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***** Indicates who will present the paper at the meeting.

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PAPERS PRESENTED AT MEETINGS

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

MEETING #	DATE	PLACE	ABSTRACT DEADLINE	ABSTRACT ISSUE
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 11	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	October 15	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
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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

WACO, TX, October 16–18, 2009

Abstracts of the 1051st Meeting.

00 ► General

1051-00-1 **Michael C. Reed***, Duke University. *Mathematics, Cell Metabolism, and Public Health.* There are now 50 years of data giving statistical associations between dietary intakes and various human health problems such as cancer, heart disease, diabetes, and birth defects. Typically the correlations are small and give little information about the causal mechanisms in cells that lead to the pathological conditions. To discover these mechanisms, we need to understand normal cell metabolism and how it changes in disease. This is a daunting task because cell metabolism is an extremely complicated nonlinear dynamical system that is seldom near equilibrium because it is usually adapting to external signals and large changes in inputs (for example, from meals). Furthermore, biological experimentation is difficult because it's hard to measure time courses of concentrations in living cells. However, physiologically based mathematical models are platforms for in silico biological experimentation. Several such models will be described and related to public health issues, including folate supplementation, birth defects, and colon cancer. New mathematical techniques for analyzing the behavior of far-from-equilibrium stochastic dynamical systems and stochastic partial differential equations are needed.. (Received June 05, 2008)

1051-00-2 **Alexander A. Kiselev***, University of Wisconsin. *Surface quasi-geostrophic equation: A review.*

The surface quasi-geostrophic equation (SQGE) is motivated by atmospheric science. It models temperature evolution on the boundary of a rotating half-space filled with fluid in the presence of gravity. It is a nonlinear, nonlocal equation that looks fairly simple, but its solutions exhibit rich and varied behaviors. An interesting feature of the SQGE is that fractional dissipation appears naturally in it. The equation looks similar to the two-dimensional Euler equation, but is less regular. In particular, this is the simplest-looking equation of fluid

dynamics for which the question of global existence of smooth solutions (or finite time blow up) remains open for supercritical dissipation.

I will review recent progress in understanding solutions of the SQGE and some new techniques developed for this purpose. In particular, I will describe nonlocal maximum principle which allows to prove global existence of smooth solutions in the critical dissipation regime, as well as other results on solution regularity and small scales creation. (Received June 18, 2008)

1051-00-3 **Igor Rodnianski***, Princeton University. *Mathematics of general relativity.*
I will review basic mathematical concepts of General Relativity, explain its influence of the fields of Geometry and PDE's based on several celebrated examples and discuss some of the recent results and challenges facing the field. (Received June 05, 2008)

1051-00-4 **David Ben-Zv1***, University of Texas at Austin. *Representation theory and gauge theory.*
One of the most exciting recent developments in representation theory (due in large part to the influence of Kapustin-Witten and Lurie) has been the realization that many of its deepest structures can be elegantly understood from the perspective of (topological) quantum field theory, specifically (supersymmetric) gauge theory. I will introduce some of these ideas, focusing on my work with Nadler in which we define and study a three-dimensional topological field theory, the character theory of a complex Lie group G, which captures much of the representation theory of G and its real forms. (Received June 05, 2008)

1051-00-62 **Kelly J Suter*** (kelly.suter@utsa.edu), Department of Biology, 1 UTSA Circle, San Antonio, TX 78249. *Computational approaches to studying hypothalamic gonadotropin releasing-hormone (GnRH) neurons.*
The gonadotropin releasing-hormone (GnRH) neurons of the hypothalamus integrate the multiple internal and external cues that regulate sexual reproduction. Their episodic release of GnRH provides the stimulus for pituitary gonadotropin secretion and the subsequent function of the gonads. We will discuss our computational models of GnRH neurons which in tandem with electrophysiological experiments using dynamic current clamping, demonstrate that somata, proximal dendrites and distal dendrites of GnRH neurons create functional microdomains within individual GnRH neurons. (Received August 11, 2009)

1051-00-209 **Martin Eugenio Avendano*** (avendano@math.tamu.edu), 306 Redmond Dr. Apt. 302, College Station, TX 77840-6602. *Descartes' Rule is Exact!* Preliminary report.
We show that for any univariate polynomial f with real coefficients, there exists a polynomial g with non-negative coefficients such that the number of positive real roots of f is exactly the number of changes of signs in the vector of coefficients of fg. If all the positive roots of f are simple, then g can also be chosen as a power of the binomial (x+1). (Received August 25, 2009)

03 ► Mathematical logic and foundations

1051-03-12 **Cyrus F Nourani*** (Akdmkrd@mail.com), Personal USA Address, PO Box 278, Cardiff, CA 92007. *Filters, Frgament Constructible Models, and Sets.* Preliminary report.
Positive forcing (author 1981) on Keisler's Lw1,K instances were proved as MA realizations, therefore, stating a correspondence between forcing and the axiom. More specifics were restated at the ASL Montreal 2006 on Functorial generic filters.From the author's 1981 we have the following with more specifics on ASL Montreal.

Theorem 1 The positive forcing T* is a F-generic filter.

Theorem 2 The power set of an inductive theory defined on Lw1,K generates a positive generic model for the theory based on a generic diagram for a canonical model.

Since 1995 author had presented a funtorial model-theory and a set fragment consistency basis has developed.

Theorem 3 There is a Horn dense counterpart to the Rasiowa-Sikorski lemma. An area the author has not explored, for example, (author 1999), is whether there is a Godel constructible set corresponence to the above, where natural forcing companions can be presented based on, for example, inductive closures on Godel operations based ZF definable fragment sets. Are there statements that can be stated on new axioms,for example, Martin's axiom's generlization, i.e.. the proper forcing axiom and Martin's maximus. (Received May 27, 2009)

05 ► Combinatorics

1051-05-29 **Fabio Rapallo**, Universita' del Piemonte Orientale, viale Teresa Michel, 11, 15121 ALESSANDRIA, ALESSANDRIA, Italy, and **Ruriko Yoshida*** (ruriko.yoshida@uky.edu), 805A Patterson Office Tower, Lexington, KY 40506. *Markov bases and subbases for bounded contingency tables.*

In this talk we study the computation of Markov bases for contingency tables whose cell entries have an upper bound. In general a Markov basis for unbounded contingency table under a certain model differs from a Markov basis for bounded tables. Rapallo, (2007) applied Lawrence lifting to compute a Markov basis for contingency tables whose cell entries are bounded. However, in the process, one has to compute the universal Gröbner basis of the ideal associated with the design matrix for a model which is, in general, larger than any reduced Gröbner basis. Thus, this is also infeasible in small- and medium-sized problems. In this talk we focus on bounded two-way contingency tables under independence model and show that if these bounds on cells are positive, i.e., they are not structural zeros, the set of basic moves of all 2×2 minors connects all tables with given margins. We end this talk with an open problem that if we know the given margins are positive, we want to find the necessary and sufficient condition on the set of structural zeros so that the set of basic moves of all 2×2 minors connects all incomplete contingency tables with given margins. (Received July 24, 2009)

1051-05-116 **Michael W. Hero** and **Jeb F. Willenbring*** (willenbring@gmail.com), University of Wisconsin - Milwaukee, Department of Mathematical Sciences, P. O. Box 0413, Milwaukee, WI 53201-0413. *Stable Hilbert series and the Kronecker coefficients.* Preliminary report.

This talk will describe a problem in invariant theory motivated by the concept of quantum entanglement. Specifically, we compute a stable formula for the Hilbert series of the invariant algebra of polynomial functions on a tensor product of defining representations of unitary groups. The example may be interpreted physically as the quantum analog of a classical system consisting of several particles in which each has a finite number of classical states.

The stable formula involves elementary combinatorics. The derivation involves the representation theory of the symmetric group. In particular, the Kronecker coefficients play an important role. (Received August 20, 2009)

1051-05-219 **Matthew Macauley*** (macaule@clemson.edu), Department of Mathematical Sciences, O-325 Martin Hall, Clemson, SC 29634-0975. *What do Coxeter groups and Boolean networks have in common?* Preliminary report.

Central to the diverse fields of Coxeter groups and Boolean networks are involutions. What has a group-theoretic interpretation on one hand may lead to insight to the dynamics on the other, and vice-versa. In this talk, I will highlight some of the central themes and common structures, as well as discuss some novel approaches to some open and open-ended problems. (Received August 25, 2009)

11 ► Number theory

1051-11-7 **Hung-ping Tsao*** (hptsao@hotmail.com), 1151 Highland Drive, Novato, CA 94949. *Second generation Stirling numbers.*

For a sequence Q in a commutative ring, we define the Stirling number s(n,k;Q) of the first kind with respect to Q as the sum of products of k numbers among the first n terms of Q with s(n,0;Q)=1 and the Stirling number S(n,k;Q) of the second kind with respect to Q to be S(n,k;Q)=s(n-k+1,1;Q)S(n,k-1;Q)- s(n-k+2,2;Q)S(n,k-2;Q)+...with the last term being s(n,n;Q) for odd k and -s(n,n;Q) for even k and S(n,0;Q)=1. We shall only consider s(n,k;a,d) and S(n,k;a,d) with respect to an arithmetic progression (a+(n-1)d). Based on s(n,k;a,d)=s(n-1,k;a,d)+ [a+(n-1)d]s(n-1,k-1;a,d) and S(n,k;a,d)=S(n-1,k;a,d)+[a+(n-k)d] S(n-1,k-1;a,d), we shall express Stirling numbers as linear combinations of binomial coefficients. The triangular arrays of coefficients in such linear combinations will be called second generation Stirling numbers. For example, s(n,1;a,d)=S(n,1;a;d)= dC(n,2)+aC(n,1), s(n,2;a,d)=3ddC(n+2,4)+d(3a-4d)C(n+1,3)+(a-d)(a-d)C(n,2) and S(n,2;a,d)=3ddC(n+1,4)+ d(3a-2d)C(n+1,3)+(a-d)(a-2d)C(n,2). We shall derive recursive formulas which will enable us to generate the second generation Stirling numbers of both kinds. They are the same except for the sign only when a=d=1. (Received March 03, 2009)

1051-11-229 **Tim Huber*** (hubertj@utpa.edu), Department of Mathematics, The University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539. *Differential Equations for Eisenstein Series on Subgroups of $SL(2,\mathbb{Z})$.*

In his 1914 paper "On certain arithmetic functions" Ramanujan showed that Eisenstein series on the full modular group satisfy a coupled system of nonlinear differential equations. His clever proof is based on the Fourier expansions for certain elliptic functions. Ramanujan's work has inspired a number of analogous differential equations for modular forms on subgroups of the modular group, including V. Ramamani's system for modular forms of level 2 and R. Maier's system for modular forms of level 2, 3, and 4. I will discuss further generalizations, corresponding to differential equations for modular forms of level N. Consequences of these differential equations motivated by results in Ramanujan's Lost Notebook will be established. (Received August 25, 2009)

13 ► Commutative rings and algebras

1051-13-32 **Hai Long Dao*** (hdao@math.ku.edu), 1021 Missouri St, Apt 4, Lawrence, KS 66044. *On structure of Hom(M,N).* Preliminary report.

Let R be a regular local ring and M,N be reflexive modules. We are interested in the module structure of Hom(M,N). We will show a result in dimension 3 that help generalize classical theorems by Auslander and Auslander-Goldman on Hom(M,M). (Received July 26, 2009)

1051-13-57 **H. Tai Ha** and **Brent D Strunk*** (strunk@ulm.edu). *Asymptotic Behavior of Multigraded Regularity Vectors.*

Let S be a standard $\mathbb{N}^k$-graded polynomial ring over a field $\mathbf{k}$, let I be a multigraded homogeneous ideal of S, and let M be a finitely generated $\mathbb{Z}^k$-graded S-module. We prove that the resolution regularity, a multigraded variant of Castelnuovo-Mumford regularity, of $I^n M$ is asymptotically a linear function. This shows that the well known $\mathbb{Z}$-graded phenomenon carries to the multigraded situation. (Received August 10, 2009)

1051-13-71 **Manoj Kummini*** (nkummini@math.purdue.edu), 150 N University St., West Lafayette, IN 47907-2067. *Arithmetic Rank of Unmixed Bipartite Edge Ideals.*

Arithmetic rank of an ideal I in a ring R is the least number s such that there exists elements $a_1, \ldots, a_s \in R$ such that $\sqrt{I} = \sqrt{(a_1, \ldots, a_n)}$. We compute the arithmetic rank of unmixed bipartite edge ideals, and show that, the arithmetic rank of certain Cohen-Macaulay edge ideals equals their height. (Received August 13, 2009)

1051-13-101 **Kuei-Nuan Lin*** (link@purdue.edu). *Rees Algebras of diagonal ideals.*

Let X be an m by n matrix of variables over a field k. R and S are rings defined by the minors of X. We consider the diagonal ideal $\mathbb{D}$, the kernel of the diagonal map. By the work of Simis-Ulrich, we know the defining equations of special fiber of $\mathbb{D}$. When $R = S$, the special fiber is known as a homogeneous coordinate ring of secant variety of the determinantal variety $\mathcal{Z}(\mathrm{Spec}(R))$. Some of the cases show that the fiber ring is $k[X]$. It is nature to ask whether $\mathbb{D}$ is an ideal of linear type, which means that the natural map from the symmetric algebra of $\mathbb{D}$, $\mathrm{Sym}(\mathbb{D})$, onto the Rees algebra of $\mathbb{D}$, $\mathcal{R}(\mathbb{D})$, is an isomorphism. We aim at a more refined study of the ideal defining $\mathcal{R}(\mathbb{D})$. By knowing the defining equations, we can show that $\mathcal{R}(\mathbb{D})$ is Cohen-Macaulay and $\mathbb{D}$ is an ideal of linear type. (Received August 19, 2009)

1051-13-111 **Susan E. Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, 601 University Dr, San Marcos, TX 78666. *Lower Bounds for Depths of Powers of Edge Ideals of Trees and Graphs.*

Lower bounds are given for the depths of R/I^t for $t \geq 1$ when I is the edge ideal of a tree or forest. The bounds are given in terms of the diameter of the tree, or in case of a forest, the largest diameter of a connected component and the number of connected components. These lower bounds provide a lower bound on the power for which the depths stabilize. For the edge ideal of a more general graph, similar bounds are given for low powers of the ideal. (Received August 20, 2009)

1051-13-113 **Tai Ha***, Department of Mathematics, 6823 St. Charles Avenue, New Orleans, LA 70118. *Associated primes of powers of square-free monomial ideals.*

Let J be a square-free monomial ideals in a polynomial ring R. I will discuss how to describe associated primes of powers of J. This problem turns out to be closely related to the coloring properties of certain hypergraph. (Received August 20, 2009)

1051-13-114 **Christopher J. Hillar** (chillar@msri.org), Mathematical Sciences Research Institute, 17 Gauss Way, Berkeley, CA 94120, and **Abraham Martín del Campo*** (asanchez@math.tamu.edu), Texas A&M University, Department of Mathematics, 3368 TAMU, College Station, TX 77843-3368. *Finiteness theorems for chains of toric ideals.*

We consider a problem that arises in both chemistry and algebraic statistics, namely, describe the algebraic relations between (a possible infinite number of) experimental measurements. These are symmetric ideals associated in a particular way to a fixed polynomial. In the special case when this fixed polynomial is a monomial, the ideal is a toric ideal.

We present a new finiteness result, which states that, up to symmetry, there are a finite number of generators for such toric ideals in possibly an infinite number of variables. This is a joint work with Chris Hillar. (Received August 20, 2009)

1051-13-119 **Ryan Karr** (rkarr@fau.edu), Wilkes Honors College, Florida Atlantic University, Jupiter, FL 33458, and **Roger Wiegand*** (rwiegand@math.unl.edu), Department of Mathematics, University of Nebraska–Lincoln, Lincoln, NE 68588-0130. *Brauer-Thrall II for one-dimensional local rings.*

Let $(R, \mathbf{m}, k)$ be a local domain of dimension one, and let $\mathcal{C}(R)$ denote the class of maximal Cohen-Macaulay (= finitely generated torsion-free) R-modules. Assume that the normalization of R is a finitely generated R-module, that k is infinite, and that $\mathcal{C}(R)$ contains infinitely many isomorphism classes of indecomposable modules. Then, for every positive integer n, $\mathcal{C}(R)$ contains $|k|$ isomorphism classes of indecomposable modules of rank n. The result can fail if the normalization is not finitely generated. (Received August 20, 2009)

1051-13-122 **Alina Iacob***, aiacob@georgiasouthern.edu, and **Srikanth B. Iyengar**. *A characterization of regular rings.*

We show that a noetherian ring R is regular if and only if each complex of injective R-modules is semi-injective if and only if each acyclic complex of injective R-modules is contractible. Analogous results are established for complexes of flat modules and of projective modules. (Received August 21, 2009)

1051-13-129 **C-Y Jean Chan** and **Christine K Cumming*** (cumming@ulm.edu), Department of Mathematics and Physics, 700 University Ave., Monroe, LA 71209, and **Huy Tai Ha**. *When are multigraded modules Cohen-Macaulay?*

Let M a finitely $\mathbb{Z}^r$-graded module over a standard $\mathbb{N}^r$-graded algebra over a local ring. We characterize the Cohen-Macaulayness of M in terms of the vanishing of specific sheaf cohomology modules. Next, we apply our result to study when multi-Rees modules are Cohen-Macaulay, extending previous studies on the Cohen-Macaulayness of multi-Rees algebras. (Received August 21, 2009)

1051-13-137 **Raymond C. Heitmann***, Mathematics Department, University of Texas, Austin, TX 78712. *Tight Closure in Non-excellent Rings.*

When R is an excellent ring, tight closure has many good properties. If x is in the tight closure of an ideal I and $\phi : R \to S$ is a homomorphism, then $\phi(x)$ is in the tight closure of $\phi(I)S$ - the persistence property. If R is also equidimensional, tight closure has the colon-capturing property. Here we offer examples showing that both persistence and colon-capturing can fail when R is not excellent. Finally, a variant of tight closure, general tight closure, is offered for local rings. General tight closure is found by extending the ideal to the completion of the ring, computing the tight closure, and then contracting to the original ring. General tight closure coincides with tight closure in the excellent case and seems to offer all of the good properties of tight closure more generally. (Received August 21, 2009)

1051-13-139 **Janet C. Vassilev*** (jvassil@math.unm.edu), Department of Mathematical Sciences, University of New Mexico, Albuquerque, NM 87131. *Operations on m-primary ideals in rings of characteristic p.* Preliminary report.

