostructures and self-assembly, they deserve another look. "Simple local rules" are anything but that, and local and global order may not be separable. (Received February 25, 2009)

1050-52-78 **Gaiane Panina** (panina@iias.spb.su), Institute for Informatics and Automation, V.O. 14 line 39, StPetersburg, 199178, Russia, and **Ileana Streinu*** (istreinu@smith.edu), Computer Science Department, Smith College, Northampton, MA 01063. *Flattening single-vertex origami: the non-expansive case.*

A single-vertex origami is a piece of paper with a fold vertex placed in its interior or on its boundary, and straight-line rays called creases emanating from it. The Single-Vertex Origami Problem asks whether it is always possible to reconfigure the creased paper from any configuration compatible with the metric, to a flat position, in such a way that the paper is not torn, stretched and, for rigid origami, not bent anywhere except along the given creases. We settle the problem in the affirmative.

Previously, Streinu and Whiteley showed how the single-vertex origami problem reduces to the spherical Carpenter's Rule Problem, and solved the cases of open, less than π and closed, less than 2π spherical polygons using spherical expansive motions. The remaining case, presented here, cannot be solved only with non-expansive motions. Our motion planning algorithm works in a finite number of discrete steps, for which we give precise bounds depending on both the number of links and the angle deficit. (Received February 25, 2009)

1050-52-84 **Daniel A Klain*** (daniel_klain@uml.edu), Department of Mathematical Sciences, University of Massachusetts Lowell, Lowell, MA 01854. *If you can hide behind it, can you hide inside it?*

Suppose that K and L are compact convex subsets of Euclidean space, and suppose that, for every direction u, the shadow (that is, the orthogonal projection) of K onto the subspace normal to u can be translated inside the corresponding shadow of the body L. Does this mean that the original body K can itself be translated into L? Can we even conclude that K has smaller volume than L?

Although these questions have easily demonstrated negative answers in dimension 2, the (possibly surprising) answer to these questions continues to be "No" in Euclidean space of any finite dimension.

In this talk I will describe concrete constructions for sets K and L in n-dimensional Euclidean space such that every (n-1)-dimensional shadow of K can be translated inside the corresponding shadow of L, while at the same time K has strictly greater volume than L.

It turns out, however, that the body L with larger (covering) shadows is guaranteed to have greater or equal volume than the set K provided that L is a cylinder, or, even more generally, provided that L can be approximated by Blaschke combinations of cylinders. This cylinder covering theorem will also be presented, along with some variations and related open questions regarding projections in convex geometry. (Received February 26, 2009)

1050-52-86 **Gordon Iam Williams*** (gordonianwilliams@mac.com), 87 Liberty Alley, Rahns, PA 19426-1821. *Quotient representations for uniform tilings.* Preliminary report.

In recent years a variety of efforts have been undertaken to better understand the structure of abstract polytopes as quotients of regular abstract polytopes. A result of particular importance in the development of this theory

was obtained by M.I. Hartley in his dissertation which observes that all abstract polytopes may be represented as quotients of regular abstract polytopes. In this talk we will explore some of the special problems and surprising insights that may be obtained about the structure of such quotients by considering the special case of the uniform tilings of the plane (those tilings whose faces are regular convex polygons and whose symmetry group acts transitively on the vertices). This talk will include a discussion of the minimal presentations for the quotients as well as some of the broader implications to the theory of quotients of polytopes that resulted from this investigation. (Received February 26, 2009)

1050-52-174 **Konstantin Rybnikov*** (konstantin_rybnikov@uml.edu), Mathematical Sciences, University of Massachusetts at Lowell, Lowell, MA 01854. *Remarkable Delaunay Polytopes derived from the Leech lattice.* Preliminary report.

Given a lattice L, a polytope D is called a Delaunay polytope if the set of its vertices is $S \cap L$ where S is a Delaunay empty sphere in L. D is called perfect if the only ellipsoid containing $S \cap L$ is exactly S. The unit interval and Gosset polytope 2_{21} are the only perfect Delaunay polytopes in dimensions 1 through 6.

We explored the geometry of 23-dimensional sublattices of the Leech lattice. Our study of such sublattices produced a number of remarkable perfect Delaunay polytopes. In particular, we find:

(1) Perfect Delaunay polytopes of lattice width 4 (the highest previously known width was 2).

(2) A perfect Delaunay polytope in a 23-dimensional lattice L which is also a perfect Delaunay polytope in a 23-dimensional superlattice of L.

(3) A perfect Delaunay polytope in a 23-dimensional lattice L whose vertex set is a *proper* subset of the vertex set of another perfect Delaunay polytope in a 23-dimensional superlattice of L.

In addition, many of the obtained Delaunay polytopes have sporadic simple groups as their isometry groups.

This is a joint work with Mathieu Dutour. (Received March 04, 2009)

53 ► Differential geometry

1050-53-5 **Octav Cornea***, Université de Montréal. *Lagrangian submanifolds: from physics to number theory.*

The study of Lagrangian submanifolds is motivated, in part, by problems of physical nature appearing in Hamiltonian dynamics but also, more recently, by issues related to string theory. In this talk I will review a number of recent developments in the subject - some obtained in joint work with Paul Biran - which show that the understanding of certain natural algebraic invariants associated to a class of Lagrangian submanifolds (called wide) is intimately related to the theory of quadratic forms. This relation is significant because it offers a conceptual perspective on the definition of some enumerative invariants involving genus zero pseudo-holomorphic curves with boundary. A variant of Hochschild homology plays an important role in this study. In essence, for a wide Lagrangian L the main symplectic algebraic invariant of interest is the quantum homology of L. This is a particular type of deformation of singular homology and Hochschild homology is the correct tool to understand the associated deformation theory. The theory of quadratic forms enters naturally here because there is a way to associate some interesting quadratic forms to the specific Hochschild co-homology classes that appear in the study of these deformations. Additionally, this version of Hochschild homology also relates this deformation theory to the topology of the free loop space of L. (Received May 15, 2008)