We will consider several operations on m-primary ideals and discuss instances when the operation agrees with the tight closure. (Received August 22, 2009)

1051-13-144 **Stefan O. Tohaneanu*** (stefan.tohaneanu@uc.edu), Department of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221. *The minimal distance of evaluation codes.*

Evaluation codes are the projective version of the Reed-Muller codes: consider Γ a set of n points in $\mathbb{P}^m$ and "evaluate" the homogeneous polynomials of degree a at the points of Γ. The geometry of Γ determine the behavior of the minimal distance of these codes. Using the Cayley-Bacharch Theorem Gold-Little-Schenck find a lower bound for the minimal distance, when Γ is a complete intersection. They generalized to $\mathbb{P}^m$ the result of

Hansen for complete intersections in $\mathbb{P}^2$. We extended their result to the case when Γ is Gorenstein. In addition, from the shifts in the graded minimal free resolution of the ideal of Γ, we found a similar lower bound for the minimal distance of the evaluation code, for any set of points in $\mathbb{P}^3$. We present all of these results, as well as other interesting lower bounds for the minimal distance (e.g., Ballico-Fontanari lower bound). (Received August 22, 2009)

1051-13-170 **Craig Huneke**, **Dan Katz** and **Tom Marley*** (tmarley@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Are the supports of local cohomology modules always closed?*

Let R be a Noetherian ring and M a finitely generated R-module. Examples due to A. Singh and M. Katzman show that the set of associated primes of a given local cohomology modules $H^i_I(M)$ may be infinite. However, it is not known whether the set of minimal associated primes of $H^i_I(M)$ is always finite, or equivalently, whether the support of $H^i_I(M)$ is always closed. We are able to answer this question affirmatively in some cases, in particular, in the case the ideal has cohomological dimension two. (Received August 24, 2009)

1051-13-171 **Oana Veliche*** (oana.veliche@gmail.com), 226 Pine Hill Circle, Waltham, MA 02451, and **Lars Winther Christensen** and **Janet Striuli**. *Growth of the Sequence of Bass Numbers.*

Let R be a local ring with maximal ideal $\mathfrak{m}$ and residue field $k = R/\mathfrak{m}$. Compared to the sequence of Betti numbers, $\{\operatorname{rank}_k \operatorname{Ext}^i_R(k,k)\}_{i\in\mathbb{Z}}$, the sequence of invariants of the ring R $\{\operatorname{rank}_k \operatorname{Ext}^i_R(k,R)\}_{i\in\mathbb{Z}}$, called *the sequence Bass numbers*, is not so well understood. In my talk I will present some recent results on the growth of the sequence of Bass numbers, over several classes of local rings. (Received August 24, 2009)

1051-13-175 **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu), **Neil Epstein** and **Karl Schwede**. *Semidualizing modules over certain Veronese subrings.* Preliminary report.

Let R be a local Cohen-Macaulay ring. A finitely generated R-module C is *semidualizing* if $\operatorname{Hom}_R(C,C) \cong R$ and $\operatorname{Ext}^i_R(C,C) = 0$ for all $i \geq 1$. A free R-module of rank 1 is semidualizing, as is a dualizing R-module. The existence of nontrivial semidualizing R-modules implies that R satisfies certain structural and numerical conditions. Hence, we are interested in describing all the semidualizing modules over certain classes of rings. In this talk, we will show that if k is a field and $R = k[\![X^d, X^{d-1}Y, \dots, Y^d]\!]$, then R has exactly two semidualzing modules, namely R and the dualizing module for R. (Received August 24, 2009)

1051-13-196 **S. D. Cutkosky**, **K. Dalili*** (dalilik@missouri.edu) and **O. Kashcheyeva**. *Asymptotic behavior of value semi-groups.*

Let v be a valuation dominating a noetherian local domain, let $S = \{v(r) | r \in R\}$ be its value semi-group and let G be its value group (the group obtained by appending inverses to S). The possible value groups G have been extensively studied and classified classically; the value semi-group S however is much less understood. In this talk we will briefly look at the known results classifying value groups and at some well known constraints on the value semi-groups. Then we will look at growth rate of the value semi-group and its asymptotic behavior to obtain new constraints on possible value semi-groups.

This is joint work with S. D. Cutkosky and O. Kashcheyeva. (Received August 25, 2009)

1051-13-204 **Liana M Sega*** (segal@umkc.edu) and **Ines Henriques**. *Free resolutions over small Gorenstein rings.*

We show that generic Gorenstein algebras R of socle degree 4 have a remarkable property: every finitely generated R-module has a syzygy which is Koszul, that is, the associated graded module (with respect to the maximal ideal) has a linear resolution. In particular, every finitely generated R-module has a rational Poincaré series. (Received August 25, 2009)

1051-13-205 **Meri T Hughes*** (mhughes@umhb.edu), 900 College Street, Belton, TX 76513. *Examining Uniqueness of Minimal Acyclic Complexes from a "Push-Forward" Perspective.*

We discuss conditions for uniqueness among minimal acyclic complexes of finitely generated free modules over a commutative local ring which share a common syzygy module. Although such uniqueness exists over Gorenstein rings, the question has been asked whether two minimal acyclic complexes in general can be isomorphic to the left and non-isomorphic to the right. We examine the possibility of this occurrence from a "push-forward" perspective, that is, given the common syzygy module, determine all possibilities (up to isomorphism) for the next module in the complex. The focus is on rings with radical cube zero. In particular, we investigate the question for graded algebras with a certain Hilbert series, and such monomial algebras possessing a special generator. (Received August 25, 2009)

1051-13-208 **Luchezar L. Avramov** (avramov@math.unl.edu), Department of Mathematics, 203 Avery Hall, PO Box 880130, Lincoln, NE 68588–0130, and **W. Frank Moore*** (frankmoore@math.cornell.edu), Department of Mathematics, 587 Malott Hall, Ithaca, NY 14853-4201. *Cohomology of Connected Sums of Local Rings.*

Given homomorphisms of rings $\varepsilon_S\colon S \to k \leftarrow T : \varepsilon_T$, and ideals in S and T that carry compatible structures of k-bimodules, we note that one can form a *connected sum* ring $S\#T$ by mimicking the standard construction of connected sum of manifolds in algebraic topology. We study homological properties of the ring obtained by choosing ε_S and ε_T to be the canonical homomorphisms of commutative noetherian local rings onto a common residue field k, and isomorphic k-vector subspaces J in their socles. When the homomorphisms $S \to S/J$ and $T \to T/J$ are Golod, we express the graded Hopf algebra $\operatorname{Ext}^*_{S\#T}(k,k)$ as a coproduct of $\operatorname{Ext}^*_S(k,k)$ and $\operatorname{Ext}^*_T(k,k)$ over the tensor algebra of the vector space $\operatorname{Hom}_k(J,k)$, concentrated in degree 2. (Received August 25, 2009)

1051-13-215 **Javid Validashti*** (jvalidas@math.ku.edu), Department of Mathematics, 405 Snow Hall, The University of Kansas, 1460 Jayhawk Blvd., Lawrence, KS 66044. *Relative multiplicities of graded algebras.*

We introduce a sequence of relative multiplicities for a pair $A \subset B$ of standard graded Noetherian algebras over a Noetherian local ring R. These numbers agree with the sequence of relative multiplicities of Simis, Ulrich and Vasconcelos when B_1/A_1 has finite length over R, and unify them with other notions of multiplicity defined by Achilles and Manaresi. We show that our sequence of multiplicities can be used to give numerical criteria for integrality and birationality of the extension $A \subset B$ without any finiteness condition. We also discuss a combinatorial interpretation of these multiplicities for when A and B are arising from Rees algebras of monomial ideals. (Received August 25, 2009)

1051-13-217 **Melissa Lindsey*** (lindsey9@math.purdue.edu), Purdue University, Department of Mathematics, 150 N. University Street, West Lafayette, IN 47907-2067. *A Class of Hilbert Series and the Strong Lefschetz Property.*

Let k be a field of characteristic zero, and let $R = k[x_1, \ldots, x_n]$ be a standard graded polynomial ring in n variables over k. We determine the class of Hilbert series $\mathcal{H}$ so that if M is a finitely generated zero-dimensional R-graded module with the strong Lefschetz property, then $M \otimes_k k[y]/(y^m)$ has the strong Lefschetz property for y an indeterminate and all positive integers m if and only if the Hilbert series of M is in $\mathcal{H}$. For $l \in R_1$ a strong Lefschetz element for M, we determine the structure of $M \otimes_k k[y]/(y^m)$ as a graded $k[l,y]$-module for it to also have the strong Lefschetz property for y an indeterminate and all positive integers m. (Received August 25, 2009)

1051-13-233 **Anders J. Frankild**, **Sean Sather-Wagstaff** and **Amelia Taylor*** (amelia.taylor@coloradocollege.edu), Department of Mathematics, Colorado College, 14 E. Cache la Poudre St., Colorado Springs, CO 80903. *Vanishing of Ext and Reflexivity.*

I will discuss a natural generalization of a question posed by Avramov, Buchweitz and Sega, that is: Given two semidualizing complexes B and C over a commutative Noetherian ring R does the vanishing of $\operatorname{Ext}^n_R(B,C)$ for $n \gg 0$ imply B is C-reflexive? The investigation of this question leads to a natural equivalence relation on the set of (isomorphism classes of) semidualizing complexes. I will describe some aspects of this relation. I will also discuss some results related to the core question, including some special cases. (Received August 25, 2009)

1051-13-249 **Bonnie B. Smith*** (bsmith17@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556. *The Core of Strongly Stable Ideals.* Preliminary report.

The core of an ideal I is the intersection of all ideals contained in I having the same integral closure as I. The core is an important object in commutative algebra with a close connection to adjoint (multiplier) ideals. I will compute the core of an interesting class of ideals which arises in graph theory. (Received August 25, 2009)

1051-13-252 **Hamid Rahmati***, Texas Tech University, Department of Mathematics and Statistic, Lubbock, TX 79409, and **Frank Moore**. *Standard systems of parameters and rings with finite local cohomology.* Preliminary report.

Let $(R,\mathfrak{m})$ be a local commutative noetherian ring. It is known that the local cohomology modules $\mathrm{H}^i_{\mathfrak{m}}(R)$, for $i < \dim R$, are finitely generated if and only if there exists an integer n such that every system of parameters $\underline{x} = x_1, \ldots, x_d$ in $\mathfrak{m}^n$ is standard, that is to say $\underline{x}$ satisfies

$$(\underline{x})\,\mathrm{H}^i_{\mathfrak{m}}(R/(x_1,\ldots,x_j)) = 0$$

for all non-negative integers i,j with $i+j<d$. We give an upper bound for the smallest n with this property. (Received August 25, 2009)

1051-13-265 **Kristen A. Beck*** (kbeck@uta.edu), The University of Texas at Arlington, Department of Mathematics, Box 19408, Arlington, TX 76019, and **David A. Jorgensen**. *On the Existence of Totally Reflexive Modules.* Preliminary report.

Totally reflexive modules form a tool of homological algebra which can be easily defined and understood in terms of totally acyclic complexes. Such modules generalize projective modules in much the same way that projective modules generalize free modules. Moreover, totally reflexive modules are the building blocks of Gorenstein resolutions and are fundamental in the theory and construction of Tate cohomology. The big question concerning these modules regards the necessary conditions for their non-trivial existence. In this talk, after discussing preliminary concepts and definitions, we will focus on investigating local rings over which non-trivial totally reflexive modules exist. In particular, it is well-known that non-regular Gorenstein rings admit such modules, as do rings with embedded deformations. We shall construct a new class of rings which generalizes these known results, and will also consider several illustrative examples. (Received August 26, 2009)

14 ► Algebraic geometry

1051-14-26 **Veniamin Kisunko*** (vkisunko@math.toronto.edu). *The Converse of Abel's theorem.* Preliminary report.

I investigate an algebraization problem. The analogous problems were raised by Lie and Darboux in connection with the classification of surfaces of double translation;by Poincare and Mumford in connection with the Schottky problem;by Griffiths and Henkin in connection with a converse of Abel's theorem;by Bol and Akivis in the connection with the algebraization problem in the theory of webs. Interestingly, the complex-analytic technique developed by Griftiths and Henkin for the holomorphic case failed to work in the real smooth setting.

I develop a technique of,what I call,complex moments.Together with a differentiation rule it provides a unified approach to all the algebraization problems considered so far (both complex-analytic and real smooth). As a result I prove two variants ('polynomial' and 'rational') of a converse of Abel's theorem which significantly generalize results of Griffiths and Henkin. Already the 'polynomial' case is nontrivial leading to a new relation between the algebraization problem in the theory of webs and the converse of Abel's theorem. (Received July 23, 2009)

1051-14-30 **Elizabeth Allman**, **Sonja Petrovic**, **John Rhodes** and **Seth Sullivant*** (smsulli2@ncsu.edu). *Identifiability of phylogenetic mixture models.*

A statistical model is generically identifiable if the map from parameters to probability distributions is generically one-to-one. We show that tree parameters of two tree phylogenetic mixture models are generically identifiable for the Jukes-Cantor and Kimura 2 parameter models and verify computationally that the stochastic parameters are identifiable. These provide the first positive results on identifiability of phylogenetic mixture models with different trees. Proofs rely on a combination of algebraic geometry and combinatorics.

I will spend most of the talk explaining the background of phylogenetic models, mixture models, identifiability problems, etc. Then I will try to highlight some algebraic surprises that arise in the proofs. (Received July 24, 2009)

1051-14-36 **J. Felipe Voloch*** (voloch@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *Factoring polynomials and an algebraic surface cryptosystem.* Preliminary report.

We discuss a possible attack on an algebraic surface cryptosystem proposed by Akiyama, Goto and Miyake, which depends on factoring in the coordinate ring of an affine surface. (Received July 28, 2009)

1051-14-50 **Chris Hillar**, **Luis García-Puente**, **Abraham Martín del Campo**, **James Ruffo**, **Stephen L. Johnson** and **Zach Teitler*** (zteitler@tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843, and **Frank Sottile**. *Experimentation at the Frontiers of Reality in Schubert Calculus.*

We describe the setup, design, and running of an experiment utilizing a supercomputer that is helping to formulate and test conjectures in the real Schubert calculus. Largely using machines in instructional computer labs during off-hours and University breaks, it has consumed in excess of 350 GigaHertz-years of computing in its first six months of operation, solving over 1.1 billion polynomial systems. This experiment can serve as a model for other large scale mathematical investigations. (Received August 05, 2009)

1051-14-56 **Leonardo C Mihalcea*** (Leonardo_Mihalcea@baylor.edu), Dept. of Mathematics, Baylor University, Waco, TX 76798, and **Anders Buch**. *Geometric properties of Gromov-Witten varieties for homogeneous spaces.*

If X is a generalized flag manifold, the Gromov-Witten variety is the space of all rational curves of fixed degree in X, passing through a fixed number of Schubert varieties, and compactified appropriately. In this talk I will discuss some geometric properties of these varieties, such as their singularities, and few instances when they are rationally connected. (Received August 09, 2009)

1051-14-81 **J. Maurice Rojas*** (rojas@math.tamu.edu), TAMU 3368, Math Department, Texas A&M University, College Station, TX 77843-3368. *Chamber Cones and Faster Real Solution Counting.*

The Chamber Cone method is a powerful technique that, among other uses, allows one to quickly count the number of real solutions of certain sparse polynomial systems. To illustrate our method, we focus on tetranomials of high degree, and a new extremal 2x2 system. Cute discriminant animations will be shown, along with new explicit complexity bounds. Parts of this work were derived in collaboration with Martin Avendano, Joel Gomez, Andrew Niles, and Korben Rusek. (Received August 14, 2009)

1051-14-92 **Elena S Dimitrova*** (edimit@clemson.edu), 0-303 Martin Hall, Clemson University, Clemson, SC 29634-0975, and **Abdul S Jarrah** (ajarrah@vbi.vt.edu), Virginia Bioinformatics Institute, Washington Street (0477), Virginia Tech, Blacksburg, VA 24061. *Probabilistic dynamical systems for reverse engineering of the yeast cell cycle network.*

We introduce probabilistic polynomial systems (PPS) for the reverse engineering of gene regulatory networks from data that are discretized into a finite number of expression levels. A PPS is a function-stochastic system over a finite field whose functions are polynomials. Given a data set of discretized time series, we present a method for generating a PPS model that contains all minimal data-fitting polynomials and for determining their chance of being selected to participate in the system evolution. We use the method to model the yeast cell-cycle network which is known to have a stochastic nature. (Received August 17, 2009)

1051-14-93 **Hirotachi Abo*** (abo@uidaho.edu), 300 Brink Hall, Department of Mathematics, University of Idaho, Moscow, ID 83844. *Secant varieties to tangential varieties of cubic Veronese embedding.*

The past several decades have seen an interest in secant varieties cross an ever widening collection of desciplines including algebraic complexity theory, algebraic statistics, interpolation as well as algebraic geometry.

A well known classification of defective secant varieties of Veronese varieties has been completed in a series of papers by Alexander and Hirschowitz. There is a conjecturally completed list of defective secant varieties to tangential varieties of Veronese varieties suggested by Geramita, Catalisano and Gimigliano.

In this talk, I will discuss an inductive approach to establish the existence of large classes of non-defective secant varieties to tangential varieties of cubicc Veronese embeddings. This approach was inspired by the work of Brambilla and Ottaviani. (Received August 17, 2009)

1051-14-95 **Ivan Soprunov*** (i.soprunov@csuohio.edu), 2121 Euclid Ave, Cleveland, OH 44115, and **Jenya Soprunova** (soprunova@math.kent.edu). *On higher dimensional toric codes.* Preliminary report.

Fix a convex lattice polytope P in $\mathbb{R}^n$ and consider a projective toric variety X_P over a finite field $\mathbb{F}_q$, together with an ample line bundle L_P on X_P. A *toric code* is defined by evaluating global sections of L_P over $\mathbb{F}_q$ at the points of the finite torus $(\mathbb{F}_q^*)^n$. It is a fundamental question to compute or give bounds for the minimum distance of toric codes, which was studied by Hansen, Joyner, Little and Schenck, and others.

In this talk I will show a strong connection between the minimum distance of a toric code and the geometry of the lattice polytope P. In particular, I will show that the minimum distance is multiplicative with respect to taking the product of polytopes, and behaves in a simple way when one builds a k-dilate of a pyramid over a polytope. This allowed us to construct a new large class of examples of higher dimensional toric codes where we can write an explicit formula for the minimum distance. (Received August 18, 2009)

1051-14-133 **Dan Bates*** (bates@math.colostate.edu), 101 Weber Building, Department of Mathematics, Colorado State University, Fort Collins, CO 80523, and **Frank Sottile**. *Khovanskii-Rolle continuation for real solutions of polynomial systems.*

Modern homotopy continuation methods provide an efficient and reliable means for collecting information about the *complex* solutions of a polynomial system. However, to find only the *real* solutions (those of most

interest to scientists and engineers), the only option is to first find all complex solutions and then filter out those with nonzero imaginary part (where "zero" is some user-defined tolerance, which may lead to errors).

There is a new numerical method - Khovanskii-Rolle continuation - which will find only the real solutions. The complexity of this method relies on the number of real solutions rather than the number of complex solutions. The method relies on Gale duality (a transformation between a polynomial system and an equivalent system of master functions on the complement of a hyperplane arrangement) and Khovanskii's generalization of Rolle's Theorem. This talk will illustrate these concepts and the new method on appropriate examples. This is joint work with Frank Sottile. (Received August 21, 2009)

1051-14-162 **Weronika J Buczynska*** (nisiabu@math.tamu.edu). *Toric models of graphs.*

The binary symmetric Markov statistical model of evolution on a trivalent tree is a projective toric variety, naturally defined in terms of the semigroup of networks of paths on the tree. This semigroup may be defined for any trivalent graph, and we call the associated toric variety the toric model of that graph. I will explain this background, establish the basic properties of the models and present our main result, that models of graphs with the same numbers of leaves and cycles are deformation equivalent. (Received August 24, 2009)

1051-14-198 **Anton Leykin***, leykin@math.gatech.edu. *Numerical Algebraic Geometry for Macaulay 2.* Preliminary report.

This long-term software project aims at implementing algorithms of numerical algebraic geometry in the computer algebra system Macaulay 2. We report on the progress in the beginning stage of the project: the performance of the current implementation of basic polynomial homotopy continuation routines is compared to that of the other software systems.

The routines used in the existing software are driven by heuristics and do not rigorously certify the correctness of homotopy path tracking. We provide a certification method and discuss the trade-offs in performance associated to implementing fully certified numerical algorithms. (Received August 25, 2009)

1051-14-210 **Chris Peterson***, 101 Weber Building, Colorado State University, Fort Collins, CO 80523-1874. *Numerical computation of the Jordan Canonical Form of a matrix via algebraic geometry.*

This talk will outline a procedure for numerically computing the Jordan Canonical Form of a matrix. A key step in stabilizing the numerical portion of the algorithm is to utilize ideas from algebraic geometry. Another important feature is to apply homotopy continuation in the vector space of sections of the tangent bundle to projective space in order to minimize the number of paths that are tracked. (Received August 25, 2009)

1051-14-270 **Sean Dodd Lawton*** (lawtonsd@utpa.edu), Department of Mathematics, The University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539, and **Carlos Florentino** (cfloren@math.ist.utl.pt), Lisboa, Portugal. *Singularities of free group character varieties.* Preliminary report.

Let $\mathfrak{X}_r$ be the moduli of $\mathrm{SL}(n,\mathbb{C})$, $\mathrm{SU}(n)$, $\mathrm{GL}(n,\mathbb{C})$, or $\mathrm{U}(n)$ valued representations of a rank r free group. We classify the singular stratification of $\mathfrak{X}_r$. This comes down to showing that the singular locus corresponds exactly to reducible representations if there exist singularities at all. Additionally, we show that the moduli $\mathfrak{X}_r$ are generally not topological manifolds, except for a few examples we explicitly describe. (Received August 26, 2009)

15 ► Linear and multilinear algebra; matrix theory

1051-15-134 **Laurene V Fausett*** (Laurene_Fausett@TAMU-Commerce.edu), Texas A&M University-Commerce, Department of Mathematics, Commerce, TX 75429-3011. *Characteristics of Certain Block Matrices with Nilpotent Components.*

Matrices with special block structure are important in a number of settings. In this talk, we consider a problem which arises in digital signal filtering. In order to optimize a cost function, it is necessary to be able to construct a matrix P such that the block matrix of the form $T = [P, JNJP, JN^2JP]$ is invertible, for a given nilpotent matrix N (in Jordan form); J is the counter-identity matrix. An algorithm is presented for construction of a sparse, binary matrix P; more general forms of P can also be formed in a similar manner. Several related problems are also considered. (Received August 21, 2009)

16 ► Associative rings and algebras

1051-16-177 **Zajj B Daugherty*** (daughert@math.wisc.edu), Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706. *Building two boundary diagram algebras.* Preliminary report.

We study families of algebras that arise as algebras of commuting operators for the action of a finite dimensional complex reductive Lie algebra on a tensor space of the form $M \otimes N \otimes V^{\otimes k}$. This work uses similar techniques employed in the study of graded Hecke and Brauer algebras as centralizer algebras to construct two boundary analogs. In this talk, we outline this construction and explore some of the elegant combinatorial properties of the representation theory of specific examples. (Received August 24, 2009)

1051-16-271 **Yevgenia Kashina**, **Susan Montgomery** and **Siu-Hung Ng***, Iowa State University, Ames, IA 50014. *On some gauge invariants of Hopf algebras.*

Frobenius-Schur indicators of the representations of a finite group have been studied for more than a century. The notion has been recently generalized to pivotal categories and these indicators are invariants of pivotal categories. However, the representation category of a finite-dimensional Hopf algebra is not necessarily pivotal. In this talk, we introduce some gauge invariants for each finite-dimensional Hopf algebra H, and we show that these invariants coincide with the Frobenius-Schur indicators of the regular representation when H is a semisimple complex Hopf algebra. As an application, we demonstrate the inequivalence of the Taft algebras by computing these gauge invariants.

Part of this talk is based on joint work with Y. Kashina and S. Montgomery. (Received August 26, 2009)

17 ► Nonassociative rings and algebras

1051-17-41 **Charles H Conley*** (conley@unt.edu), Department of Mathematics, Denton, TX 76203. *Modules of differential operators for vector field Lie algebras.*

The Lie algebra $\mathrm{Vec}(\mathbb{R}^m)$ of vector fields on Euclidean space contains the projective Lie algebra $\mathfrak{sl}(m+1)$ as a maximal subalgebra. The space of differential operators on $\mathbb{R}^m$ is naturally a module under $\mathrm{Vec}(\mathbb{R}^m)$. In this talk we will discuss the decomposition of this module under the projective subalgebra, and the use of this decomposition in analyzing the action of $\mathrm{Vec}(\mathbb{R}^m)$. We will also mention some generalizations: the module of differential operators can be generalized to modules of differential operators between arbitrary tensor field modules, and in odd dimensions, $\mathrm{Vec}(\mathbb{R}^m)$ can be replaced by the Lie algebra of contact vector fields, in which case the projective subalgebra is replaced by the conformal subalgebra, a copy of $\mathfrak{sp}(m+1)$. (Received August 03, 2009)

1051-17-97 **Nathan Geer**, Dept. of Mathematics, Utah State University, Logan, UT 84322, **Jonathan Kujawa***, Dept. of Mathematics, University of Oklahoma, Norman, OK 73019, and **Bertrand Patureau-Mirand**, Dept. of Mathematics, Université de Bretagne-Sud, Vann, France. *Generalized Trace and Dimension Functions in Ribbon Categories.*

Ribbon categories are ubiquitous in representation theory. They appear as the finite dimensional representations of groups, Lie (super)algebras, and quantum (super)groups. An essential tool in studying these categories is the trace of an endomorphism and the dimension of object. Using low dimensional topology we generalize these notions and prove that these functions provide new insights into representation theory. (Received August 18, 2009)

1051-17-192 **W. Andrew Pruett*** (drew_pruett@baylor.edu), 2114 Rawhide Trail, Temple, TX 76502, and **Markus Hunziker** (markus_hunziker@baylor.edu), Baylor University, Waco, TX 76702. *Applications of generalized Young diagrams for Hermitian symmetric spaces.*

Using a generalization of Young diagrams, we give a unified description of the BGG resolutions of unitary highest weight modules. These diagrams also give a uniform closed form construction of R-polynomials, allowing a proof of combinatorial invariance in the Hermitian symmetric case. (Received August 24, 2009)

1051-17-199 **Elena Poletaeva*** (elenap@utpa.edu), Department of Mathematics, University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539. *On realizations of Lie superalgebras in matrices over a Weyl algebra.*

Superconformal algebras are superextensions of the Virasoro algebra. They are spanned by a number of fields, one of which is the Virasoro field. The $N = 2$ superconformal algebra, the big $N = 4$ superconformal algebra and the $N = 6$ superconformal algebra are spanned by 4, 16 and 32 fields, respectively. We obtain realizations of these Lie superalgebras in matrices of size 2, 4 and 8 over a Weyl algebra, which is generated by Laurent

polynomials and a derivation d. These matrix realizations are closely connected with spin representations of the orthogonal Lie algebras.

$D(2,1;\alpha)$ is a family of classical simple Lie superalgebras of dimension 17. It is related to the big $N = 4$ superconformal algebra. We also obtain realization of this family in matrices of size 4 over a Weyl algebra. (Received August 25, 2009)

18 ► Category theory; homological algebra

1051-18-13 **Zhenghan Wang*** (zhenghwa@microsoft.com), Microsoft Station Q, CNSI Rm 2237, UC Santa Barbara, Santa Barbara, CA 93106. *AMC on a TV.* Preliminary report.

We will discuss arithmetic varieties of pentagon solutions of tensor categories. This is an on-going project with Orit Davidovich of UT Austin and Tobias Hagge of UT Dallas. (Received May 29, 2009)

1051-18-61 **Deepak Naidu**, **Dmitri Nikshych** and **Sarah Witherspoon*** (sjw@math.tamu.edu). *Fusion subcategories of Rep(D(G)).*

We describe all fusion subcategories of the representation category of the (twisted) Drinfeld double of a finite group G in terms of group-theoretical data: They are indexed by normal subgroups and bicharacters satisfying certain conditions. As a consequence we obtain a description of all group-theoretical braided fusion categories. (Received August 11, 2009)

1051-18-80 **Jonny Comes*** (jcomes@uoregon.edu). *Blocks in Deligne's Rep(S_t).*

Recently Deligne introduced the tensor category $Rep(S_t)$ where t is not necessarily an integer. When t is not a nonnegative integer, $Rep(S_t)$ is a semisimple category. When t is a nonnegative integer, $Rep(S_t)$ is a non-semisimple category which "interpolates" representations of the symmetric group S_t. In this talk I will define the category $Rep(S_t)$ for arbitrary t, and describe the blocks of $Rep(S_t)$ in the non-semisimple cases. (Received August 14, 2009)

1051-18-100 **David A. Jordan*** (djordan@math.mit.edu), Department of Mathematics, MIT, Bldg 2 Rm 2-236, Cambridge, MA 02139, and **Eric Larson**. *Fusion categories of dimension pq^2, and $\mathbb{Z}/3\mathbb{Z}$-graded Tambara-Yamagami categories.*

We completely classify fusion categories of dimension pq^2; in particular, we construct new examples of integral, non-group theoretical fusion categories of dimension pq^2. We also classify $\mathbb{Z}/3\mathbb{Z}$-graded Tambara-Yamagami categories. Our results are based on recent work of Etingof, Nikshych, and Ostrik on extensions of fusion categories. (Received August 18, 2009)

1051-18-150 **Orit Davidovich*** (odavidovich@math.utexas.edu). *Modular Categories and Galois Twists.*

In joint work with Zhenghan Wang (Microsoft) and Tobias Hagge (UT Dallas) we prove that any modular category defined over the complex numbers is a scalar extension of a modular category defined over a number field. One can use this claim to twist a given modular category by means of a Galois automorphism as a way of producing a new modular category from an old one, while keeping the Grothendieck ring fixed. Modular categories from quantum groups at roots of unity of fixed degree are related to one another by such twists. One hopes that the Galois group action will give new insight into the classification of modular categories. (Received August 23, 2009)

1051-18-174 **Scott Morrison*** (scott@tqft.net) and **Noah Snyder**. *Small fusion categories and subfactors II.* Preliminary report.

As explained in the previous talk there is a correspondence between unitary fusion categories and finite depth subfactors. Under this correspondence objects of small dimension correspond to subfactors of small index. In this talk we summarize previous work on subfactors of small index, explain some new results, and give a peek at work in progress. In particular, we sketch a program which should show that the smallest possible dimension bigger than 2 for an object in a unitary fusion category is $\sqrt{\frac{5}{2} + \frac{\sqrt{21}}{2}}$.

This is joint work with Emily Peters, and some of our results are also joint with Stephen Bigelow and Vaughan Jones. (Received August 24, 2009)

1051-18-176 **Noah Snyder*** (nsnyder@gmail.com) and **Scott Morrison**. *Small fusion categories and subfactors I.* Preliminary report.

One goal in studying fusion categories is to classify all "small fusion categories." This problem comes in many flavors depending on what definition of "small" you use. Unitary fusion categories are intimately related to finite depth subfactors. Certain definitions of "size" for fusion categories match up with already studied questions in Subfactor theory. The end goal of these talks is to try to answer the following question "What is the smallest possible dimension bigger than 2 for an object in a unitary fusion category." (Received August 24, 2009)

1051-18-182 **Jesse Liptrap*** (jliptrap@math.ucsb.edu), Mathematics Department, University of California, Santa Barbara, CA 93106. *Enriched Fusion Categories.* Preliminary report.

We completely describe fusion categories of nilpotence class two and universal grading group of order two, generalizing a theorem of Tambara and Yamagami. As a special case, we find no fusion category with the fermionic Moore-Read fusion rule. Therefore the notion of a fusion category must be generalized in order to model fractional quantum Hall quasiparticles. To that end, we introduce the notion of an enriched fusion category. (Received August 24, 2009)

1051-18-268 **Spencer Stirling*** (stirling@spencerstirling.com). *Quantum information flow in Braided Categorical Quantum Mechanics.*

Over the past decade Categorical Quantum Mechanics has emerged from the efforts of Abramsky, Coecke, Selinger, Duncan, and others. The motivation is to unify von Neumann's axioms for quantum mechanics together with quantum information processes (e.g. teleportation, entanglement swapping) under a higher-level categorical framework.

In this talk I will discuss aspects of a generalization to braided sytems that I and Yong-Shi Wu have been studying. (Received August 26, 2009)

20 ► Group theory and generalizations

1051-20-142 **Pramod N Achar*** (pramod@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Andersen-Jantzen sheaves and the affine Grassmannian.* Preliminary report.

An Andersen-Jantzen sheaf is a coherent sheaf on the nilpotent cone arising as the push-forward of a dominant line bundle on the cotangent bundle of the flag variety. In this talk, I will explain how to use the geometric Satake equivalence to compute the Ext-algebra of an Andersen-Jantzen sheaf in terms of the cohomology of an orbit in the dual affine Grassmannian. (Received August 22, 2009)

1051-20-143 **Victor Ostrik*** (vostrik@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Weakly group theoretical fusion categories.*

I will report on a joint work with P.Etingof and D.Nikshych. Weakly group theoretical fusion categories form a large class of weakly integral fusion categories which contains all known examples. In principle the categories from this class can be classified in group theoretical terms. Our main result is that categories of dimension $p^a q^b$ (where p, q are primes, and a, b are integers) are weakly group theoretical. (Received August 22, 2009)

1051-20-159 **Martin Malandro*** (malandro@shsu.edu), Box 2206, Sam Houston State University, Huntsville, TX 77341-2206. *Inverse semigroup Fourier analysis for partially ranked data.* Preliminary report.

The symmetric group is the group of all $n \times n$ matrices with exactly one 1 in every row and every column. The rook monoid is the monoid of all $n \times n$ matrices with *at most* one 1 in every row and every column. In 1989 Persi Diaconis gave an application of Fourier analysis on the symmetric group to the statistical analysis of partially ranked and fully ranked voting data.

We review these notions and extend them to the rook monoid. We explore applications of Fourier analysis on the rook monoid to the analysis of partially ranked data, and we point out the similarities and differences between our approach and Diaconis's. (Received August 23, 2009)

22 ► Topological groups, Lie groups

1051-22-38 **Floyd L. Williams*** (williams@math.umass.edu), University of Massachusetts, Department of Mathematics, 710 North Plesant Street, Amherst, MA 01003-9305. *Casimir energy and local zeta function for higher rank symmetric spaces.* Preliminary report.

The calculation of Casimir energy for massless scalar fields on compact space forms of a non-compact,rank 1 symmetric space X has been carried out in full generality with the help of the Selberg trace formula.In joint work with Tomas Godoy and Roberto Miatello we consider the problem of carrying out this calculation when the rank of X exceeds 1,the initial step being a careful analysis of the local zeta function attached to X.We focus,for example,on X whose group of isometries is SL(3,R) or SU(2,2)-two cases of immediate physical interest. (Received July 29, 2009)

1051-22-65 **Hongyu He*** (hongyu@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **Huajun Huang** (huanghu@auburn.edu), Department of Math, Auburn University, Auburn, AL. *Symmetric Subgroup Action on Isotropic Grassmanian.*

Functions on Isotropic Grassmanian can be used to construct the degenerate principal series. In this talk, I will discuss the action of a symmetric subgroup on the isotropic Grassmanian. There are finite number of orbits, parametrized by Matsuki-Springer. We will classify the structure of each orbit and determine the open orbits. (Received August 11, 2009)

1051-22-145 **Jared L. Culbertson*** (jared@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Perverse Poisson sheaves on the nilpotent cone.*

If G is a complex reductive algebraic group with Lie algebra $\mathfrak{g}$, then the nilpotent cone $\mathcal{N} \subset \mathfrak{g}^*$ admits a Poisson stratification which coincides with the stratification by coadjoint orbits. We exploit this connection to study the (G-equivariant) perverse coherent sheaves of Bezrukavnikov-Deligne. Specifically, we develop a basic theory of the Poisson derived category including the perverse Poisson t-structure. It is then possible to relate the resulting perverse Poisson sheaves to perverse coherent sheaves. (Received August 22, 2009)

1051-22-183 **Mark Colarusso*** (mcolarus@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556-4618, and **Sam Evens** (sevens@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556-4618. *Algebraic integrability of the Gelfand-Zeitlin system on* $\mathfrak{gl}(n, \mathbb{C})$.

The Gelfand-Zeitlin integrable system on $\mathfrak{gl}(n, \mathbb{C})$ was constructed by Kostant and Wallach. They showed that it integrates to an action of a complex Lie group $A \cong \mathbb{C}^{\frac{n(n-1)}{2}}$ on $\mathfrak{gl}(n, \mathbb{C})$. Orbits of the group A of maximal dimension $\frac{n(n-1)}{2}$ form the leaves of a polarization of an open, dense subvariety of a regular adjoint orbit. We call an element of $\mathfrak{gl}(n, \mathbb{C})$ *strongly regular* if its orbit under the action of A is $\frac{n(n-1)}{2}$ -dimensional. In this talk, we discuss joint work with Sam Evens in which we extend a result of Kostant and Wallach concerning the algebraic integrability of the Gelfand-Zeitlin system to the full locus of strongly regular elements. We use decomposition classes to stratify the strongly regular set by smooth subvarieties. For each stratum we construct an étale covering and use Poisson geometry to lift the Hamiltonian vector fields of the Gelfand-Zeitlin system to the covering and integrate them to an action of a connected, commutative algebraic group. (Received August 24, 2009)

1051-22-220 **William Graham*** (wag@math.uga.edu) and **Roger Zierau**. *Smooth components of Springer fibers.*

We study components of Springer fibers for $GL(n)$ that are associated to closed orbits of $GL(p) \times GL(q)$ on the flag variety of $GL(n)$, $n = p+q$. These components occur in any Springer fiber. We show that, in contrast to the case for arbitrary components, these components are smooth varieties, and are invariant under a maximal torus of $GL(n)$. This is done by using results of Barchini and Zierau to give a precise description of these components as iterated bundles. (Received August 25, 2009)

1051-22-247 **Jennifer Daniel*** (jennifer.daniel@lamar.edu) and **Daniel Gagliardi**. *Weight lattices of real reductive symmetric spaces.*

The fine structure of a local real reductive symmetric space can be realized as a complex reductive Lie algebra with a pair of commuting involutions. In this paper, we explore the relationship between the weight space of the symmetric space and projected weight space of the associated Lie algebra. For each case, we show that these two spaces are equal and provide formulas for the weights of each in terms of the other. (Received August 25, 2009)

1051-22-269 **Leticia I Barchini*** (leticia@math.okstate.edu), 403 Mathematical Sciences, Stillwater, OK 74078. *On the geometry of certain components of the Springer Fiber.* Preliminary report.