1050-53-10 **Zhigang Han*** (han@math.umass.edu), Department of Mathematics and Statistics, University of Massachusetts, Amherst, MA 01003-9305. *A nonextension result on the spectral metric.*

The spectral metric is a bi-invariant metric on the Hamiltonian diffeomorphism group defined by Schwarz and Oh using Floer-theoretical method. In this talk, I will first explain the definition of the spectral metric for symplectically aspherical manifolds. Then I will explain why for certain symplectic manifolds, this metric does not extend to bi-invariant metric on the full group of symplectomorphisms. (Received December 29, 2008)

1050-53-11 **Maksim Maydanskiy*** (maksimm@math.mit.edu), MIT Department of Mathematics, 77 Massachusetts Avenue, 2-492, Cambridge, MA 02139. *"Fake" symplectic manifolds via Lefschetz fibrations.*

Stein manifolds are known to symplectic geometers as Liouville domains and are an especially nice class of open symplectic manifolds. I construct, in all odd complex dimensions, pairs of Lioville domains W_0 and W_1 which are diffeomorphic to the sphere cotangent bundle with one extra subcritical handle, but are not symplectomorphic. In fact, while W_0 is symplectically very similar to the cotangent bundle itself, W_1 is more unusual, and in

particular contains no compact exact Lagrangian submanifolds. Constructions are given by explicit Lefschetz fibrations, and the proofs involve calculations of wrapped Floer homologies. (Received December 31, 2008)

1050-53-13 **R Goldin**, **M Harada** and **T Holm*** (tsh@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853-4201, and **T Kimura**. *The Full Orbifold K-theory of Abelian Symplectic Quotients.*

In their 2007 paper, Jarvis, Kaufmann, and Kimura defined the full orbifold K-theory of an orbifold $\mathfrak{X}$, analogous to the Chen-Ruan orbifold cohomology of $\mathfrak{X}$ in that it uses the obstruction bundle as a quantum correction to the multiplicative structure. We give an explicit algorithm for the computation of this orbifold invariant in the case when $\mathfrak{X}$ arises as an abelian symplectic quotient. As an example, we discuss the full computation of the full orbifold K-theory of weighted projective spaces. Our computations hold over the integers, and in the particular case of weighted projective spaces, we may show that the associated invariant is torsion-free. (Received January 01, 2009)

1050-53-16 **Ely Kerman*** (ekerman@math.uiuc.edu). *Hofer's geometry and Maslov class rigidity.*

A path of Hamiltonian diffeomorphisms which does not minimize the Hofer length functional has closed orbits with special properties. These orbits can be related to several symplectic rigidity phenomena. In this talk I will describe the how these special periodic orbits can be used to determine new restrictions on the Maslov class of displaceable Lagrangian submanifolds. (Received January 03, 2009)

1050-53-17 **Katrin Wehrheim***, MIT, Department of Mathematics, 77 Massachusetts Ave, Cambridge, MA 02139. *Lagrangian correspondences and holomorphic quilts.*

I will present some current results in a joint project with Sikimeti Mau and Chris Woodward, building a theory of Lagrangian correspondences and holomorphic quilts.

A Lagrangian correspondence is a Lagrangian submanifold in the product of two symplectic manifolds. This generalizes the notion of a symplectomorphism and was introduced by Weinstein in an attempt to build a symplectic category that has morphisms between any pair of symplectic manifolds (not just symplectomorphic pairs). We define such a cateory, in which all Lagrangian correspondences are composable morphisms and extend it to a 2-category by extending Floer homology to generalized Lagrangian correspondences. This is based on counts of 'holomorphic quilts' — a collection of holomorphic curves in different manifolds with 'seam values' in the Lagrangian correspondences. A fundamental isomorphism of Floer homologies ensures that our constructions are compatible with the geometric composition of Lagrangian correspondences. This provides e.g. a general prescription for constructing topological invariants. We are currently working on extending our setup to construct an A_∞ 2-category on chain level, which would provide a powerful tool in mirror symmetry proofs outlined by Nadler and Abouzaid. (Received January 03, 2009)

1050-53-23 **Andrew Cotton-Clay*** (acotton@math.berkeley.edu), Department of Mathematics, Room 2-314, M.I.T., 77 Massachusetts Ave., Cambridge, MA 02139. *Symplectic Floer homology of area-preserving surface diffeomorphisms and sharp fixed point bounds.*

The symplectic Floer homology $HF_*(\phi)$ of a symplectomorphism ϕ encodes data about the fixed points of ϕ using counts of holomorphic cylinders in $\mathbb{R} \times M_\phi$, where M_ϕ is the mapping torus of ϕ. We give an algorithm to compute $HF_*(\phi)$ for ϕ a surface symplectomorphism in a pseudo-Anosov or reducible mapping class, completing the computation of Seidel's $HF_*(h)$ for h any orientation-preserving mapping class. We also show that the rank of a certain twisted version of symplectic Floer homology gives a bound on the number of fixed points of any map with nondegenerate fixed points in a given symplectic mapping class on a monotone symplectic manifold. By calculating this twisted version for surfaces we obtain a sharp lower bound on the number of fixed points of an area-preserving map (with nondegenerate fixed points) in any prescribed mapping class, generalizing the Poincaré-Birkhoff fixed point theorem. (Received January 06, 2009)

1050-53-28 **Sikimeti Ma'u*** (sikimeti@math.mit.edu), **Katrin Wehrheim** and **Chris Woodward**. *Quilted disks in Lagrangian Floer theory.* Preliminary report.