We assume that G is a complex classical group with real form G_o and fix a Cartan involution θ. The variety $\mathcal{B}$ of Borel subalgebras in $\mathfrak{g}$ is acted upon by G^θ with orbits $\{Z_i\}$. Let $\mu : T^*(\mathcal{B}) \to \mathcal{N}^*$ denote the moment map. The fiber, $\mu^{-1}(\xi)$, at a point $\xi \in \mathcal{N}^*$ is known as the Springer fiber.

For each Z_i, we write $T^*_{Z_i}(\mathcal{B}) \subset T^*(\mathcal{B})$ for the conormal bundle to Z_i. It is known that $\mu(\overline{T^*_{Z_i}(\mathcal{B})})$ is the closure of a nilpotent K-orbit, $\mathcal{O}$. When a K-orbit Z is associated to a nilpotent orbit $\mathcal{O}$, the intersection $\mu^{-1}(\xi) \cap T^*_Z(\mathcal{B})$ is dense in a unique irreducible component of the Springer fiber.

In this talk we discuss $\mu^{-1}(\xi) \cap T^*_Z(\mathcal{B})$ for a class or orbits Z. (Received August 26, 2009)

30 ► Functions of a complex variable

1051-30-76 **C. David Minda*** (minda@ucmail.uc.edu), Department of Mathematical Sciences, Mail Location 0025, University of Cincinnati, Cincinnati, OH 45221-0025. *Hyperbolic distortion for holomorphic maps.*

Suppose Ω_j is a hyperbolic region in the complex plane $\mathbb{C}$ with hyperbolic metric $\lambda_j(z)|dz|$ and associated hyperbolic distance function $h_j(z, w)$, $j = 1, 2$. Let $\mathcal{H} = \mathcal{H}(\Omega_1, \Omega_2)$ be the family of holomorphic maps $f : \Omega_1 \to \Omega_2$. Various distortion theorems for functions $f \in \mathcal{H}$ will be discussed. The distortion is measured in terms of the hyperbolic metrics or the hyperbolic distances on the domain and range. (Received August 13, 2009)

1051-30-86 **Tadeusz Iwaniec**, **Leonid V. Kovalev*** (lvkovale@syr.edu) and **Jani Onninen**. *The Nitsche conjecture.*

In 1962 J.C.C. Nitsche raised the question of the existence of a harmonic homeomorphism between circular annuli $\{z \in \mathbb{C} : r < |z| < R\}$ and $\{z \in \mathbb{C} : r^* < |z| < R^*\}$. He conjectured that such a mapping exists if and only if $R^*/r^* \geq (R/r + r/R)/2$. I will sketch the proof of this conjecture and discuss related open problems. (Received August 16, 2009)

1051-30-131 **Albert Baernstein II*** (al@math.wustl.edu) and **A. Yu. Solynin**. *Monotonicity and comparison results for conformal invariants.* Preliminary report.

Suppose that Ω is an n-fold symmetric domain in the plane which satisfies a differential inequality $\Delta u \geq \gamma(u) + f$ in Ω. Assume also that u is constant outside Ω. We prove that if γ and f satisfies certain conditions, among them that f be n-fold symmetric, then u is n-fold symmetric. We prove also that if u is desymmetrized in a certain way, then the function thus obtained is majorized by a function v which satisfies $\Delta v \leq \gamma(v) + f_1$, where f_1 is a corresponding desymmetrization of f. These results permit us to solve some extremal problems involving Poincaré metrics, harmonic measure and capacities. (Received August 21, 2009)

1051-30-132 **James T Gill*** (jimtgill79@gmail.com), Department of Mathematics, University of Washington, Seattle, WA 98195. *Some sufficient conditions for obtaining bi-Lipschitz quasiconformal maps.*

Recently a paper by Mateu, Orobitig and Verdera has shown a sufficient condition on the complex dilatation for a quasiconformal map to be bi-Lipschitz. We show a slightly shorter proof of this result, and also discuss the case of domains with corners. This is joint work with Steffen Rohde. (Received August 21, 2009)

1051-30-151 **Zair Ibragimov*** (zibragimov@fullerton.edu), 154 McCarthy Hall, Fullerton, CA 92831. *Hyperbolizing Hyperspaces.*

We construct a Gromov hyperbolic metric space by prescribing any complete metric space with no isolated points as its boundary at infinity. Our construction comes equipped with an extension operator that takes the power quasisymmetries between the boundaries at infinity to the quasiisometries between the spaces. In addition, the extension operator has a desirable property of compatibility under composition. Chordal metrics in arbitrary metric spaces are introduced in order to prescribe unbounded metric spaces as boundaries at infinity. The chordal metrics will also serve as visual metrics on the boundary at infinity. For example, when the Euclidean space $\mathbb{R}^n$ is prescribed, the space we construct is (up to a rough isometry) the hyperbolic space $\mathbb{H}^{n+1}$ and the chordal metric we define coincides with the standard chordal metric on $\mathbb{R}^n \cup \{\infty\}$. As an application we show that the Bearling-Ahlfors extension operator has "rough" composition property. (Received August 23, 2009)

1051-30-165 **Michael Dorff*** (mdorff@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602, and **Magdalena Woloszkiewicz** (magda@math.byu.edu). *Convex combinations of harmonic mappings.*

Complex-valued harmonic mappings can be regarded as generalizations of analytic functions. We are interested in investigating univalent harmonic mappings. These are connected with minimal surfaces in $\mathbb{R}^3$. In this paper, we prove results concerning the univalence of the convex combinations of harmonic mappings. One application of these results offers an easy way to construct harmonic mappings onto nonconvex polygonal domains and to construct the corresponding minimal graphs over these nonconvex domains. This results in the family of the Jenkins-Serre minimal surfaces. (Received August 24, 2009)

1051-30-193 **Nageswari Shanmugalingam*** (nages@math.uc.edu), Department of Mathematical Sciences, P.O.Box 210025, University of Cincinnati, Cincinnati, OH 45221-0025, **Pekka Koskela**, Department of Mathematics and Statistics, P.O.Box 35 (Mattilaniemi D), FI-40014 University of Jyvaskyla, FI-40014 Jyvaskyla, Finland, and **Michele Miranda** (michele.miranda@unife.it), Department of Mathematics, University of Ferrara, Via Machavelli 35, 44100 Ferrara, Italy. *Geometric characterization of planar BV extension domains.*

We will discuss Euclidean domains that are extension domains for functions of bounded variation (BV). A characterization of Burago and Maz'ya of such domains reduces the condition of BV extension domains to extension properties of sets of finite perimeter. In the case that the domain is planar and finitely connected, we give explicit geometric characterization of BV extension property that is much simpler to verify than the condition of Burago-Maz'ya. (Received August 24, 2009)

1051-30-223 **Alexander S Williams*** (alexander.williams@ttu.edu), Department of Mathematics and Statistics, 2500 Broadway St, Lubbock, TX 79409-1042, **Roger W Barnard** (roger.w.barnard@ttu.edu), Department of Mathematics and Statistics, 2500 Broadway St, Lubbock, TX 79409-1042, and **Alexander Yu Solynin** (alex.solynin@ttu.edu), Department of Mathematics and Statistics, 2500 Broadway St, Lubbock, TX 79409-1042. *Some Geometric Properties of Symmetric Lemniscates.*

We consider geometric properties of lemniscates $E(p,c) = \{z \in \mathbb{C} : |p(z)| \leq c\}$ of a complex polynomial $p(z)$ of degree n. The symmetric lemniscates $E(z^n - 1, c)$ are of particular interest. To address a conjecture by G. Piranian, J. Butler derived an explicit analytic representation for the length of symmetric lemniscates and discovered that the length is not monotonic with respect to c. We have derived an analogous analytic representation for the area of symmetric lemniscates and have studied its geometric properties. Using the analytic representations for the length and area of symmetric lemniscates, the isoperimetric quotient and the area-squared inradius quotient in the context of symmetric lemniscates have been investigated as well. (Received August 25, 2009)

1051-30-236 **Eric D Schippers*** (eric_schippers@umanitoba.ca), Department of Mathematics, Machray Hall, 186 Dysart Rd, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada. *Derivative of the Nehari functional.*

Nehari invented a method of producing inequalities in function theory through the use of the Dirichlet principle. In this talk, we focus on the case bounded univalent functions. In one formulation of Nehari's method, given a quadratic differential which is a perfect square, and for which the boundary of the disk is a trajectory, the result is an inequality which is sharp for mappings admissible for this quadratic differential.

We give an expression for the functional derivative of Nehari's functional, using the Loewner method and the power matrix. At an extremal function, the functional derivative has a simple expression in terms of the pull-back of the original quadratic differential. (Received August 25, 2009)

1051-30-248 **Eric M. Murphy*** (Eric.M.Murphy@comcast.net), 804 Hydric Court, Apt 304, Odenton, MD 21113. *Applications of Circle Packing to Civil/Military Force Structures.* Preliminary report.

In this presentation, we develop a new approach for the description and evaluation of military and civil force structures in the context of an uncertain future. This method exploits techniques of random walks, pheromone-driven control theory, and discrete analytic function theory (circle packing) to define a robust sufficiency as the primary measure of merit. This approach has broad application to questions of homeland security and defense, counterinsurgency and other forms of low-intensity conflict, general problems of indications and warning, and conventional major combat operations. While the schema may be generally applied to any force structure

element, we present a brief discussion of Intelligence, Surveillance, and Reconnaissance (ISR) force structures as an illustrative example. (Received August 25, 2009)

32 ► Several complex variables and analytic spaces

1051-32-67 **John A Pfaltzgraff*** (jap@email.unc.edu), 511 Caswell Rd., Chapel Hill, NC 27514.
Loewner theory and Schwarzians in $\mathbb{C}^n$.

The theory of Loewner chains and preSchwarzian univalence criteria were generalized to higher dimensions in 1974-75. The problems of identifying what should play the role of Schwarzian derivative, $(f''(z)/f'(z))' - (1/2)(f''(z)/f'(z))^2$, and constructing appropriate L-chains in higher dimensions proved to be a difficult challenge and remained unsolved.

We now give solutions with the construction of appropriate L-chains for the higher dimensional theory involving Schwarzian invariants with n-Dim versions of the main Schwarzian univalence criteria of Nehari, Ahlfors, Becker, Epstein, etc. (including pi-squared criteria).

The talk will focus on

(i) The new Loewner chains constructed for higher dimensional Schwarzian univalence criteria.

(ii) What are the Schwarzian invariants and how can they be derived with a Cartan matrix tool in projective space? (Received August 12, 2009)

33 ► Special functions

1051-33-52 **Ibrahim A. Salehbhai*** (ibrahimmaths@gmail.com), Department of Mathematics, S.V. National Institute of Technology, Surat-395 007, Surat, 395007, India. *Laguerre Transform in two Variables and its properties.*

Laguerre polynomials play an important role in the field of science, engineering, numerical mathematics, quantum mechanics, communication theory and numerical inverse Laplace transform. Some explicit evaluation of integrals involving Laguerre polynomials are required in applied areas of mathematical and physical sciences. In 1960, Debnath [2] first introduced the Laguerre transform of one variable and its properties; he also discussed its applications in study of heat conduction, diffusion equation and to the oscillations of a very long and heavy chain with variable tension. Debnath et al. [3] reported this work in their book. Recently Shukla et al. [1] introduced Laguerre transform in two variables. Present talk is extension of this paper [1] and some new properties are to be discussed. In the last section we have also examined the MAPLE/MATHEMATICA implementation. [1] A.K. Shukla, I.A. Salehbhai and J.C. Prajapati, On the Laguerre transform in two variables, Integral Transforms and Special Functions, Vol. 20, No. 6, June 2009, 459-470. [2] Debnath, L.: On Laguerre transform, Bull. Cal. Math. Soc., 55 (1960) 69-77. [3] L. Debnath and D. Bhatta, Integral Transforms and their Applications, Chapman & Hall/CRC Press, Boca Raton/London/New York, 2007. (Received August 07, 2009)

1051-33-94 **Atul A Dixit*** (aadixit2@illinois.edu), 1009 W. Clark St, Apt. 101, Urbana, IL 61801. *Transformation formulas associated with integrals involving the Riemann Ξ-function.*

Page 220 of Ramanujan's Lost Notebook contains a beautiful transformation formula involving the digamma function which is also associated with an integral involving the Riemann Ξ-function. Here we discuss some new transformation formulas of this type, of which one generalizes Ramanujan's transformation formula. Also included are new extensions of formulas of N.S. Koshliakov, A.P. Guinand and W.L. Ferrar. (Received August 18, 2009)

1051-33-127 **Bruce C. Berndt*** (berndt@illinois.edu), Dept. of Mathematics, University of Illinois, 1409 West Green St., Urbana, IL 61801, and **Atul Dixit** (aadixit2@illinois.edu), Dept. of Mathematics, University of Illinois, 1409 West Green St., Urbana, IL 61801. *A Transformation Formula Involving the Gamma and Riemann Zeta Functions Found in Ramanujan's Lost Notebook.*

Published with Ramanujan's lost notebook are several partial manuscripts by Ramanujan that were copied by G. N. Watson; the original manuscripts in Ramanujan's handwriting have evidently been lost. One of these, on Fourier and Laplace transforms, features a beautiful transformation formula involving the logarithmic derivative of the Gamma function and the Riemann zeta function, or, more precisely, Riemann's Ξ-function. We describe the interesting features and history of this transformation formula and sketch two proofs of it due to the speaker and Atul Dixit. (Received August 21, 2009)

1051-33-211 **R Barnard**, **A Swaminathan** and **G L Ornas*** (gornas@mcneese.edu), DMCS, Box 92340, MSU, Lake Charles, LA 70609. *Zero of Generalized Cesàro Averaging Operators: Prelimanary Report.* Preliminary report.

We present proofs of results concerning limit sets of the zeros of Generalized Cesàro operators and their zero free regions. These resultsgeneralize results known for Classical Cesàro Means. (Received August 25, 2009)

1051-33-232 **Hasan Coskun*** (hasan_coskun@tamu-commerce.edu), Department of Mathematics, 2600 S Neal St, PO Box 3011, Commerce, TX 75429. *Elliptic Macdonald Functions and Jackson Coefficients on BCn.*

We present two new families of symmetric rational functions, called elliptic Macdonald functions and Jackson coefficients on the root system BCn, that generalize Macdonald polynomials, interpolation Macdonald polynomials and other special functions. We will discuss several important properties of these functions and some of their remarkable applications such as a multiple generalization of the famous Euler's Pentagonal Number Theorem. (Received August 25, 2009)

34 ► Ordinary differential equations

1051-34-16 **Jeffrey W Lyons*** (Jeff_Lyons@baylor.edu), 1226 James Ave Apt 210, Waco, TX 76706. *Boundary Data Smoothness for Solutions of Nonlocal Boundary Value Problems for Second Order Difference Equations.*

Under certain conditions, derivatives and differences, with respect to boundary data and parameters, are studied for solutions of the discrete nonlocal boundary value problem, $w(m+2) = f(m, w(m), w(m+1)), w(m_1) = w_1$ and $w(m_2) - \sum_{i=1}^{r} \alpha_i w(\eta_i) = w_2$, where $m_1 < m_1 + 1 < \eta_1 < \eta_1 + 1 < \eta_2 < \eta_2 + 1 < \cdots < \eta_r < \eta_r + 1 < m_2$ in $\mathbb{Z}$ and $\alpha_1, \alpha_2, \ldots, \alpha_r \in \mathbb{R}$. (Received June 10, 2009)

1051-34-19 **Lingju Kong*** (Lingju-Kong@utc.edu), Department of Mathematics, University of Tennessee at Chattanooga, Chattanooga, TN 37403. *Uniqueness and dependence of positive solutions of second order singular boundary value problems with integral boundary conditions.*

We study the second order singular boundary value problem

$$u'' + \lambda f(t,u) = 0,\ t \in (0,1),$$
$$u(0) = \int_0^1 u(s)d\xi(s),\ u(1) = \int_0^1 u(s)d\eta(s).$$

Sufficient conditions are obtained for the existence and uniqueness of positive solutions. The dependence of positive solutions on the parameter λ is also studied. Moreover, application of our theory to a special problem is discussed. To prove our theorem, we utilize some results from the mixed monotone operator theory. (Received June 24, 2009)

1051-34-22 **Raegan Higgins*** (raegan.higgins@ttu.edu), Box 41042, Lubbock, TX 79402-1042. *Asymptotic Behavior of Second Order Nonlinear Differential Equations.* Preliminary report.

Using the method of upper and lower solutions and results from calculus, we will establish necessary and sufficient conditions for the existence of certain types of solutions of

$$(p(t)y'(t))' + f(t, y(t))g(p(t)y'(t)) = 0.$$

We assume p, f, and g satisfy certain conditions. These results extend some earlier ones for the case $p(t) = 1$. (Received June 29, 2009)

1051-34-24 **Archie Wilmer*** (Archie.Wilmer@usma.edu), 274A Bowman Loop, West Point, NY 10996. *Connecting constant and variable coefficient differential equations.*

Use of the differential operator is extended to obtain analytic solutions for certain classes of second-order linear differential equations with variable coefficients. The approach includes the use of repeated iterated integration and represents a different way to acquire an analytic solution compared to classic power series techniques and other approaches. It is, at times, more involved than traditional methods. This approach underscores a connection between the analysis of constant and variable coefficient differential equations. (Received July 16, 2009)

1051-34-48 **Qingkai Kong*** (kong@math.niu.edu), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115, and **Min Wang**. *Positive solutions of even order system periodic boundary value problems.*

We study an even order system boundary value problem with periodic boundary conditions. By establishing the existence of a positive eigenvalue of certain associated linear Sturm-Liouville problem and using the fixed point index theory, we obtain results on the existence of positive solutions. A series of criteria are also derived for the existence of an arbitrary and even countably infinite number of positive solutions, together with a criterion for the nonexistence. Our results extend, improve, and supplement those in the literature for related scalar and system boundary value problems. (Received August 05, 2009)

1051-34-82 **Gro Hovhannisyan*** (ghovhann@kent.edu), 6000 Frank Avenue, NW, North Canton, OH 44720. *Fundamental Solution of Dirac System on Time Scales.* Preliminary report.

We construct the fundamental solution of time dependent linear Dirac system on time scales in terms on phase functions. Unknown phase functions could be found by asymptotic methods, for example by perturbation methods.

We establish the error estimates for representation of solutions via asymptotic solutions as well. We show that for any choice of approximate phase functions the error functions could be estimated by the characteristic functional on phase functions. From these estimates it is concluded that one could minimize the error functions by choosing appropriate phase functions that are minimizing the characteristic functional.

Using this representation we introduce the adiabatic invariants for the Dirac system on time scales, which are close to the adiabatic invariant of Lorentz's pendulum. Using a small parameter method we show that the change of the adiabatic invariants approaches zero with power speed as small parameter approaches zero.

As another application of the fundamental solution we calculate the transition probabilities for the discrete Dirac system. We show that for the special choice of electromagnetic field the only transition of an electron to the positron with the opposite spin orientation is possible. (Received August 15, 2009)

1051-34-106 **John V. Baxley*** (baxley@wfu.edu), Box 7388, Winston-Salem, NC 27109. *Existence of Solutions for a Class of Singular Nonlinear Third Order Boundary Value Problems.* Preliminary report.

We consider a class of third order boundary value problems of the form

$$y''' = f(y, y', y''), \quad 0 < t < \infty,$$
$$y(0) = 0, \ \ y'(0) = a, \ \ \lim_{t\to\infty} y'(t) = b.$$

We provide conditions on f which guarantee the existence of a unique solution; qualitative properties of the solution are included. The work was motivated by the example $f(y, y', y'') = -yy'' + (y')^2 - b^2$, with $a = 1$, studied in in a 2007 paper by Paullet and Weidman, in which the authors showed that the problem arises in the analysis of stagnation point flow toward a stretching sheet. (Received August 20, 2009)

1051-34-107 **Lynn Erbe**, **Allan Peterson** and **Jacob Weiss*** (weissjj@unk.edu), 905 W. 25th St., Founders Hall 2142, Kearney, NE 68849-1296. *Positive Solutions to a Singular Second Order Boundary Value Problem.*

In this talk, I will establish some criteria for the existence of positive solutions for certain two point boundary value problems for the singular nonlinear second order equation

$$-(ru^{\Delta})^{\Delta} + qu^{\sigma} = \lambda f(t, u^{\sigma})$$

on a time scale $\mathbb{T}$. (Received August 20, 2009)

1051-34-115 **Robert Carlson*** (rcarlson@uccs.edu), Department of Mathematics, University of Colorado at Colorado Springs, 1420 Austin Bluffs Parkway, Colorado Springs, CO 80933. *Two Themes of Rational Quantum Graphs.*

Suppose Δ is the Laplace operator for a finite metric graph with the standard continuity and derivative conditions at all vertices. If the edge lengths are rational multiples of a common value, then the eigenvalues have a simple explicit description based on the spectrum of a vertex Laplace operator defined on an extended finite set of vertices. This regularity can be used in several ways.

It is possible to develop asymptotic expansions for the operator characteristic function of $\Delta + q$; this leads to explicit and implicit asymptotics for the eigenvalues of $\Delta + q$. (joint work with V. Pivovarchik)

In a different direction, one can consider restricting the eigenfunctions of Δ to a set of uniformly spaced sample points along the graph edges. This leads to a graph Discrete Fourier Transform, and efficient algorithms (FFT) for its computation. These ideas may be used to analyze the trapezoidal rule for integration on the two sphere using spherical coordinates. (Received August 20, 2009)

1051-34-118 **Matthew Rudd*** (mrudd@uidaho.edu), Department of Mathematics, University of Idaho, 300 Brink Hall, Moscow, ID 83844. *Positive symmetric solutions of singular semipositone boundary value problems.*

We use the method of upper and lower solutions to prove that the singular BVP

$$-u'' = f(u)u^{-\alpha} \quad \text{in} \quad (0,1), \quad u'(0) = 0 = u(1)\,,$$

has a positive solution when $0 < \alpha < 1$ and $f : \mathbb{R} \to \mathbb{R}$ is an appropriate nonlinearity that is bounded below; in particular, f can satisfy the semipositone condition $f(0) < 0$. We obtain a positive subsolution (the main difficulty) by piecing together solutions of two auxiliary problems, one of which relies on a novel application of Schauder's Theorem. (Received August 20, 2009)

1051-34-244 **Dylan R Poulsen*** (dpoulsen@pugetsound.edu), 2248 Wheelock Student Center, 1500 N Warner, Tacoma, WA 98416-2248. *Coupled Conditions for Asymptotic Equivalence on Time Scales.* Preliminary report.

Given a time scale $\mathbb{T}$, we consider a system of dynamic equations of the form

$$y^{\Delta}(t) = [\Lambda(t) + R(t)]\, y(t) \quad t \geq t_0, t \in \mathbb{T} \tag{1}$$

where $\Lambda(t)$ is a $d \times d$ diagonal matrix and $R(t)$ is a perturbation matrix with $R_{ii}(t) = 0$ for $1 \leq i \leq n$ and all $t \in \mathbb{T}$. Since we cannot, in general, find closed-form solutions to (1), we instead find conditions on $R(t)$ such that the solutions to (1) converge to solutions of the unperturbed system

$$z^{\Delta}(t) = \Lambda(t)z(t) \quad t \geq t_0, t \in \mathbb{T}.$$

Sufficient conditions have been developed for the differential equations and difference equations case (Elias and Gingold, 2003; Gingold and Xue, 2006). In this talk, we present a new derivation of the result and extend it to general time scales. (Received August 25, 2009)

1051-34-257 **Elvan Akin-Bohner*** (akine@mst.edu), 400 W 12th Street, Rolla, MO 65409-0020. *Oscillatory Properties for Three-Dimensional Systems.*

In this talk, we consider oscillation and asymptotic properties for three-dimensional systems of dynamic equations. (Received August 25, 2009)

35 ► Partial differential equations

1051-35-23 **Giles Auchmuty*** (auchmuty@uh.edu), Dept of Mathematics, University of Houston, Houston, TX 77204-3008. *Mixed Steklov Eigenproblems and Partial Dirichlet to Neumann Maps.*

This talk will describe some results about mixed Steklov eigenproblems. These are Steklov eigenproblems for elliptic operators with zero Dirichlet conditions imposed on part of the boundary. They are of interest for the analysis of surface waves, in electrostatics - as well as for solvability conditions for mixed Dirichlet and Neumann elliptic boundary value problems. They also provide the eigenvalues and eigenfunctions for Dirichlet to Neumann maps where these only involve part of the boundary. (Received July 01, 2009)

1051-35-28 **Goong Chen*** (gchen@math.tamu.edu), Department of Mathematics, Room 620E Blocker Bldg., Texas A&M University, College Station, TX 77843, **Zhonghai Ding** (zhonghai.ding@unlv.edu), Department of Mathematical Science, University of Nevada, Las Vegas, NV 89154-4020, **Chang-Shou Lin** (cslin@math.ntu.edu.tw), Department of Mathematics, National Taiwan University, Taipei, Taiwan, and **Alain Perronnet**, **Viswanath Ramakrishna** and **Joe Ward**. *Extrapolation of elliptic eigenvalue calculations on the whole space by the virial theorem.*

The calculations of eigenvalues of partial differential operators posed on the whole space are important in many applications. A typical model is the Schrodinger equation with various types of potentials in chemical physics where the eigenvalues are energy levels of an atom or molecule. The partial differential operator normally consists of sums of Laplacians signifying the quantized kinetic energy, and the potential energy operators can take various forms. The eigenvalues are then sums of the respective kinetic and potential energies. A common feature of these systems is that the kinetic and potential energy operators often have power law scaling properties such that the virial theorem is applicable. In this paper, we propose and prove extrapolation schemes that can be used to improve the accuracy of eigenvalue calculations by utilizing the virial theorem. Concrete data and examples from the finite element computation of the hydrogen atom and a quartic harmonic oscillator in three dimensions are illustrated.

This is joint work by Goong Chen, Zhonghai Ding, Chang-Shou Lin, Alain Perronnet, Viswanath Ramakrishna, and Joe Ward. (Received July 23, 2009)

1051-35-34 **Myles Baker*** (myles_baker@baylor.edu), One Bear Place #81135, Waco, TX 76798, and **Sarah Farell** (sf457@bard.edu). *An Adaptively Weighted Least-Squares Finite Element Method for Convection Dominated Diffusion PDEs.* Preliminary report.

Convection-dominated partial differential equations give rise to error as a by-product of approximation, which is difficult to resolve using quantitative solution methods. Due to the nature of computational methods for solving PDEs, cost-efficiency is important; boundary layers of elliptical PDEs cause solutions of the least-squares approach to be overly smoothed and our goal is to improve the least-squares method by using an adaptive weight approach in the most computationally effective way. We develop a new adaptively weighted least-squares finite element method that works in conjunction with adaptive mesh refinement to balance error in approximations. This method also allows us to improve solutions in terms of both accuracy and computational cost. We use FreeFem++ to illustrate how our adaptive weighted methods affect approximated solutions to convection-dominated diffusion PDEs. We extend this method by applying it to various test problems and the Navier-Stokes equations. (Received July 27, 2009)

1051-35-35 **Myles Baker*** (myles_baker@baylor.edu), One Bear Place #81135, Waco, TX 76798, and **Daniel Sheng** (ur4sail@gmail.com). *On the consistency of finite difference approximations of the Black-Schole's equation on nonuniform grids.*

The Black-Schole's equation has been used for modeling option pricing extensively. However, when the volatility of financial markets creates irregularities, the model equation is difficult to solve numerically. Nonuniform grids are often introduced for achieving a better accuracy. This paper studies the numerical consistency of the popular explicit, implicit and leapfrog finite difference schemes for solving the Black-Schole's equation when nonuniform meshes are utilized. Mathematical tools including Taylor expansions are used throughout our analysis. The consistency ensures the basic reliability of the finite difference schemes based on choices of temporal and variable spacial derivative approximations. Truncation error terms are derived and discussed, and numerical experiments using C, C++ and Matlab are given to illustrate our discussions. We show that, though orders of accuracy are lower compared with their peers on uniform grids, nonuniform algorithms are easy to implement and use for turbulent financial markets. (Received July 27, 2009)

1051-35-44 **Alessio Figalli***, Department of Mathematics, The University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712. *Regularity of optimal transport maps and applications to the geometry of the cut locus.*

In this talk I will describe some recent developments on the regularity theory for optimal transport maps on a Riemannian manifold, when the cost function is given by the squared distance. We will also see that the regularity theory of optimal maps allows to study the geometry of the cut locus of the manifold. In particular we can prove that if (M, g) is a C^4-perturbation of the standard round sphere, then all its tangent cut loci are uniformly convex (joint work with Ludovic Rifford and Cédric Villani). (Received August 04, 2009)

1051-35-54 **Radu C Cascaval*** (rcascava@uccs.edu) and **C. Travis Hunter**, Department of Mathematics, Colorado Springs, CO. *Numerical Studies of Interface Problems on Networks.*

Recent theoretical developments in the study of initial-boundary value problems for linear and nonlinear evolution equations have motivated further numerical studies for interface problems for PDEs posed on networks. One relevant application is modeling pressure and flow velocity waves in the vascular network. We investigate the transfer (response) functions and its nonlinear analogue for the (non)linear Schrödinger equation and the Boussinesq equation, as prototype models for bidirectional wave propagation in physical media. Two methods (finite difference and pseudo-spectral) are used for numerical computations and a comparison of the results with some analytical solutions is performed. (Received August 07, 2009)

1051-35-64 **Anatoli Babin** (ababine@math.uci.edu), Department of Mathematics, The University of California, Irvine, CA 92697-3875, **Alexei Ilyin** (ilyin@spp.keldysh.ru), Keldysh Institute of Applied Mathematics, Russian Academy of Sciences, Miusskaya Sq. 4, Moscow, 125047, Russia, and **Edriss S. Titi*** (etiti@math.uci.edu), Department of Computer Science & Applied Math, The Weizmann Institute of Science, 76100 Rehovot, Israel. *On the Regularization Mechanism for the Periodic Korteweg-de Vries Equation.*

We employ the averaging method for explaining the regularization mechanism and proving global existence, uniqueness, and Lipschitz continuous dependence on the initial data of solutions to the periodic Korteweg–de Vries equation in the Sobolev spaces $\dot{H}^s$ for $s \geq 0$. For solutions with initial data in L_2 we also show the

Lipschitz continuous dependence of these solutions with respect to the initial data as maps from $\dot{H}^s$ to $\dot{H}^s$ for $s \in (-1, 0]$. (Received August 11, 2009)

1051-35-70 **Amit D Patel*** (ptlamit83@yahoo.com), Department of Mathematics, S.V. National Institute of Technology, Ichchhanath, Surat, Gujarat 395007, India, **Ajay K Shukla** (ajayshukla2@rediffmail.com), Department of Mathematics, S.V. National Institute of Technology, Ichchhanath, Surat, Gujarat 395007, India, and **V K Katiyar** (vktmafma@iitr.ernet.in), Department of Mathematics, Indian Institute of Technology, Roorkee, Roorkee, Uttrakhand 247667, India. *AN APPLICATION OF BESSEL FUNCTION IN NARROWING SYSTEMS PROBLEM.*

Narrowing of pipeline network is an important aspect in drinking water distribution systems, Sewage system and in oil-well techniques. In the proposed problem, a flow equation in simple pipeline network has been studied to solve the velocity flow. The deposition causing narrowing has been replaced by using sinusoidal model with axial velocity. In this paper, we used MAPLE 11.02 for plotting the graphs. (Received August 13, 2009)

1051-35-72 **Hongjie Dong*** (Hongjie_Dong@brown.edu), 182 George Street, Providence, RI 02906. *Partial Schauder estimates for second-order elliptic and parabolic equations.*

By modifying a method of Safonov, we establish Schauder estimates for second order elliptic and parabolic equations involving Hölder semi-norms not with respect to all, but only with respect to some of the independent variables. This is joint work with Seick Kim. (Received August 13, 2009)

1051-35-78 **Luis A Caffarelli*** (caffarel@math.utexas.edu), 1 University Station/C1200, Austin, TX 78712. *Some non linear problems involving non local diffusions.*

We will review several mathematical issues involving non linear problems with non local diffusions:divergence versus on divergence, porous media type equations, problems with constraints and optimal control. (Received August 13, 2009)

1051-35-98 **Ricardo M. S. Rosa*** (rrosa@im.ufrj.br), Matematica, Univ. Federal do Rio de Janeiro, Av. Athos da Silveira Ramos 149, Ilha do Fundao, Caixa Postal 68530, Rio de Janeiro, RJ 21.941-909, Brazil. *Navier-Stokes equations, turbulence and statistical solutions.*

Turbulent flows appear in many different phenomena and are of fundamental importance in science and technology. Great part of the classical theory of turbulence, however, is based on heuristic arguments and empirical information. The statistical theory of turbulence aims towards a rigorous foundation for the classical theory. In this talk we motivate the definition of statistical solution for treating turbulent flows, illustrate some applications of the theory describing a few rigorous results obtained recently, and mention some delicate abstract problems connected with theory. (Received August 18, 2009)

1051-35-99 **Thomas Chen*** (tc@math.utexas.edu), Department of Mathematics, The University of Texas at Austin, 1 University Station, C1200, Austin, TX 78712, and **Natasa Pavlovic** and **Nikolaos Tzirakis**. *On the Cauchy problem and blowup of solutions for the Gross-Pitaevskii hierarchy.*

We report on some recent results about the well-posedness of the Cauchy problem for the so-called Gross-Pitaevskii hierarchy, which describes a system of infinitely many interacting bosons in a mean field limit. We introduce a new conserved functional describing the energy per particle, and prove that whenever it is negative, blowup occurs on the L2 critical and supercritical level. This is based on work of Chen-Pavlovic-Tzirakis. Moreover, some recent results about global well-posedness are surveyed, which are due to work of Chen-Pavlovic. (Received August 18, 2009)

1051-35-110 **Xuan Hien Nguyen*** (xhnguyen@math.ksu.edu), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506. *Construction of self-similar surfaces under mean curvature flow.* Preliminary report.

We will describe a construction of new examples of complete embedded self-similar surfaces for the mean curvature flow. The strategy consists in using two known examples, a sphere and a plane, and desingularizing their intersection using gluing techniques. (Received August 20, 2009)

1051-35-117 **Jeremy L Marzuola*** (jm3058@columbia.edu), 200 S.W. Mudd Building, MC 4701, 500 W. 120th St., New York City, NY 10027, and **Herbert Koch** (koch@math.uni-bonn.de), Endenicher Allee 60, 53115 Bonn, NRW, Germany. *Dispersive estimates for the linearized Quartic KdV equation and applications.*

In this note we prove refined estimates for the linearized KdV operator, which allow us to prove scattering for perturbations of solitons in the scaling space appropriate for the quartic nonlinearity, $\dot{H}^{-\frac{1}{6}}$. This is an improvement of the work of Tao in that we are able to work purely in the scaling space without additional regularity assumptions. (Received August 20, 2009)

1051-35-128 **Vera Mikyoung Hur*** (verahur@math.uiuc.edu), 1409 W Green Street, University of Illinois at Urbana-Champaign, Department of Mathematics, Urbana, IL 61801. *Rotational Stokes waves.*

I will speak on traveling waves on the surface of a liquid body under the influence of gravity. I will begin by giving a precise account of the formulation of the surface water-wave problem and discuss its defining features. Particular emphasis is on the effects of the vorticity. Stokes waves refer to as traveling periodic waves whose profile rises and falls exactly once per wavelength. I will describe my recent work on their existence of all amplitudes for a general class of vorticities with some ideas of proof. If time permit, I will discuss on the limiting wave. (Received August 21, 2009)

1051-35-138 **Alexander Kiselev*** (kiselev@math.wisc.edu), Department of Mathematics, 480 Lincoln dr., UW-Madison, Madison, WI 53706, and **Fedor Nazarov**. *A variation on a theme of Caffarelli and Vasseur.*

Recently, using DiGiorgi-type techniques, Caffarelli and Vasseur showed that a certain class of weak solutions to the drift diffusion equation with initial data in L^2 gain Hölder continuity provided that the BMO norm of the drift velocity is bounded uniformly in time. We show a related result: a uniform bound on BMO norm of a smooth velocity implies uniform bound on the C^β norm of the solution for some $\beta > 0$. We use elementary tools involving control of Hölder norms using test functions. In particular, our approach offers a third proof of the global regularity for the critical surface quasi-geostrophic equation. (Received August 22, 2009)

1051-35-147 **Peter S. Constantin***, Department of Mathematics, 5734 S. University Ave., Chicago, IL 60637, and **Gregory Seregin**. *Navier-Stokes equations driven by singular forces.*

We will describe bounds on the pressure and on L^p norms of the velocity in 2D based on a simple generalized Ladyzhenskaya inequality. We will show how to they are used to prove Hölder continuity of velocity when the driving forces are singular ($W^{-1,p}$, and worse). This is joint work with G. Seregin.
(Received August 23, 2009)

1051-35-148 **Peter S. Constantin***, Department of Mathematics, 5734 S. University Ave., Chicago, IL. *Nonlinear Fokker Planck Equations.* Preliminary report.