Using the quilted Floer theory of Wehrheim and Woodward, we describe how a Lagrangian correspondence L between symplectic manifolds M and N can be used to define an A_∞ functor between suitably enlarged Fukaya categories of M and N. The construction uses a family of quilted surfaces called quilted disks, which realize a family of polytopes called the multiplihedra, close relatives of the associahedra. This is joint work with Wehrheim and Woodward. (Received January 06, 2009)

1050-53-30 **Fabian J. Ziltener*** (fabian@math.toronto.edu), 8 Lanark Avenue, Apartment # 2, Toronto, Ontario M6C 2B3, Canada. *Coisotropic Submanifolds, Leaf-wise Fixed Points, and Presymplectic Embeddings.*

Let (M, ω) be a symplectic manifold, $N \subseteq M$ a coisotropic submanifold, and $\varphi : M \to M$ a Hamiltonian diffeomorphism. The main result presented in this talk is that the number of leaf-wise fixed points of φ is at least the sum of the $\mathbb{Z}_2$-Betti numbers of N, if φ is Hofer close to the identity and some other assumptions hold. In the extreme case $N = M$ these points are the fixed points of φ. On the other hand, if N is Lagrangian and connected, then they are the intersection points of N with $\varphi^{-1}(N)$. As an application, I will discuss a presymplectic non-embedding result, which naturally generalizes Gromov's Lagrangian non-embedding result. (Received January 06, 2009)

1050-53-31 **Joseph A Johns*** (jjohns@cims.nyu.edu), 251 Mercer street, New York, NY 10012. *Complexifications of Morse functions and exact Lagrangian submanifolds in cotangent bundles.* Preliminary report.

I will discuss complexifications of Morse functions viewed as symplectic Lefschetz fibrations, and hopefully some applications to exact Lagrangian submanifolds in cotangent bundles. (Received January 12, 2009)

1050-53-36 **Mike Chance*** (mchance@math.sunysb.edu). *Degenerate Maxima for Hamiltonian Loops.* Preliminary report.

We examine degenerate global maxima for loops of Hamiltonian symplectomorphisms. We show that global maxima and minima cannot be completely degenerate. We also show implications for the structure of the group of Hamiltonians for symplectic 4 manifolds. (Received January 27, 2009)

1050-53-46 **Martin Pinsonnault*** (mpinson@uwo.ca), Department of Mathematics, Middlesex College, The University of Western Ontario, London, Ontario N6A 5B7, Canada. *Connexity of some symplectomorphism groups.*

We will show that the group of all symplectomorphisms of the k-fold blow-up of CP^2 that act as the identity on homology is connected when $k \in \{3, 4\}$. If time permits, some applications will be discussed. (Received February 19, 2009)

1050-53-77 **Ciprian S. Borcea*** (borcea@rider.edu), Department of Mathematics, Rider University, Lawrenceville, NJ 08648, and **Ileana Streinu** (istreinu@smith.edu), Computer Science Department, Smith College, Northampton, MA 01063. *Extremal configurations of revolute-jointed robot arms.*

We present a complete theoretical solution for the determination of the maximum distance between a point on the first link and a point on the last link of a serial manipulator with revolute joints. The known necessary condition for critical configurations is developed into a simple necessary and sufficient criterion for the global maximum. We use Morse-Bott theory for the squared distance function and establish at the same time a formula for the Euler characteristic of the inverse kinematics solution space in terms of indices of critical configurations. For manipulators with coplanar consecutive joints this approach identifies all extremal configurations. Our proofs work in arbitrary dimension d. (Received February 25, 2009)

1050-53-109 **Joel W Fish*** (joelfish.math@gmail.com), Stanford University, Mathematics Department, 450 Serra Mall, Building 380, Stanford, CA 94305. *Target-local Gromov-compactness for J-curves.* Preliminary report.

We discuss a version of Gromov-compactness which holds locally in the target symplectic manifold. Rather than considering the curves as holomorphically parameterized maps, we instead regard them as (almost) immersed submanifolds with arbitrarily many free boundary components in the boundary of a symplectic manifold. We provide applications to Symplectic Field Theory and degenerating connected sums in contact homology. (Received March 01, 2009)

1050-53-135 **Richard Siefring*** (siefring@math.msu.edu), Dept. of Mathematics, A212 Wells Hall, Michigan State University, East Lansing, MI 48824. *Asymptotics and intersection theory of punctured pseudoholomorphic curves.*

Positivity of intersections for pseudoholomorphic curves and the resulting topological controls on intersections and embeddedness of closed pseudoholomorphic curves have been useful for applications of pseudoholomorphic curves to 4-dimensional symplectic topology. In a 4-dimensional symplectic cobordism, a precise description of the asymptotic behavior of punctured pseudoholomorphic curves allows for similar algebraic-topological controls on intersections and embeddedness despite the fact that the intersection number of two curves is no longer a homotopy-invariant quantity. In this talk we will explain the relevant results about the asymptotic behavior

of curves near a puncture, and the resulting algebraic controls on intersections and embeddedness. (Received March 02, 2009)

1050-53-164 **Rosa Sena-Dias***, rsenadias@math.mit.edu. *Spectral measures on toric manifolds.* Preliminary report.