We will present a framework, results and open problems concerning the evolution of probability densities of interacting systems. (Received August 23, 2009)

1051-35-154 **Mickael D. Chekroun**, **Francesco Di Plinio*** (fradipli@indiana.edu), **Nathan E. Glatt-Holtz** and **Vittorino Pata**. *Regularization properties and asymptotics of the Coleman-Gurtin model.*

Models with extra terms accounting for hereditary memory have become prominent in both theories of viscoelasticity (for example, Kelvin-Voigt viscoelastic law) and of heat conduction (Coleman-Gurtin heat law). Due to the intrinsic "hyperbolic" nature of the memory term, complete finite-time smoothing is not generally possible for these systems. However, in some cases where the corresponding system without memory has regularizing properties, a partial smoothing of the non-memory part of the equation can be obtained. Working in the history space setting, this property is then used to construct global and exponential attractors of optimal regularity and finite fractal dimension for the differential system arising from the Coleman-Gurtin model. (Received August 23, 2009)

1051-35-156 **Nestor Guillen*** (nguillen@math.utexas.edu), 1 University Station, C1200, Austin, TX 78712. *Regularity for flows through semipermeable membranes.*

I will discuss the regularity of a quasi stationary flow in a porous medium which is surrounded by a semipermeable membrane. (Received August 23, 2009)

1051-35-157 **Yuri A. Melnikov*** (ymelniko@mtsu.edu), 1301 E. Main Street, Murfreesboro, TN 37132. *Computer-friendly representations of Green's functions for Laplace and Klein-Gordon equations.*

The classical scheme of the method of eigenfunction expansion is analyzed as applied to the construction of Green's functions for a number of different boundary-value problem settings for the two-dimensional Laplace and Klein-Gordon equations. Resulting Green's functions are represented, within this method, in a series form. Such representations are not quite suitable for immediate computer implementation because the series are not (and cannot be, due to the singular character of Green's functions) uniformly convergent. The emphasis in this talk is put on such a technique which transforms the series expressions of Green's functions into a computer-friendly form. This becomes possible by splitting off those components of the series expressions of Green's functions, which are responsible for their singular components. Numerous graphical illustrations bring a confidence in the potential of the suggested technique. (Received August 23, 2009)

1051-35-158 **Susan Friedlander*** (susanfri@usc.edu), Math Dept, 3620 S Vermont, USC, Los Angeles, CA 90089, and **Vlad Vicol** (vicol@usc.edu), USC, LA, CA 90089. *Nonlinear instability and the SQG equation.*

We describe a boot-strap method which proves under certain conditions that linear instability implies nonlinear instability. This method has been used for the two dimensional Euler equations and the n-dimensional Navier-Stokes equations. Recently is has been applied to the critically dissipative surface quasi-geostrophic equation. We recall the approximations made in obtaining this equation for the full fluid equations in a rapidly rotating frame of reference. Further details will be given in the talk of Vlad Vicol. Aspects of the work are joint with Pavlovic, Shvydkoy, Vicol and Vishik. (Received August 23, 2009)

1051-35-163 **Daniela De Silva*** (desilva@math.columbia.edu), 2900 Broadway, New York, NY 10027, and **Enrico Valdinoci**. *A fully nonlinear free boundary problem in the plane.*

We condider a fully nonlinear analogue of the jet-fluid model of Alt and Caffarelli. We describe a symmetry result for global solutions of this free boundary problem, based on maximum principle techniques and convexity arguments. (Received August 24, 2009)

1051-35-164 **Bartłomiej Siudeja*** (siudeja@illinois.edu), University of Illinois at Urbana-Champaign. *Sharp bounds for eigenvalues of triangles.*

Eigenvalues of the Laplacian on triangular domains cannot be computed exactly, in general. But the triangles that extremize the first eigenvalue (the fundamental tone of the membrane) often turn out to be equilateral, or degenerate in some way. These special triangles give sharp eigenvalue bounds for the general case.

Among all triangles with fixed diameter, we prove the degenerate acute isosceles triangle minimizes the Neumann fundamental tone. In the other direction, if we fix perimeter (or area) then the equilateral triangle maximizes the Neumann fundamental tone. Our approach involves variational principles and geometric transformations of the domain, and relies on the special (eigen)functions of equilateral triangles and circular sectors. (Received August 24, 2009)

1051-35-185 **Anna L Mazzucato*** (alm24@psu.edu), McAllister Building, University Park, PA 16802, and **Radu Costantinescu**, **Nick Costanzino** and **Victor Nistor**. *Approximate solutions to parabolic equations.* Preliminary report.

We discuss an elementary approach to short-time asymptotic expansions of solutions to second-order, linear parabolic equations. We allow for certain type of degenerate coefficients such as those arising in stochastic volatility models. We obtain error bounds in weighted spaces by means of pseudodifferential symbol calculus. (Received August 24, 2009)

1051-35-187 **Igor Kukavica** (kukavica@usc.edu), University of Southern California, 3620 South Vermont Ave., Los Angeles, CA 90089, and **Vlad Vicol*** (vicol@usc.edu), University of Southern California, 3620 South Vermont Ave., Los Angeles, CA 90089. *Analyticity and Gevrey-class regularity up to the boundary for the Euler equations.*

We address the analyticity and Gevrey-class regularity of solutions to the 3D Euler equations on the half-space and on a bounded domain. We give lower bounds for the rate of decay of the real-analyticity radius of the solution $u(t)$ in terms of $\exp \int_0^t \|\nabla u(s)\|_{L^\infty} ds$, improving the previously known results. In the case of the bounded domain, by following particle trajectories, we prove the persistence of the non-analytic Gevrey-class regularity, with an explicit rate of decay of the Gevrey-class radius. (Received August 24, 2009)

1051-35-188 **Susan Friedlander** (susanfri@usc.edu), University of Southern California, Los Angeles, CA 90089, **Natasa Pavlovic** (natasa@math.utexas.edu), The University of Texas at Austin, Austin, 78712, and **Vlad Vicol*** (vicol@usc.edu), University of Southern California, Los Angeles, CA 90089. *Nonlinear instability for the critically dissipative surface quasi-geostrophic equation.*

We address the stability of steady state solutions to the critically dissipative surface quasi-geostrophic equation. We prove that if the unstable spectrum of the linearized operator is not empty, then the steady state is nonlinearly unstable in the energy norm. A key ingredient is the well-posedness of the forced nonlinear problem, which is proven using the nonlinear maximum principle of Kiselev et.al. (Received August 24, 2009)

1051-35-214 **Alexis F. Vasseur*** (vasseur@math.utexas.edu) and **Cristina Caputo**. *Global regularity of solutions to a class of systems of reaction-diffusion.*

In this talk, we present the study of the regularity of solutions to some systems of reaction–diffusion equations, with reaction terms having a subquadratic growth. We show the global boundedness and regularity of solutions, without smallness assumptions, in any dimension N. The proof is based on blow-up techniques. The natural entropy of the system plays a crucial role in the analysis. It allows us to use of De Giorgi type methods introduced for elliptic regularity with rough coefficients. Even if those systems are entropy supercritical, it is possible to control the hypothetical blow-ups, in the critical scaling, via a very weak norm. (Received August 25, 2009)

1051-35-235 **Aynur Bulut*** (abulut@math.utexas.edu), University of Texas at Austin, Department of Mathematics, 1 University Station, C1200, Austin, TX 78712-0257. *Existence of Maximizers for the Wave Strichartz Inequalities.*

In this talk, we will discuss the existence of maximizers for Strichartz inequalities for the wave equation. Inspired by the corresponding work of Shao in the context of the Schrödinger equation, the main tool that we use is an extension of the linear profile decomposition result of Bahouri and Gerard to higher dimensions. (Received August 25, 2009)

1051-35-240 **Peter Frempong-Mireku*** (pfmireku@dillard.edu), 2601 Gentilly Blvd, New Orleans, LA 70122, and **Haewon Lee** (hlee@dillard.edu), 2601 GENTILLY BLVD, New Orleans, LA 70122. *Stepanov-like Almost Automorphic Solutions of Abstract Fractional Differential Equations with Nonlocal Initial Conditions.*

We consider the existence and uniqueness of Stepanov-like almost automorphic solution of abstract fractional differential equations with nonlocal Initial COnditions:

$$D_t^\alpha u(t) = Au(t) + f(t, u(t)), u(0) + g(u) = u_0, \qquad t \geq 0$$

where the linear operator $A : D(A) \subset X \to X$ is the infinitesmal generator of an exponentially stable C_0-semigroup $\{T(t)\}_{t\geq 0}$ on Banach space X and $f : \mathbb{R} \times X \to X$ satisfies a Lipschitz-type condition with respect to second argument. (Received August 25, 2009)

1051-35-243 **Alexey Cheskidov*** (acheskid@math.uic.edu), MSCS, 851 S Morgan St, Chicago, IL 60607, and **Roman Shvydkoy** (acheskid@math.uic.edu), Chicago, IL 60607. *Ill-posedness of the 3D Navier-Stokes equations in Besov spaces.*

We discuss some recent results on ill-posedness of the 3D Navier-Stokes equations in Besov spaces. (Received August 25, 2009)

1051-35-250 **Dirk Hundertmark*** (dirk@math.uiuc.edu), Department of Mathematics, Altgeld Hall, 1409 W Green Street, Champaign, IL 61801. *Exponential decay of dispersion management solitons.*

The propagation of pulses through a dispersion managed glass fiber cable is described by a non-local version of the non-linear Schrödinger equation. This equation has been extensively studied numerically and on the level of theoretical physics due to its enormous practical relevance in the modeling of signal-transfer through ultra-high speed glass-fiber cables, but rigorous results are rare. This is mainly due to the non-local nature of this equation which makes it hard to study. As a test: if one googles 'dispersion management' one gets an overwhelming amount of hits (ca 551,000 on google scholar at the moment, much more on plain google) but only very few are rigorous (I know of 6).

We describe very recent work on the decay and regularity properties of solitary solutions, the so-called dispersion management solitons. Our results include a simple proof of existence, regularity, and, most recently, a proof of exponential decay of dispersion management solitons. The main tool for the proof of exponential decay are exponentially weighted multi-linear estimates. This is joint work with Burak Erdoğan and Young-Ran Lee. (Received August 25, 2009)

1051-35-254 **Serge Prudhomme*** (serge@ices.utexas.edu), 1 University Station C0200, Austin, TX 78735, and **J. Tinsley Oden**, **Andrea Hawkins** and **Kris van der Zee**. *Modeling and Numerical Simulation of Tumor Growth.*

While a large and growing literature exists on mathematical and computational models of tumor growth, to date tumor growth models are largely qualitative in nature, and fall far short of being able to provide predictive results important in life-and-death decisions. This is largely due to the enormous complexity of evolving biological and chemical processes in living tissue and the complex interactions of many cellular and vascular constituents in living organisms. Significant progress in this important area could however be foreseen thanks to the development of so-called phase-field, or diffusive interface models, which can be developed using continuum mixture theory, and which provide a general framework for modeling the action of multiple interacting constituents. These are based on generalizations of the Cahn-Hilliard models and have been used recently in certain tumor growth theories. In this talk, we describe a general phenomenological thermomechanical theory of mixtures that employs phase-field or diffuse interface models of surface energies and reactions and present preliminary numerical simulations for tumor growth modeling. (Received August 25, 2009)

1051-35-259 **Igor Kukavica*** (kukavica@usc.edu) and **Mohammed Ziane** (ziane@usc.edu). *Regularity of the primitive equations of the ocean.*

We prove the existence of global strong solutions of the primitive equations of the ocean in the case of the Dirichlet boundary conditions and variable boundary. We also discuss the dissipativity of the system and uniform gradient bounds for solutions. (Received August 25, 2009)

1051-35-261 **Igor Kukavica*** (kukavica@usc.edu). *On the partial regularity for solutions of the Navier-Stokes system.*

A classical result of Caffarelli, Kohn, and Nirenberg states that the one dimensional Hausdorff measure of singularities of a suitable weak solution of the Navier-Stokes system is zero. We present a short proof of the partial regularity result which allows the force to belong to a singular Morrey space. (Received August 25, 2009)

37 ► Dynamical systems and ergodic theory

1051-37-96 **Youssef N Raffoul*** (youssef.raffoul@notes.udayton.edu), Dayton, OH 45469-2316. *Existence of resolvent for Volterra integral equations on time scales.*

This research is the first of its kind in which we establish sufficient conditions for the existence of the resolvent for the Volterra integro-dynamic equation on time scales

$$x(t) = f(t) + \int_0^t a(t,s)x(s)\Delta s.$$

The paper will serve as the foundation for future research on the qualitative analysis of solutions of Volterra integro-dynamic equation on time scale, using the notion of the resolvent.
(Received August 18, 2009)

1051-37-181 **Judy Anita Kennedy*** (kennedy9905@gmail.com), Dept. Mathematics, PO Box 10047, Lamar University, Beaumont, TX 77710, and **Barry Peratt**, Dept. Mathematics, Winona State University, Winona, MN. *The topology of tank stirring.* Preliminary report.

We consider simple, discrete maps, which when combined, mimic stirring in a tank with a recycle loop as the combined maps are iterated. We have both rigorous and computational results that we will discuss. (Received August 24, 2009)

1051-37-186 **Brian R Williams*** (brian_williams1@baylor.edu), Department of Mathematics, Baylor University, One Bear Place #97328, Waco, TX 76798. *Inverse Limits of Postcritically Finite Polynomials.*

We examine inverse limits of postcritically finite polynomials restricted to their Julia sets. (Received August 24, 2009)

1051-37-264 **Zoran Sunic*** (sunic@math.tamu.edu). *Spectra of self-similar groups.*

We provide examples of spectral calculations related to Schreier graphs of self-similar groups. The method relies on the use of Schur complements and higher-dimensional rational maps. (Received August 25, 2009)

39 ► Difference and functional equations

1051-39-14 **Ferhan M Atici** (ferhan.atici@wku.edu) and **Paul W Eloe*** (Paul.Eloe@notes.udayton.edu), Department of Mathematics, University of Dayton, Dayton, OH 454692316. *Discrete Fractional Calculus with the Nabla Operator.*

Properties of discrete fractional calculus in the sense of a backward difference are introduced and developed. Exponential laws and a product rule are developed and relations to the forward fractional calculus are explored. Properties of the Laplace transform for the nabla derivative on the time scale of integers are developed and a fractional finite difference equation is solved with a transform method. As a corollary, two new identities for the gamma function are exhibited. (Received June 03, 2009)

1051-39-69 **Ferhan M. Atici*** (ferhan.atici@wku.edu), Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101-3576, and **Paul W. Eloe** (paul.eloe@notes.udayton.edu), Department of Mathematics, University of Dayton, Dayton, OH 45469-2316. *An Application of Discrete Fractional Difference Equations in Biology.*

A direct generalization of the discrete exponential function $(\frac{1}{1-a})^t$ will be defined and named as the discrete Mittag-Leffer function. This function will allow us to solve a first order nabla fractional difference equation with an initial condition. As an application, a compartmental model which explains how the concentration of a drug in blood plasma declines over time will be discussed. (Received August 12, 2009)

1051-39-79 **Lynn H. Erbe** and **Taher S. Hassan**, , Egypt, and **Allan C. Peterson*** (apeterson1@math.unl.edu), 237 Avery Hall, Math. Dept., Lincoln, NE 685880130. *Oscillation criteria for first order dynamic equations.*

We will investigate the asymptotic behavior of solutions of a first order dynamic equation on a time scale. (Received August 13, 2009)

1051-39-91 **Sevgi Sengul*** (sevgi.sengul339@wku.edu), Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101, and **Ferhan Atici** (ferhan.atici@wku.edu), Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101. *Discrete Fractional Gompertzian Model for Tumor Growth.*

Recently, fractional calculus is an emerging field of research drawing attention from both theoretical and applied disciplines such as Applied Mathematics and Bioengineering. First, the left and right discrete fractional difference operators will be defined to obtain the summation by parts formula in discrete fractional calculus. Also these discrete operators will be used to define the simplest discrete fractional variation problem in the theory of Calculus of Variations. Last, discrete fractional Gompertzian model will be discussed for tumor growth. And its solution will be given with some illustrations of a real data. (Received August 17, 2009)

1051-39-112 **Billy Jackson*** (billy.jackson@unco.edu) and **Joan Hoffacker**. *A Time Scale Model for Interacting Transgenic and Wild Mosquito Populations.* Preliminary report.

Based on the work of Li(2008) and others, we provide a second order system of dynamic equations on time scales that govern the dynamics of the interaction between populations of wild and genetically altered mosquitoes, the former of which have been altered so as to prevent disease transmission to humans. We provide relevant stability results and focus mainly on the differential-difference model as time scales analysis is particularly adept at handling this case. The differential-difference model allows us to account for periods of latency, a notorious trait of mosquito populations. (Received August 20, 2009)

1051-39-130 **Lynn H Erbe*** (lerbe2@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588, and **Allan C Peterson** and **Baoguo Jia**. *Kiguradze-Belohorec type oscillation criteria for nonlinear second order dynamic equations.*

We consider extensions of the well-known Kiguradze and Belohorec oscillation criteria for second order superlinear and subliner dynamic equations on time scales. Some examples and comparison with previous results are also presented. (Received August 21, 2009)

1051-39-135 **Jeffrey J DaCunha*** (jeffrey_dacunha@yahoo.com), 4801 Clayton Ct., Midland, TX 79707. *Classification of forms of the solutions to time varying and time invariant linear dynamic systems.* Preliminary report.

The intent of this paper is to classify the structure of the solutions to first order systems of dynamic equations on time scales as well as provide bounds of the solutions in terms of time scales exponential functions. In a

previous paper, the Peano-baker series is introduced for time varying and time invariant system matrices in the generalized time scales case. There is an infinite series representation given for the matrix exponential when the system matrix is constant.

In this paper, we show that the form of the $n \times n$ matrix exponential (as a solution to a first order system of dynamic equations) is an extension of the solution in the scalar case.

In this paper, we examine the form of the solution to dynamic systems when the time varying matrix commutes with its integral (known as Lappo-Danilevskii systems). It is the author's hope that these new structures of the transition matrix and the matrix exponential will offer easier calculations for solutions to time varying and time invariant linear dynamic systems on general time scales. (Received August 21, 2009)

1051-39-153 **Britney Hopkins*** (bhopkins3@uco.edu), University of Central Oklahoma, Department of Mathematics and Statistics, 100 N. University Dr., Edmond, OK 73034. *Multiplicity of Positive Solutions for a Fourth-order Nonhomogeneous Boundary Value Problem.*

In this talk, we focus on the existence of multiple positive solutions for the fourth order difference equation, $\Delta^4 u(t-2) = \lambda h(t, u(t), \Delta^2 u(t-1))$, $t \in (0, N+2)_{\mathbb{Z}}$ satisfying the boundary conditions, $u(0) = 0$, $\Delta^2 u(-1) = 0$, $u(N+2) = a$, and $\Delta^2 u(N+1) = -b$, where $a, b, \lambda \geq 0$, $a+b > 0$, and $h : [0, N+2]_{\mathbb{Z}} \times [0, \infty) \times (-\infty, 0] \to [0, \infty)$. We transform the even order boundary value problem into a system of second order difference equations satisfying homogeneous boundary conditions. Then, by applying the Guo-Krasnosel'skii Fixed Point Theorem several times, we show the existence of multiple positive solutions. (Received August 23, 2009)

1051-39-160 **Rajendra Dahal*** (rdahal@coastal.edu), Departement of Mathematics and Statistics, Coastal Carolina University, P.O. Box 261954, Conway, SC 29528. *Existence of positive solutions of semipositone dynamic boundary value problems.*

abstract

In this talk, using well known fixed points theorem, I will show the existence of positive solutions for the following second-order singular semipositone boundary value problem:

$$-x^{\Delta\nabla} = f(t, x) + g(t, x), \qquad t \in (\rho(a), \sigma(b))$$
$$x(\rho(a)) = 0 = x(\sigma(b)),$$

where $f(t, x) \geq 0$, and g may change sign. (Received August 24, 2009)

1051-39-169 **Chris Ahrendt*** (s-cahrend1@math.unl.edu), University of Nebraska-Lincoln, 203 Avery Hall - Dept. of Mathematics, P.O. Box 880130, Lincoln, NE 68588-0130. *Some Basic Properties of the Laplace Transform on Time Scales.*

We first discuss several properties of the generalized exponential function which will allow us to explore some of the fundamental properties of the Laplace transform on time scales. We then give a description of the region in the complex plane for which the improper integral in the definition of the Laplace transform converges, and how this region is affected by the time scale in question. Conditions under which the Laplace transform of a power series can be computed term-by-term are given. Regressivity and its relationship to the Laplace transform is examined. (Received August 24, 2009)

1051-39-207 **Heidi A Berger*** (heidi.berger@simpson.edu), Simpson College, Dept. of Mathematics, 701 N. C Street, Indianola, IA 50125. *Using Critical Point Theory to Solve Boundary Value Problems.*

I will use Clark's Theorem to show the existence of multiple solutions to a self–adjoint dynamic boundary value problem on an isolated time scale interval. This work generalizes the results of Bai and Xu from 2007, in the discrete case, and Rabinowitz/Clark from the continuous PDE case. Examples of these results will be given. (Received August 25, 2009)

1051-39-218 **Martin Bohner*** (bohner@mst.edu), Missouri S&T, Department of Mathematics and Statistics, Rolla, MO 65409-0020, and **Gregory Gelles**. *Dynamic Risk Aversion.*

In this talk we discuss utility functions for money, where allowable money values are from an arbitrary nonempty closed subset of the real numbers. Thus the classical case, where this subset is the set of all real numbers, is included in the study. The discrete case, where this subset is the set of all integer numbers, is also included. In a sense this discrete case (which has not been addressed in the literature thus far) is more suitable for real-world applications than the continuous case. The concepts of risk aversion and risk premium are defined and an analogue of Pratt's fundamental theorem is proved. (Received August 25, 2009)

43 ► Abstract harmonic analysis

1051-43-68 **Gestur Olafsson*** (olafsson@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803, and **J Wolf**. *Invariants and application to harmonic analysis.*

Assume that $G_1 \subset G_2$ are semisimple Lie groups and $\mathfrak{h}_1 \subset \mathfrak{h}_2$ are Cartan subalgebras of $\mathfrak{g}_1$ respectively $\mathfrak{g}_2$. Furthermore, assume that $\theta_2 : G_2 \to G_2$ is a Cartan involution leaving G_1 invariant. Then $\theta_1 := \theta_2|_{G_1}$ is a Cartan involution on G_1 and we have an inclusion $G_1/K_1 \subseteq G_2/K_2$. Let

$$\mathfrak{g}_1 = \mathfrak{k}_1 \oplus \mathfrak{s}_1 \subset \mathfrak{k}_2 \oplus \mathfrak{s}_2 = \mathfrak{g}_2$$

be the corresponding Cartan decomposition. Let $\mathfrak{a}_1 \subset \mathfrak{a}_2$ be maximal abelian in $\mathfrak{s}_1$ respectively $\mathfrak{s}_2$. We let W_j be the Weyl group in $\mathfrak{h}_j$ and $\mathcal{W}_j$ be the Weyl group in $\mathfrak{a}_j$. Then it is well known that $\mathcal{W}_j = \{w|_{\mathfrak{a}_j} \mid w \in W_j,\ w(\mathfrak{a}_j) = \mathfrak{a}_j\}$. We give sufficient condition such that

$$S(\mathfrak{h}_2)^{W_2}|_{\mathfrak{h}_1} = S(\mathfrak{h}_1)^{W_1} \quad \text{and} \quad S(\mathfrak{a}_2)^{\mathcal{W}_2}|_{\mathfrak{a}_1} = S(\mathfrak{a}_1)^{\mathcal{W}_1}\,.$$

We apply this to harmonic analysis on symmetric spaces and inductive limits of symmetric spaces. (Received August 12, 2009)

47 ► Operator theory

1051-47-17 **Richard I Avery*** (rich.avery@dsu.edu), Dakota State University, 820 North Washington Avenue, Madison, SD 57042, and **Johnny L Henderson** and **Douglas R Anderson**. *An Extension of the Leggett-Williams Fixed Point Theorem.*

An extension of the Leggett-Williams Fixed Point Theorem is presented which requires neither of the functional boundaries to be invariant with respect to the functional wedge. (Received June 23, 2009)

1051-47-89 **Jeremy Sain*** (jeremy.sain@clarendoncollege.edu). *Berezin Quantization of Quantum Homogeneous Spaces.*

We explain how, in a suitable sense, Berezin quantization "commutes" with Rieffel's deformation quantization from actions of $\mathbb{R}^d$. For our main example, we discuss how the usual Berezin quantization of coadjoint orbits can be deformed to give a Berezin quantization for the θ-deformed coset spaces introduced by Varilly. (Received August 16, 2009)

1051-47-105 **Zheng Gan*** (zheng.gan@rice.edu), Department of Mathematics, MS-136 , Rice University, Houston, TX 77005, and **David Damanik**. *Limit-Periodic Schrödinger Operators in the Regime of Positive Lyapunov Exponents.* Preliminary report.

We investigate the spectral properties of the discrete one-dimensional Schrödinger operators whose potentials are generated by continuous sampling along the orbits of a minimal translation of a Cantor group. We show that for given Cantor group and minimal translation, there is a dense set of continuous sampling functions such that the spectrum of the associated operators has zero Hausdorff dimension and all spectral measures are purely singular continuous. The associated Lyapunov exponent is a continuous strictly positive function of the energy. It is possible to include a coupling constant in the model and these results then hold for every non-zero value of the coupling constant. (Received August 19, 2009)

49 ► Calculus of variations and optimal control; optimization

1051-49-6 **Mostafa Ghandehari*** (ghandeha@uta.edu), Mathematics Department, Univ. of Texas at Arlington, Box 19408, Arlington, TX 76019, and **Roger Kirby**. *Maximum curvature splines.*

Variational techniques are used to find maximum curvature splines. Various conditions on curvature for example bounded curvature splines are considered. Optimization methods are used to find coefficient of polynomials. (Received December 08, 2008)

1051-49-255 **Nick Wintz*** (njwn7d@mst.edu), Missouri University of Science and Technology, Department of Mathematics and Statistics, Rolla, MO 65409. *The Linear Quadratic Regulator on Time Scales.*

We will unify and extend an optimal control problem for systems on time scales. Here, we will consider a linear system associated with a quadratic performance index. First, we will find an optimal control when the final state is fixed, resulting in an open-loop control. Next, we consider when the final state is free, resulting in a closed-loop control. Finally, we consider some extensions to the regulator problem, including tracking and disturbance/rejection models. (Received August 25, 2009)

51 ► Geometry

1051-51-33 **Ben Schmidt***, D308 Wells Hall, East Lansing, MI 48824. *The three gap theorem and Riemannian geometry.*

The classical three gap theorem asserts that for a natural number n and a real number p, there are at most three distinct distances between consecutive elements in the subset of [0,1) consisting of the reductions modulo 1 of the first n multiples of p. I'll discuss analogues of this theorem pertaining to isometries of a Riemannian manifold M and to equally spaced points along a geodesic in M. This talk is based on joint work with Ian Biringer. (Received July 27, 2009)

1051-51-266 **John Head*** (john.head@aei.mpg.de). *Mean Curvature Flow with Surgeries.* Preliminary report.

We consider an appropriate sequence of surgery constructions for mean curvature flow of two-convex hypersurfaces in which we vary the parameters controlling the surgery procedure, and show that in the limit we retrieve the well-known weak solution of the level set flow. (Received August 26, 2009)

53 ► Differential geometry

1051-53-46 **David A Glickenstein*** (glickenstein@math.arizona.edu), Department of Mathematics, 617 N Santa Rita, Tucson, AZ 85721. *Riemannian groupoids, homogeneous spaces, and Ricci flow.*

I plan to give a brief introduction to Riemannian groupoids as singularity models of Ricci flow by looking at one or more examples of the flow on quotients of 3D unimodular Lie groups with left-invariant metrics. In some instances, the flow converges to a three-dimensional groupoid which has a singular (i.e., lower dimensional) Gromov-Hausdorff limit (for instance, the limit of almost flat nilmanifolds which have collapsed to a point). These limit spaces generally have the structure of homogeneous spaces, at least locally. Understanding the spectrum of partial differential operators (for instance, linearization of the Ricci tensor) on these limit spaces could lead to a more detailed stability analysis of the Ricci flow system. We will try to frame the stability question in this setting, with the hope of generating discussion on how to attack it. (Received August 04, 2009)

1051-53-58 **Taechang Byun*** (tcbyun@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019. *Horizontal displacement of curves in bundle* $SO(3) \to SO_0(1,3) \to \mathbb{H}^3$. Preliminary report.

Consider the principal bundle $\mathrm{SO}(n) \longrightarrow \mathrm{SO}_0(1,n) \xrightarrow{\pi} \mathbb{H}^n$, where π is a Riemannian submersion. Let γ be a simple closed curve in the base $\mathbb{H}^n$, bounding an embedded disk S. We are concerned with the horizontal lift of γ starting at $e \in \mathrm{SO}(n)$. The horizontal displacement for γ gives rise to a point p in the fiber $\mathrm{SO}(n)$.

When $n = 2$, it was known that the distance between e and $p \in \mathrm{SO}(2)$ is the same as the area of the S. We study the case when $n = 3$. The surface S enables us to find a curve f connecting e and p in $\mathrm{SO}(3)$, whose length is exactly the area of the surface S. In addition, on a dense subset of the domain of f, the left translations of the tangent vectors $\dot{f}(t)$ to e will be related to the curvature of the connection of the principal bundle $\mathrm{SO}(1,3) \to \mathbb{H}^3$ with respect to the 2-dimensional horizontal distribution in $\mathrm{SO}(1,3)$, induced from the tangent planes of S in $\mathbb{H}^3$. (Received August 10, 2009)

1051-53-103 **Sigurd B. Angenent**, **M. Cristina Caputo** and **Dan F. Knopf*** (danknopf@math.utexas.edu), University of Texas, Department of Mathematics, 1 University Station, C1200, Austin, TX 78712-0257. *Minimally invasive surgery for Ricci flow singularities.*

We construct smooth forward Ricci flow evolutions of singular initial metrics resulting from rotationally symmetric neckpinches on S^{n+1}, without performing an intervening surgery. In the restrictive context of rotational symmetry, this construction gives evidence in favor of Perelman's hope for a "canonically defined Ricci flow through singularities". (Received August 19, 2009)

1051-53-104 **Dan F. Knopf*** (danknopf@math.utexas.edu), University of Texas, Department of Mathematics, 1 University Station, C1200, Austin, TX 78712-0257. *Convergence and stability of locally $\mathbb{R}^N$-invariant solutions of Ricci flow.*

Many solutions of Ricci flow exist for all positive time but fail to converge. Instead, they collapse with bounded curvature. Among homogeneous metrics, this behavior is modeled by a dynamical system on a finite-dimensional space; for general metrics, an infinite-dimensional Banach space is required. There is a sense in which collapsing solutions may converge (after pullback to the universal cover and modification by diffeomorphisms) to homogeneous Ricci soliton metrics on nilpotent or solvable Lie groups.

We will explain the role of locally G-invariant solutions in this picture, and discuss what they tell us about the stability of homogeneous Ricci soliton metrics in the infinite-dimensional setting. (Received August 19, 2009)

1051-53-120 **Martin Kerin** and **Krishnan Shankar*** (shankar@math.ou.edu), Department of Mathematics, 601 Elm Avenue, PHSC 423, Norman, OK 73019. *Riemannian submersions from simple, compact Lie groups.*

We construct infinitely many examples of Riemannian submersions $G \longrightarrow B$, where G is a simple, compact Lie group with bi-invariant metric and B is a smooth Riemannian manifold such that B is not a quotient of G by any group action. This partially answers a question of K. Grove's about the structure of Riemannian submersions from compact, Lie groups. (Received August 20, 2009)

1051-53-121 **Zuang-dan Daniel Guan*** (zguan@math.ucr.edu), Department of Mathematics, University of California, Riverside, CA 92521. *KE metrics, stability and Ricci flow.* Preliminary report.

I will give some examples of compact Fano manifolds with or without Kähler-Einstein metrics. The existence is exactly the same as a stability. The stability is described by a topological integral inequality. An interesting question is on the formation of singularity of the Ricci flow when the manifolds are not stable, i.e., when the Ricci class does not admit a KE metric. We notice that since the automorphism groups are semisimple, there is no Ricci soliton for these manifolds. (Received August 20, 2009)

1051-53-123 **Thalia D. Jeffres*** (jeffres@math.wichita.edu), 1845 Fairmount, Wichita, KS 67260, and **Julie M. Rowlett** (rowlett@math.uni-bonn.de), Villa Maria Endenicher Allee 62, D-53115 Bonn, Germany. *Conformal Deformations of Singular Metrics To Constant Scalar Curvature: The Negative Curvature Case.* Preliminary report.

Julie Rowlett and I studied a version of the Yamabe problem for certain incomplete metrics of negative scalar curvature, in the complement of a submanifold Λ of a compact manifold X. These metrics g have conical singularities near zero-dimensional components of Λ, and near higher-dimensional components the space together with the metric resembles a product of a cone with a smooth, compact manifold.

We showed that if (X, g) is such a singular space, with scalar curvature $S(g) < 0$, then g can be deformed within the same singularity type to a new metric $\tilde{g} = u^{4/(n-2)}g$ having $S(\tilde{g}) \equiv -1$ if and only if the restriction of the original metric g to the link of the cone has scalar curvature identically equal to $m(m-1)$, where m is the dimension of the link. This condition can be interpreted as a restriction on the cone angle. (Received August 21, 2009)

1051-53-152 **Zhou Zhang*** (zhangou@umich.edu), 4835 East Hall, Department of Mathematics, 530 Church Street, Ann Arbor, MI 48109-1043. *the Singularities of Kähler-Ricci Flows.* Preliminary report.

In this talk, we discuss different kinds of singularities appearing in Kähler-Ricci flows, finite and infinite time cases, volume non-collapsing and collapsing cases. The ultimate goal is to realize Tian's program of defining global (weak) Kähler-Ricci flow and applying it to the study of algebraic manifolds. (Received August 23, 2009)

1051-53-161 **Fernando Galaz-Garcia*** (galazg@math.umd.edu), Mathematisches Institut, WWU Münster, Einsteinstrasse 62, Münster, Germany. *On nonnegatively curved low-dimensional fixed point homogeneous Riemannian manifolds.*

Let G be a compact Lie group acting isometrically on a compact Riemannian manifold M with nonempty fixed point set $Fix(M, G)$. We say that M is *fixed point homogeneous* if G acts transitively on a normal sphere to some component of $Fix(M, G)$. Fixed point homogeneous manifolds with positive sectional curvature have been completely classified. We will discuss the structure of fixed point homogeneous Riemannian manifolds with nonnegative curvature and their classification in low dimensions. (Received August 24, 2009)

1051-53-166 **Chenxu He*** (hech@math.upenn.edu), 209 South 33rd Street, Philadelphia, PA 19104. *Non-negatively curved cohomogeneity one manifolds.*

Non-negatively or positively curved manifolds play an important role in global Riemannian geometry. Though there are many examples of non-negative curved manifold, the construction methods are few. Recently Grove-Ziller discovered many new examples in cohomogeneity one manifolds, i.e., it admits an isometric action by a compact Lie group with one dimensional orbit. However not every cohomogeneity one manifold supports non-negatively curved invariant metric. The first examples were discovered by Grove-Wilking-Verdiani-Ziller.