We will talk about some properties of the spectrum of a toric manifold. We will focus on some asymptotic properties of some special spectral measures and their relations to the geometry of the toric manifold. (Received March 03, 2009)

55 ► Algebraic topology

1050-55-24 **Catalin Zara***, UMass Boston, Department of Mathematics, 100 Morrissey Boulevard, Boston, MA 02125. *GKM Fiber Bundles.*

For GKM manifolds the equivariant cohomology ring of the manifold is isomorphic to the cohomology ring of its GKM graph. We explore the implications of this fact for equivariant fibrations for which the total space and the base space are both GKM, and derive a graph theoretical description of the equivariant cohomology of the total space from the equivariant cohomology of the base and of the fiber. As application we obtain bases for the equivariant cohomology of flag varieties. This is joint work with Victor Guillemin and Silvia Sabatini. (Received January 06, 2009)

1050-55-176 **Daniel C. Cohen** and **Goderdzi Pruidze*** (gio@math.lsu.edu). *Motion planning in tori and topological complexity of basis-conjugating automorphism groups.*

Let X be a subcomplex of the standard CW-decomposition of the n-dimensional torus. We exhibit an explicit optimal motion planning algorithm for X. This construction is used to calculate the topological complexity of complements of general position arrangements and Eilenberg–Mac Lane spaces associated to right-angled Artin groups. As time permits, we will also discuss the topological complexity of basis-conjugating automorphism groups. (Received March 04, 2009)

57 ► Manifolds and cell complexes

1050-57-15 **Dennis Sullivan** and **Michael Sullivan*** (sullivan@math.umass.edu). *Open string topology and classical knots.* Preliminary report.

I will discuss some new string topology operations for open strings and apply them to knots. These operations, in principle, should be useful for studying holomorphic curves. (Received January 02, 2009)

1050-57-21 **Tim Perutz*** (perutz@math.columbia.edu). *Lagrangian sphere-bundles.*

Lagrangian correspondences between symplectic manifolds are the "maps" of symplectic geometry. They make good boundary conditions for pseudo-holomorphic curves. Lagrangian correspondences that are sphere-bundles (especially circle-bundles) are notable both for their geometric prevalence, and for the interesting structure of their Floer homology theory, one of whose features is an analogue of the Gysin sequence from algebraic topology. (Received January 05, 2009)

1050-57-27 **Weimin Chen*** (wchen@math.umass.edu), Department of Mathematics and Statistics, University of Massachusetts -Amherst, Amherst, MA 01003. *On the Floer homology of symplectic orbifolds.*

This is an on-going project in which we will develop, in the orbifold context, a general framework for the various Floer homology theories, in particular, the Floer homology theory for the problem of periodic orbits in a symplectic orbifold. Special attention will be given to the case of the symmetric products of a symplectic manifold. Applications to orbifold string topology will also be considered. (Received January 06, 2009)

1050-57-72 **Hans K Shmidheiser*** (shmid@cims.nyu.edu), New York University, 251 Mercer St, New York, NY 10012. *The Lattice Faddeev Model.* Preliminary report.

We describe the Faddeev Model for knotted solitons. We briefly mention the known results, including the 3/4 energy growth law and the existence results of Lin and Yang. We discuss how the numerical investigations of Faddeev, Battye and Sutcliffe, and Ward, motivated the study of the Lattice Faddeev Model. In particular, we focus on how one computes a Hopf number for a nice map $u : \mathbb{R}^3 \to S^2$ (that decays to constant at infinity) from the data $\{x, u(x)\}_{x\in\mathbb{Z}^3}$. Alternatively, we show how one can use this to ascribe a "Hopf number" to a map

$u : \mathbb{Z}^3 \to S^2$. This technique can be used in a more general setting to compute topological invariants for maps between manifolds, given in terms of differential forms, by sampling at discrete points. Finally, will mention the existence results for the Lattice Faddeev Model. (Received February 25, 2009)

1050-57-94 **Yi-Jen Lee*** (yjlee@math.purdue.edu) and **C Taubes**. *Period Floer homology and Seieberg-Witten cohomology.*

I will report on a joint work with C.Taubes proving the equivalence between the the Periodic Floer homology defined by Hutchings and certain versions of Seiberg-Witten cohomology. (Received February 27, 2009)

1050-57-131 **Olga Plamenevskaya*** (olga@math.sunysb.edu), Department of Mathematics, Stony Brook University, Stony Brook, NY 11790. *Transverse knots and their branched covers.*

We study transverse knots via their cyclic branched covers, which are contact manifolds naturally associated to transverse knots. We show that in many cases branched covers of two transverse knots are contactomorphic if the knots have the same smooth type and self-linking number. This happens even when the knots are not transversely isotopic. In particular, many pairs of transverse knots distinguished by Heegaard Floer transverse invariant (due to Ozsvath-Szabo-Thurston), as well as knots constructed by Birman-Menasco, yield contactmorphic branched covers. (Joint with S.Harvey and K.Kawamuro.) (Received March 02, 2009)

1050-57-133 **David H Crombecque*** (dcrombecque@muhlenberg.edu), PA. *Nonorientable Contact Structures on 3-manifolds.*

Since Bennequin's work, it is well known that in 3-dimensional topology, there is a dichotomy between TIGHT and OVERTWISTED contact structures. While overtwisted structures are well understood, the study of tightness from a 3-dimensional perspective is still at its early stage. In most studies, contact structures are always considered orientable. (Recall that a contact 3-manifold is always orientable, but its contact structure does NOT have to be). It is often thought that if one has to deal with a nonorientable structure, one may work with its orientation double cover. Our motivation is to realize that one cannot merely switch to the orientation double cover when studying tightness. In this talk, we will present some examples of nonorientable tight contact structures which have an overtwisted orientation double cover. (Received March 02, 2009)

1050-57-159 **Li Han*** (lhan@clarku.edu), 950 Main Street, Worcester, MA 01610, and **Lee Rudolph**. *Simplex-Tree Based Kinematics of Foldable Objects as Multi-body Systems Involving Loops.*

Many practical multi-body systems involve loops. Studying the kinematics of such systems has been challenging, partly because of the requirement of maintaining loop closure constraints, which have conventionally been formulated as highly nonlinear equations in joint parameters. In earlier work, we introduced parameters defined by trees of triangles for a broad class of linkage systems involving loops (such as, for instance, spatial loops with spherical joints and planar loops with revolute joints); these parameters greatly simplify kinematics related computations and endow system configuration spaces with highly tractable piecewise convex geometries. More recently, we have developed a more general approach for those multi-body systems (many of them with loops) that allow *construction trees of simplices*. We will illustrate the applicability and efficiency of our simplex-tree based approach to the kinematics of foldable objects by a study of single-vertex rigid folds. (Received March 03, 2009)

1050-57-160 **Lee Rudolph*** (lrudolph@black.clarku.eud), 950 Main Street, Worcester, MA 01610, and **Li Han**. *Planning Regular Homotopies of Planar Loops with Revolute Joints.* Preliminary report.

In recent work with Clark University undergraduate students Sam Dorsey-Gordon '09, Dylan Glotzer '11, Dan Menard '09, Jon Moran '10 and James R. Wilson '09, we used triangle-based parameters for configurations of a planar loop $\mathcal{L}$ with revolute joints (equivalently, a planar polygon with edges of fixed length) to give an efficient description of the bending and kissing loci in the configuration space of $\mathcal{L}$, which includes the self-contact subspace of $\mathcal{L}$ (generally as a strict subset). Using that work as a framework, we indicate how to develop procedures for planning regular homotopies of $\mathcal{L}$. (Received March 03, 2009)

1050-57-171 **Alexander I. Suciu*** (a.suciu@neu.edu), Department of Mathematics, Northeastern University, Boston, MA 02115. *A look at polyhedral products.*

A general construction associates to a simplicial complex K on n vertices, and a pair of spaces, (X, A), a certain subspace, $\mathcal{Z}_K(X, A)$, of the cartesian product of n copies of X. I will discuss several aspects of this construction, with emphasis on the case when X is a circle, and A is a point. (Received March 03, 2009)

58 ► Global analysis, analysis on manifolds

1050-58-3 **Fengbo Hang***, Courant Institute of New York University. *Topology of weakly differentiable maps.*

In many problems from math physics and differential geometry, we are looking for solutions bearing specific topological informations. In dealing with these questions by variational methods, various spaces of weakly differentiable maps are introduced. A basic problem is the comparison between the suitably defined topological quantity of weakly differentiable maps and those of continuous maps. We will discuss some research in this direction. (Received May 15, 2008)

1050-58-12 **Eduardo Gonzalez*** (eduardo@math.umb.edu) and **Chris Woodward**. *Area-dependence in gauged Gromov-Witten theory.*

I will describe joint work with Chris Woodward, in which we study the variation of the moduli space of symplectic vortices on a fixed holomorphic curve with respect to the area form. For compact, convex varieties we define gauged Gromov-Witten invariants and prove a wall-crossing formula for them. As an application, we prove a vortex version of the *abelianization (or quantum Martin) conjecture* of Bertram, Ciocan-Fontanine, and Kim, which relates Gromov-Witten invariants of geometric invariant theory quotients by a group and its maximal torus, for vortices on non-trivial bundles. (Received January 01, 2009)

1050-58-26 **Samuel T Lisi*** (lisi@math.stanford.edu), Department of Mathematics, bldg 380, Stanford, CA 94305. *Homoclinic orbits and pseudoholomorphic curves.* Preliminary report.

This talk will present work in progress on developing a Floer theory for homoclinic orbits. To this end, we will consider pseudoholomorphic planes with two different asymptotic boundary conditions : a finite energy condition in one direction, and an asymptotic periodicity condition in the other direction. (These conditions are a natural generalization of ones considered previously by Cieliebak and Séré.) We will focus on the analytical aspects that are new in this setting. (Received January 06, 2009)

1050-58-61 **Yisong Yang*** (yisong.yang@yu.edu), New York, NY 10033. *Compactness and Minimization for Two-Dimensional Skyrme Energy.* Preliminary report.

The original Skyrme model arising in particle physics governs maps from R^3 into S^3 which are topologically stratified by their topological degrees. In this talk, we present some existence results for a modified Skyrme model, referred to as the baby Skyrme model by physicists, governing maps from R^2 into S^2. The structure of the energy functinal allows an effective application of the principle of concentration-compactness when the coupling parameters obey a restrictive condition. Here we show that, a new method, which we referred to as the method of substantial inequalities resembling the energy splitting and charge conservation relations in a nuclear fission process, gives us a more effective tool in solving such a topologically constrained minimization problem. (Joint work with Fanghua Lin) (Received February 22, 2009)

1050-58-123 **Tobias Lamm**, Department of Mathematics, University of British Columbia, Vancouver, Canada, and **Changyou Wang Wang***, Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Boundary Regularity of Biharmonic Maps.*

We consider biharmonic maps between manifolds. When the dimension of domain is 4, complete boundary regularity is obtained. When the dimension of domain is larger than 4, a partial boundary regularity of stationary biharmonic maps is obtained. This is a joint work with T. Lamm. (Received March 02, 2009)

60 ► Probability theory and stochastic processes

1050-60-96 **Jun Masamune*** (masamune@wpi.edu), 100 Institute Road, Worcester, MA 01609-2280. *The Mosco convergence and the weak convergence of the Wiener measures for the weighted thin layers and boundaries.*

A domain containing highly weighted thin layers has been one of the most interesting models in both analysis and stochastic analysis. A natural problem is to consider the ϵ-neighborhood of the layers and to study the asymptotic behaviors of the spectral structures and the convergence of the associated Wiener measures as $\epsilon \to 0$.

There are many works devoted to the study of the stochastic process in this limit space; however, there are no results which study the weak convergence of the Wiener measures in this setting. The difficulty comes from the high concentration of the weight on the neighborhood of the layers, to which the existing approximation theories for Wiener measures do not apply. On the other hands, the convergence of the spectral structures via Mosco convergence with fixed speed measures has been studied since 1970s.

In the present paper, we establish the Mosco convergence with changing speed measures and show the tightness of the associated Wiener measures. Combining these two results, we obtain the weak convergence of the Wiener measures. (Received February 28, 2009)

1050-60-115 **Alexander Teplyaev*** (teplyaev@math.uconn.edu), Department of Mathematics, University of Connecticut, Storrs, CT 06269-3009. *Uniqueness of locally invariant Laplacian, Dirichlet form and Brownian motion on Sierpinski carpets.*

We prove that, up to scalar multiples, there exists only one Dirichlet form on a generalized Sierpinski carpet that is invariant with respect to the local symmetries of the carpet. Consequently for each such fractal the law of Brownian motion is uniquely determined and the notion of Laplacian is well defined.

This is a joint work with M. T. Barlow, R. F. Bass, T. Kumagai. (Received March 02, 2009)

65 ► Numerical analysis

1050-65-146 **Marcus Sarkis*** (msarkis@wpi.edu) and **Juan Galvis**. *Approximating a SPDE with a coefficient with infinity number of scales.*

In this talk we consider a stochastic Darcy's pressure equation with log-normal permeability and random right-hand side forcing term. To accommodate the lack of ellipticity, singular forcing terms, and general representations of the permeability stochastic fields, we introduce continuous and discrete weak formulations involving distinct spaces for the solution and the test functions. We present inf-sup conditions, well-posedness, a priori error estimations and numerical experiments. This is joint work with Dr. Juan Galvis (Texas AM). (Received March 03, 2009)

1050-65-178 **Olof B. Widlund*** (widlund@cims.nyu.edu), 251 Mercer Street, New York, NY 10012. *Accommodating Irregular Subdomains in Domain Decomposition Theory*

In the theory for domain decomposition methods, we have previously often assumed that each subdomain is the union of a small set of coarse shape-regular triangles or tetrahedra. In this talk, we discuss recent progress which makes it possible to analyze cases with irregular subdomains such as those provided by mesh partitioners.

Our goal is to extend our analytic tools to problems on subdomains that might not even be Lipschitz and to characterize the rates of convergence of our methods in terms of a few, easy to understand, geometric parameters of the subregions. For two dimensions, we have already obtained some best possible results for scalar elliptic and linear elasticity problems: the subdomains should be John or Jones domains and the rate of convergence is determined using the parameters that define such domains and that of an isoperametric inequality. Progress on three dimensions will also be reported. (Received March 09, 2009)

74 ► Mechanics of deformable solids

1050-74-147 **Gianni Dal Maso*** (dalmaso@sissa.it). *Quasistatic crack growth in finite elasticity with noninterpenetration.*

We present a variational model to study the quasistatic growth of brittle cracks in hyperelastic materials, in the framework of finite elasticity, taking into account the non-interpenetration condition. (Received March 03, 2009)

1050-74-148 **Florin Maris*** (florinmaris@WPI.EDU). *On crack initiation in dynamic brittle fracture.* Preliminary report.

We describe some preliminary results on the question of whether crack initiation is possible in models for dynamic brittle fracture (Received March 03, 2009)

1050-74-149 **Chris Larsen*** (cjlarsen@wpi.edu). *Models for dynamic brittle fracture.*

We introduce mathematical models for "sharp interface" dynamic brittle fracture, that make no assumption about crack geometry, etc. We show how they relate to existing models for static/quasi-static fracture, and to phase-field models for dynamic brittle fracture. (Received March 03, 2009)

1050-74-152 **Christoph Ortner*** (christoph.ortner@merton.ox.ac.uk). *Simulation of Brittle Fracture using Phase Field Approximations and AFEM.*

I will describe an adaptive finite element algorithm for the approximation of the Ambrosio–Tortorelli approximation to the Griffith functional. The main idea is that, rather than minimizing the discretized AT-functional, the

AT-functional will be minimized in function space and each minimization step is discretized by an adaptive finite element method. The convergence of the algorithm to critical points of the AT-functional can be established rigorously. I will moreover present a generalization of the AT-approximation which can be "tuned" so that the phase field v and the displacement u have more efficient "shapes". For example, it is possible to formulate an AT-approximation where v has compact support which has both numerical and mechanical advantages. (Joint with Siobhan Burke and Endre Süli). (Received March 03, 2009)

1050-74-165 **Matthew P. Bell*** (mbell@cs.dartmouth.edu), Hanover, NH , and **Devin J. Balkcom** (devin@cs.dartmouth.edu). *Knot tying with single-piece fixtures.*

Manipulation of flexible objects like string and cloth poses a challenge to robotic and human manipulation due to the difficulty of regrasping a flexible object. Without sensing, it becomes nearly impossible to guess where a grasp should go. However, we can try to simplify the problem in several ways. For tying knots in string, we can use a fixture to continually grasp the string during the entire tying process. We have developed fixtures for overhand and square knots, and can use a slightly modified overhand fixture to tie the knot around an object. Additionally, we are exploring automated methods of designing these fixtures, as well as a new class of fixture that works reliably with string as well as wire. (Received March 03, 2009)

1050-74-166 **Yury Grabovsky*** (yury@temple.edu), Temple University 038-16, Department of Mathematics, 1805 N Broad St, Philadelphia, PA 19122, and **Lev Truskinovsky** (trusk@lms.polytechnique.fr), Laboratoire de Mécanique des Solides, Route de Saclay, 91128 Palaiseau CEDEX, France. *On buckling instability in hyperelasticity.*

Buckling has been understood either as a bifurcation in dimensionally reduced models for rods and plates or exhibited explicitly for 3D non-linearly elastic bodies with simple geometry and constitutive law. We view buckling as a failure of second variation to stay positive for 3D slender bodies under compressive loading. The source of that behavior of second variation is the principle of objectivity that is also responsible for flip instability in a purely soft device. Buckling occurs when the stabilizing effect of energy convexity and mixed device loading expressed by the Korn constant is overcome by the destabilizing effect of the compressive loading. Our theory is largely independent of the precise details of geometry, loading or constitutive anisotropy and non-linearity. As such, it applies to complex geometries. (Received March 03, 2009)

76 ► Fluid mechanics

1050-76-158 **Amala Mahadevan*** (amala@bu.edu), Earth Sciences, Boston University, 675 Commonwealth Avenue, Boston, MA 02215. *Challenges to physical-biological coupling in climate models.*

Our increasing physical understanding and computational abilities have led to significant advances in modeling the climate system. Some of the greatest uncertainties lie in the carbon cycle, and in using biological models for prediction. Capturing the underlying physics is necessary for realistically modeling physical-biological feedbacks. Using some examples from oceanography, I will demonstrate the challenges for climate models with a carbon cycle. (Received March 03, 2009)

81 ► Quantum theory

1050-81-62 **Yisong Yang*** (yisong.yang@yu.edu), New York, NY 10033. *Existence and Nonexistence of Electricity in Two-Dimensional Static Gauge Field Theories.* Preliminary report.

It is a well accepted principle that finite-energy static solutions in the classical relativistic gauge field theory over the $(2 + 1)$-dimensional Minkowski spacetime must be electrically neutral. Such a statement is referred to as the Julia–Zee theorem by field theorists. Here we present a mathematical proof of this fundamental structural property. As applications, we see that the static Abelian Higgs theory is necessarily the Ginzburg–Landau theory which is purely magnetic, and that, the presence of a Chern–Simons term is essential to allow the existence of a solution carrying both electric and magnetic charges, known as dyons. (Joint work with Joel Spruck) (Received February 22, 2009)

1050-81-153 **Israel Michael Sigal*** (imsigal@math.ias.edu), Institute for Advance Study, School of Mathematics, Princeton, NJ 08540. *Mean-field limit of quantum systems of many bosons.*
In this talk I will review recent results on the mean-field limit of the quantum systems of many boson particles. In particular I will discuss derivation of Hartree and Hartree-Fock-Bogolubov equations. (Received March 03, 2009)

82 ► Statistical mechanics, structure of matter

1050-82-9 **Jacob C Mower*** (jmower@stevens.edu), Box S-1268, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ 07030. *Non-Existence Results for Coagulation Kinetics.*
Discrete coagulation models stochastically characterize the rate of growth and decay of particulate elements in many-bodied systems. Rates are determined by the coagulation kernel, which is specific to the simulated process. In finite time, gelation has been shown to occur for certain kernel choices, whereby macroparticles of infinite mass form. The condition for instantaneous gelation, and therefore the non-existence of solutions, has also been shown analytically for specific coagulation kernels. It is desirable to demonstrate a condition for determining the nonexistence of solutions that relies upon numerical simulations which can be readily applied to nearly all kernels. Such a method is presented, using the Smoluchowski and Dubovski discrete coagulation equations. It is shown that when a given kernel is applied to both the Dubovski and Smoluchowski models and gelation is numerically predicted to occur in the Dubovski model before it occurs in the Smoluchowski model, no solution can exist for either equation. We demonstrate the excellent agreement of our predictions with previous analytic work on nonexistence by Ball and Carr, given various choices of kernels. We finally present predictions for nonexistence using complex kernels not previously investigated for this purpose. (Received December 02, 2008)

1050-82-124 **Richard Kenyon***, Mathematics Dept., 151 Thayer St., Providence, RI 02912. *Limit shapes and the complex Burgers equation.*
This is joint work with Andrei Okounkov. We study surfaces in R^3 that arise as limit shapes in random surface models related to planar dimers. These limit shapes are *surface tension minimizers*, that is, they minimize a functional of the form $\int \sigma(\nabla h)\,dx\,dy$ among all Lipschitz functions h taking given values on the boundary of the domain. The surface tension σ has singularities and is not strictly convex, which leads to formation of *facets* and *edges* in the limit shapes.

We find a change of variables that reduces the Euler-Lagrange equation for the variational problem to the complex inviscid Burgers equation. The equation can thus be solved in terms of an arbitrary holomorphic function, which is somewhat similar in spirit to Weierstrass parametrization of minimal surfaces. We further show that for a natural dense set of boundary conditions, the holomorphic function in question is, in fact, *algebraic*. The tools of algebraic geometry can thus be brought in to study the minimizers and, especially, the formation of their singularities. (Received March 02, 2009)

86 ► Geophysics

1050-86-60 **William F. Langford*** (wlangfor@uoguelph.ca), Dept. of Mathematics and Statistics, University of Guelph, Guelph, Ontario N1G 3C5, Canada, and **Greg Lewis**. *Poleward Expansion of Hadley Cells.*
Recent reanalyses of meteorological data by climate scientists have indicated that the Hadley cells of the atmospheric circulation are expanding toward the poles as well as slowing in their circulation velocity. A majority of GCM simulations forecast that these trends will continue at least to the end of the 21st century. If true, the poleward expansion of Hadley cells would lead to desertification of economically important regions. Similar reanalyses of meteorological data for recent decades show a poleward movement of the jet streams that affect midlatitude weather. Although the precise mechanism of these changes in Hadley cells and jet streams is not fully understood, it is believed to be linked with global warming. In this paper, we apply pseudo-arclength continuation to a model of a fluid in a differentially heated rotating spherical shell that uses the Navier-Stokes equations in the Boussinesq approximation. We demonstrate that a decrease in the pole-to-equator temperature gradient leads to an expansion and slowing of the Hadley circulation and a poleward movement of jet streams, thus indicating a possible mechanism for the observed changes.
(Received February 22, 2009)

1050-86-91 **J. S. Wettlaufer*** (john.wettlaufer@yale.edu), Yale University, 210 Whitney Avenue, New Haven, CT 06520-8109. *Nonlinear threshold behavior during the loss of Arctic sea ice.*
In light of the rapid recent retreat of Arctic sea ice, a number of studies have discussed the possibility of a critical threshold beyond which the ice–albedo feedback causes the ice cover to melt away in an irreversible process. The focus has typically been centered on the annual minimum (September) ice cover, which is often seen as particularly susceptible to destabilization by the ice–albedo feedback. Here, we examine the central physical processes associated with the transition from ice-covered to ice-free Arctic Ocean conditions. We show that although the ice–albedo feedback promotes the existence of multiple ice-cover states, the stabilizing thermodynamic effects of sea ice mitigate this when the Arctic Ocean is ice covered during a sufficiently large fraction of the year. These results suggest that critical threshold behavior is unlikely during the approach from current perennial sea-ice conditions to seasonally ice-free conditions. In a further warmed climate, however, we find that a critical threshold associated with the sudden loss of the remaining wintertime-only sea ice cover may be likely. Comments concerning the connections with ergodic theory are made. (Received February 27, 2009)

1050-86-107 **Mary Lou Zeeman*** (mlzeeman@bowdoin.edu), Dept. of Mathematics, Bowdoin College, 8600 College Station, Brunswick, ME 04011. *Introduction to the Mathematics of Climate Change.*
We will describe some of the essential observations and physical processes of climate change, and introduce a few simple models that begin to give intuition for the historical data, the earth's radiative energy balance, and the ice-albedo and greenhouse gas feedback processes. We will also illustrate the wide range of mathematical challenges and opportunities in climate change research, with a few examples. (Received March 01, 2009)

92 ► Biology and other natural sciences

1050-92-67 **Janet A Nye*** (janet,nye@noaa.gov), 166 Water Street, East Falmouth, MA 02543, **Jason S. Link** (jason.link@noaa.gov), 166 Water Street, Woods Hole, MA 02543, and **Jonathan A. Hare** (jon.hare@noaa.gov), 28 Tarzwell Drive, Narragansett, RI 02882. *Climate-induced changes in spatial distribution of Northwest Atlantic fish stocks: implications for management.* Preliminary report.
Fish populations may respond to climate change in a number of different ways, including changes in vital rates, changes in sources of mortality, and shifts in spatial distribution. All of these responses have important ramifications on the population dynamics of these fish and may hinder our ability to properly assess their status. In this work, we focused on the hypothesized first response of fish to warming, a shift in spatial distribution. In a meta-analysis of 36 fish stocks on the Northeast US coast, we found that over half of these fish stocks exhibited distributional responses consistent with warming, including a poleward shift in mean center of biomass, an increase in mean depth, and an expansion or contraction of their range. Such shifts in distribution suggest that we re-evaluate the population unit at which we model and manage fisheries upon these species. Defining the "unit stock" is the first and arguably most important step in performing a stock assessment on commercially important fish stocks. We suggest a general framework to detect and re-evaluate stock definitions. We then use red hake Urophycis chuss as an example of how changing spatial distribution affects stock assessments and advice given to fisheries managers. (Received February 23, 2009)

1050-92-99 **Abdul-Aziz Yakubu*** (ayakubu@howard.edu), Mathematics Department, Howard University, Washington, DC 20059, and **Jon Conrad** and **Mary Lou Zeeman**. *Periodic Versus Constant Proportion Fish Exploitation Policies.* Preliminary report.
We use a single-species discrete-time model to demonstrate changes that introduction of the strong Allee mechanism and periodic exploitation policy have on compensatory and overcompensatory stock dynamics through comparison with corresponding models that lack such constraints. Periodic and constant exploitation policies simplify complex overcompensatory stock dynamics with or without the Allee effect. Both constant and periodic exploitation policies force a sudden collapse to extinction of fisheries systems that exhibit the Allee mechanism. However, in the absence of the Allee effect, fisheries systems decline to zero smoothly under high exploitation. Also, we will explore the impact of climate change on the extinction of exploited species. (Received February 28, 2009)

1050-92-154 **Pavel M Lushnikov*** (plushnik@math.unm.edu), University of New Mexico, MSC03-2150, Albuquerque, NM 87131, **Mark Alber**, University of Notre Dame, 255 Hurley Hall, Notre Dame, IN 46556, and **Nan Chen**, University of Notre Dame, Notre Dame, IN 46556.

Regularization of collapse in dynamics of biological cells.

Biological cells interact through chemotaxis when cells secret diffusing chemical (chemoattractant) and move towards gradient of chemoattractant creating effective nonlocal attraction between cells. Macroscopic description of cellular density dynamics through Keller-Segel model has striking qualitative similarities with nonlinear Schrodinger equation including critical collapse in two dimensions and supercritical in three dimensions. Critical collapse has logarithmic corrections to $(t_0 - t)^{1/2}$ scaling law of self-similar solution. Microscopic motion of eucaryotic cells is accompanied by random fluctuations of their shapes. We derive a nonlinear diffusion equation coupled with chemoattractant from microscopic cellular dynamics in dimensions one and two using excluded volume approach. Nonlinear diffusion coefficient depends on cellular volume fraction and it provides regularization (prevention) of cellular density collapse. A very good agreement is shown between Monte Carlo simulations of the microscopic Cellular Potts Model and numerical solutions of the macroscopic equations for relatively large cellular volume fractions. (Received March 03, 2009)

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16 Associative rings and algebras
17 Nonassociative rings and algebras
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19 *K*-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
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31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
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42 Fourier analysis
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45 Integral equations
46 Functional analysis
47 Operator theory
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52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
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62 Statistics
65 Numerical analysis
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70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
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