I will present more examples of obstructions to negatively curved metric in cohomogeneity one manifold which generalize the earlier results. I will also show some new manifolds with cohomogeneity one action which have a small family of invariant metrics. (Received August 24, 2009)

1051-53-168 **Huai-Dong Cao***, Department of Math, Lehigh University, Bethlehem, PA 18015. *Remarks on Ricci solitons.*

We shall present some recent progress on Ricci solitons. (Received August 24, 2009)

1051-53-191 **Rachelle DeCoste**, **Lisa DeMeyer** and **Maura Mast*** (maura.mast@umb.edu), Department of Mathematics, University of Massachusetts Boston, 100 Morrissey Blvd., Boston, MA 021253393. *Geodesics in Heisenberg-like Nilmanifolds.*

Two-step nilpotent Lie groups are the non-abelian Lie groups that come as close as possible to being abelian. As such, their geometry is both accessible and interesting. If such a Lie group is endowed with a left-invariant metric, then its geometry can be understood using a set of linear transformations defined on the center of the corresponding Lie algebra. We use this approach to study geodesic behavior in two-step nilpotent metric Lie groups and nilmanifolds. In particular, we focus on Heisenberg-like Lie groups. This class of Lie groups generalizes in a very natural way from the Lie groups of Heisenberg type and many questions about geodesics in Heisenberg type groups can be re-cast in this larger context. We explore some of these questions, including the question of when a compact nilmanfiold has density of closed geodesics. (Received August 25, 2009)

1051-53-203 **Brett L Kotschwar*** (kotschwar@math.mit.edu), Massachusetts Institute of Technology, 77 Massachusetts Ave., 2-279, Cambridge, MA 02139. *Backwards-uniqueness of the Ricci flow.*

I will discuss a unique continuation or "backwards-uniqueness" theorem for solutions to the Ricci flow. The theorem implies, in particular, that the isometry group of a solution cannot expand, nor the solution become self-similar, within finite time. (Received August 25, 2009)

1051-53-212 **William Wylie*** (wylie@math.upenn.edu), Department of Mathematics, David Rittenhouse Labratory, 209 South 33rd Street, Philadelphia, PA 19104, and **P Petersen**. *On the classification of gradient Ricci solitons and Quasi-Einstein manifolds.*

Gradient Ricci solitons and Quasi-Einstein metrics are generalizations of Einstein manifolds and appear as singularity models in Ricci flow. In this talk I will discuss various conditions of curvature and symmetry that allow us to classify these objects. (Received August 25, 2009)

1051-53-231 **Andrea N Young***, ayoung@math.arizona.edu, and **Michael Jablonksi**. *Ricci Yang-Mills solitons on nilpotent Lie groups.*

In this talk, I will define Ricci Yang-Mills solitons, which are generalized fixed points of the Ricci Yang-Mills flow. These metrics are related to Ricci solitons; however, they are defined on principal G-bundles and are designed to detect more of the bundle structure. On nilpotent Lie groups, one can say precisely in what sense Ricci Yang-Mills solitons are weaker than Ricci solitons. I will provide examples of 2-step nilpotent Lie groups that admit Ricci Yang-Mills solitons but that do not admit Ricci solitons. This is joint work with Mike Jablonski. (Received August 25, 2009)

1051-53-237 **Michael Jablonski*** (mjablonski@math.ou.edu), Department of Mathematics, University of Oklahoma, Norman, OK 73019-0315. *Applications of geometric invariant theory to the geometry of Lie groups with left-invariant metrics.*

We present the basic framework for studying (simply connected) Lie groups with left-invariant metrics from the perspective of being points in a variety of Lie structures. In this setting, isomorphism classes of Lie group structures correspond to orbits of a $GL_n\mathbb{R}$-action.

The geometry of these $GL_n\mathbb{R}$-orbits has strong implications on the types of left-invariant Riemannian metrics that a group can admit. In particular, one can understand the existence of Ricci soliton (resp. Einstein) metrics on nilpotent (resp. non-unimodular solvable) groups via geometric properties of these orbits. This is the study of so-called 'distinguished orbits'.

In the nilpotent case, we show that Ricci soliton metrics are the most 'symmetric' metrics that such a group can admit; that is, they have the largest isometry groups among all left-invariant metrics. Moreover, we obtain a nice decomposition of the automorphism group of nilpotent Lie groups which admit Ricci soliton metrics. (Received August 25, 2009)

54 ► General topology

1051-54-42 **Piotr Minc*** (mincpio@auburn.edu), Department of Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849-5310. *A monotonically irreducible map of a reducible continuum onto* $[0,1]$.

We construct a continuum X which not irreducible, and which admits a monotone map f onto $[0,1]$ such that f is monotonically irreducible in the following sense: For each closed proper subset D of X such that $f(D) = [0,1]$, f restricted to D is not monotone. The example answers a question by L. Mohler and L. E. Ward. (Received August 03, 2009)

1051-54-47 **Leobardo Fernandez*** (leobardof@ciencias.unam.mx), Instituto de Matematicas, UNAM., Circuito exterior, Ciudad Universitaria, Mexico D.F. CP 04510. Mexico., 04510 Mexico City, Mexico. *The set functions $\mathcal{T}$ and $\mathcal{K}$ on irreducible continua.* Preliminary report.

Given a continuum X, the set $C(X)$ is the set of all subcontinua of X. The *set function* $\mathcal{T}$ is defined as follows: for each $A \subseteq X$, $\mathcal{T}(A) = \{x \in X \mid$ if $W \in C(X)$ and $x \in Int(W)$, then $W \cap A \neq \emptyset\}$. Also, the *set function* $\mathcal{K}$ is defined as follows: for each $A \subseteq X$, $\mathcal{K}(A) = \bigcap\{W \in C(X) \mid A \subseteq Int(W)\}$. A continuum X is *irreducible* if there exist two points of X such that no proper subcontinuum of X contains both points. Some properties of the set functions $\mathcal{T}$ and $\mathcal{K}$ on irreducible continua are going to be presented. (Received August 04, 2009)

1051-54-109 **Wayne Lewis*** (waynelewistx@gmail.com), Dept. of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. *Homeomorphisms of the Pseudo-Arc.*

We discuss some observations, results and question about homeomorphisms of the pseudo-arc./ (Received August 20, 2009)

1051-54-124 **Isabel Puga*** (ispues@yahoo.com.mx), Departamento de Matematicas, Facultad de Ciencias, UNAM, Mexico city, Mexico, and **Rocio Leonel**. *Shore sets and points.*

In a paper in 1991 we introduced the concept of shore sets and points. Later the concept has been studied by Jo Heath and Van C. Nall. In this ocassion, we will recall some results and talk about some new results. (Received August 21, 2009)

1051-54-149 **Kevin B. Gammon*** (kgammon@troy.edu), 500 University Drive, Dothan, AL 36303. *The Cartesian product of the pseudo-arc and a pseudo-solenoid is factorwise rigid.*

The Cartesian product of two spaces is called factorwise rigid if any self homeomorphism can be written as a product homeomorphism. In 1983, D. Bellamy and J. Lysko proved that the Cartesian product of two pseudo-arcs is factorwise rigid. This argument relied on the fact that the pseudo-arc is chainable and therefore does not easily generalize to products involving non-chainable continua. In 2009, the author extended the result to the Cartesian product of the pseudo-arc and pseudo-circle. In this talk, the author provides an argument to extend the result for the Cartesian product of the pseudo-arc and a pseudo-solenoid. (Received August 23, 2009)

1051-54-179 **Eric L McDowell*** (emcdowell@berry.edu), Department of Mathematics and Computer Sci, 2277 Martha Berry Highway, Mount Berry, GA 30149. *Commuting Self-maps of the Unit Interval.*

It was conjectured in the mid-1950s that every pair of commuting self-maps of the unit interval must share a common fixed point. In 1967, John Philip Huneke and William M. Boyce independently produced a counterexample to this claim. We survey some of the literature regarding commuting functions and common fixed points and offer motivation for continued investigation. (Received August 24, 2009)

1051-54-201 **Van C Nall*** (vnall@richmond.edu), Department of Mathematics, University of Richmond, Richmond, VA 23173. *The Connectedness of Inverse Limits with Set Valued Functions.*

The inverse limit with a single set valued bonding map with a connected graph may not be connected. We will present some easy to verify conditions for the graph of the bonding map that guarantee the connectedness of the inverse limit. (Received August 25, 2009)

1051-54-202 **W. T. Ingram*** (ingram@mst.edu), 284 Windmill Mountain, Spring Branch, TX 78070. *Inverse limits with upper semi-continuous bonding functions: a problem set.*

Certain tools employed in the study of inverse limits with mappings fail in the setting of inverse limits with upper semi-continuous bonding functions. As frustrating as this may be, it presents a golden opportunity for research. We discuss some problems in the theory of inverse limits with set-valued functions most of which arise from this phenomenon. (Received August 25, 2009)

1051-54-206 **Dale Daniel*** (dale.daniel@lamar.edu), Lamar University, Department of Mathematics, Box 10047, Beaumont, TX 77710-0047. *A General Lifting Characterization of Images of Arcs.*

Let X be a continuum and G an upper semi-continuous decomposition of X. If each element of G and the quotient space X/G are continuous images of arcs, when is X the continuous image of an arc? We study this question by giving a very general characterization of such X that admit a lift to X of a map of an arc onto a quotient space of X. We then obtain a number of corollaries - some of which are new and some of which are already found in the literature. (Received August 25, 2009)

1051-54-225 **James E Keesling*** (kees@ufl.edu), Department of Mathematics, University of Florida, P.O. Box 118105, Gainesville, FL 32611-8105. *The Group of Homeomorphisms of Certain Inverse Limit Spaces.*

Many spaces in continuum theory are given as inverse limits. Attractors in dynamical systems can be shown to have that structure. Compact topological groups also have this structure with the inverse system consisting of Lie groups and the bonding maps continuous homomorphisms.

Even if the homeomorphisms are known for the spaces in the inverse system, the homeomorphisms of the limit may not be easily determined. This talk will examine the structure of the group of homeomorphisms for certain inverse limit spaces. (Received August 25, 2009)

1051-54-246 **Carlos Islas*** (carlos.islas@uacm.edu.mx), San Lorenzo 290, Col. del Valle, Del. Benito Juárez, 03100 México, D. F., Mexico. *On 2-equivalent continua.*

A continuum X is said to be 2-equivalent provided that X has only 2 nondegenerate, mutually non homeomorphic subcontinua. The simple closed curve and the simple triod are the only ones known 2-equivalent continua which are not irreducible. In this talk, we will prove that the 2-equivalent continua are either hereditarily decomposable or irreducible. Though the conjecture that we have is that the only ones 2 - equivalent irreducible continua are the mentioned ones before. Some examples will be presented. (Received August 25, 2009)

1051-54-256 **Alejandro Illanes*** (illanes@matem.unam.mx), Instituto de Matematicas, Circuito Exterior, Cd. Universidaria, 04510 Mexico, D.F., Mexico. *The circle is not the generalized inverse limit of a subset of a subset of the square.*

Given a closed subset of the square [0,1]x[0,1], we consider the generalized inverse limit as it was defined by Mahavier. Answering a question by Van Nall, we prove that a simple closed curve cannot be obtained as the generalized inverse limit of a subset of the square. (Received August 25, 2009)

1051-54-260 **Veronica Martinez-de-la-Vega*** (vmvm@matem.unam.mx), Instituto de Matematicas, Circuito Exterior, Cd. Universidaria, 04510 Mexico, D.F., Coyoacan, Mexico. *The generalized inverse limits and simple n-ods.*

In this talk I will discuss the problem of showing if we can obtain or not a simple 3-od or a simple n-od as the generalized inverse limit (of a closed subset of the square)defined by W. Mahavier. (Received August 25, 2009)

1051-54-262 **James T Rogers***, 2926 Calhoun St, New Orleans, LA 70118. *Some interesting things about continua.* Preliminary report.

We discuss some interesting things about continua (Received August 25, 2009)

57 ► Manifolds and cell complexes

1051-57-45 **Joseph E Borzellino*** (jborzell@calpoly.edu), Department of Mathematics, California Polytechnic State University, 1 Grand Avenue, San Luis Obispo, CA 93407, and **Victor Brunsden** (vwb2@psu.edu), Department of Mathematics and Statistics, Penn State Altoona, 3000 Ivyside Park, Altoona, PA 16601. *Spaces of Smooth Orbifold Mappings.*

A well-known result in the theory of differentiable dynamical systems states that the set of smooth maps between a compact manifold M and a manifold N has the structure of a smooth infinite-dimensional manifold. By considering only diffeomorphisms, one sees that $\mathrm{Diff}(M)$ is an infinite-dimensional group with a local smooth manifold structure. In this talk, I will discuss generalizations of this result to the group of orbifold diffeomorphisms. Time permitting, I will discuss some recent work on analogous results for other classes of smooth orbifold maps. Part of the talk will review orbifolds and the mappings between them. (Received August 04, 2009)

1051-57-222 **Paul A Fabel*** (fabel@ra.msstate.edu), Drawer MA, Mississippi State, MS 39762. *Prime end theory and inverse limits of Hadamard spaces.* Preliminary report.

Stamdard prime end theory has strong ties to inverse limits of compact Hadamard spaces.

For example every contractible open planar set U admits a canonical internal metric whose completion is a Hadamard space, realized as the closure of a nested sequence of compact convex subspaces.

Moreover the topological inverse limit of the factors is the familiar closed unit disk, and U invariant homeomorphisms of the closure of U are semiconjugate to homeomorphisms of the inverse limit space.

This approach yields a new way of constructing higher dimensional analogues of standard prime end theory so that the aforementioned properties remain valid. (Received August 25, 2009)

1051-57-241 **F. T. Farrell** and **J.-F. Lafont*** (jlafont@math.ohio-state.edu). *Marked length spectrum and diffeomorphism type.*

I will discuss examples of pairs of aspherical smooth manifolds having the same marked length spectrum, but having the property that the isomorphism of fundamental groups cannot be realized by any diffeomorphism between the manifolds. The examples are constructed via the Sunada method, and require finding Sunada pairs exhibiting certain specific cohomological properties. This is joint work with F. T. Farrell (Binghamton University). (Received August 25, 2009)

58 ► Global analysis, analysis on manifolds

1051-58-31 **Zhuang-dan Daniel Guan*** (zguan@math.ucr.edu), Department of Mathematics, University of California, at Riverside, Riverside, CA 92521. *compact solvmanifolds with symplectic structures must have at most three steps.*

Thurston used the Kodaira-Thurston manifold as the first example of compact nonkahler symplectic manifold. There are many interests in the compact solvmanifolds with symplectic structures in the last thirty years. Recently, we finally proved a conjecture that the corresponding solvable Lie group has a trivial third commutator. This gave a very strong topological obstruction for the fundamental group of this kind of manifolds and leads to a program to classify this kind of manifolds. (Received July 24, 2009)

1051-58-59 **Juan B. Gil**, Penn State Altoona, Mathematics and Statistics, 3000 Ivyside Park, Altoona, PA 16601, **Thomas Krainer*** (krainer@psu.edu), Penn State Altoona, Mathematics and Statistics, 3000 Ivyside Park, Altoona, PA 16601, and **Gerardo A. Mendoza**, Temple University, Department of Mathematics, Philadelphia, PA 19122. *Trace expansions for elliptic cone operators.*

We give a full asymptotic expansion of the trace of the resolvent of an elliptic cone differential operator as the spectral parameter tends to infinity. The hypotheses involve only minimal conditions on the symbols of the operator. In particular, our results are applicable to generic closed extensions of not necessarily symmetric elliptic operators on compact manifolds with conical singularities. (Received August 10, 2009)

1051-58-75 **Franz W. Kamber*** (kamber@math.uiuc.edu), Department of Mathematics, 1409 W. Green Street, Urbana, IL 61801, and **Kenneth S. Richardson**. *Decompositions of equivariant vector bundles.* Preliminary report.

We investigate various decompositions of equivariant vector bundles over manifolds with a single orbit-type; that is, manifolds all of whose isotropy groups are conjugate. These decompositions are constructed relative to the fixed point set of an isotropy group.

The main application is as follows:

In a forthcoming paper, we prove explicit formulas for the equivariant indices of equivariant differential operators which are transversally elliptic with respect to the action of a compact Lie group. The indices are computed as a sum over the strata of the group action on the base manifold, which are of the above type, i. e. they have a single orbit-type. (Received August 20, 2009)

1051-58-77 **Igor Prokhorenkov*** (i.prokhorenkov@tcu.edu), Department of Mathematics, TCU Box 298900, Fort Worth, TX 76129, and **Ken Richardson** (k.richardson@tcu.edu), Department of Mathematics, TCU Box 298900, Fort Worth, TX 76129. *Natural Equivariant Dirac Operators.*

We describe a new class of natural, explicitly defined, transversally elliptic differential operators over manifolds with compact group actions. Under certain assumptions, the symbols of these operators generate all the possible values of the equivariant index. Moreover, the components of the representation-valued equivariant index coincide with those of an elliptic operator constructed from the original data. (Received August 13, 2009)

1051-58-85 **Krystyna M Kuperberg*** (kuperkm@auburn.edu), Department of Mathematics and Statistics, 221 Parker Hall, Auburn, AL 36849. *Periodic points near an adding machine.* Preliminary report.

Let $\mathbf{C}$ be the Cantor set $\Pi_{n=1}^{\infty}\mathbb{Z}/k_n\mathbb{Z}$ associated with the sequence of integers $(k_1, k_2, k_3, \ldots)$, each greater than one. An adding machine is a homeomorphism $\alpha : \mathbf{C} \to \mathbf{C}$ such that if $\alpha(i_1, i_2, i_3, \ldots) = (j_1, j_2, j_3, \ldots)$, then

(1) if for $m \geq 1$, $i_n = k_n - 1$ for $n < m$ and $i_m < k_m - 1$, then $j_n = 0$ for $n < m$, $j_m = i_m + 1$, and $j_n = i_n$ for $n > m$,

(2) if $i_m = k_m - 1$ for all $m \geq 1$, then $j_m = 0$ for all $m \geq 1$.

Assume that $\mathbf{C}$ is a subset of the plane $\mathbb{R}^2$ and let $h : \mathbb{R}^2 \to \mathbb{R}^2$ be a homeomorphism such that h restricted to $\mathbf{C}$ is an adding machine. We investigate the existence of points close to $\mathbf{C}$ that are periodic under h. (Received August 16, 2009)

1051-58-173 **Christine M Guenther*** (guenther@pacificu.edu), Department of Mathematics and Computer Scienc, 2043 College Way, Pacific University, Forest Grove, OR 97116. *Some preliminary results on the second order renormalization group flow.* Preliminary report.

The geometric evolution equation

$$\frac{\partial g}{\partial t} = -2Rc - \frac{\alpha}{2}Rm^2$$

arises as the second order renormalization group flow of quantum field theory. (Here g is a Riemannian metric, Rc is the Ricci curvature tensor, $Rm_{ij} = g^{rs}g^{mn}g^{kl}R_{irmk}R_{jsnl}$, and $\alpha << 1$ is a parameter.) It has been of interest to physicists, but as yet little is known about it mathematically. In this talk we will present a basic introduction to the equation, and some preliminary results obtained by geometric analytical methods. (Received August 24, 2009)

1051-58-195 **Catherine E Searle*** (csearle@matcuer.unam.mx), IMATE-UNAM Cuernavaca, Av. Universidad s/n, Col. Lomas de Chamilpa, 62210 Cuernavaca, Morelos, Mexico, and **Fernando Galaz-Garcia** (fernando.galazgarcia@gmail.com), Muenster, Germany.
3-Dimensional Cohomogeneity One Aleksandrov Spaces. Preliminary report.

We classify closed, 3-dimensional, cohomogeneity one Alexandrov spaces. As a corollary, we obtain the classification of closed, n-dimensional, cohomogeneity one Alexandrov spaces admitting an isometric T^{n-1} action. (Received August 25, 2009)

60 ► Probability theory and stochastic processes

1051-60-27 **Berton A Earnshaw*** (earnshaw@math.msu.edu) and **James P Keener** (keener@math.utah.edu). *Global asymptotic stability of solutions of nonautonomous master equations: extensions of van Kampen's theorem.*

From chemical reactions to ion channel kinetics, many stochastic processes in biology are modeled as finite-state, continuous-time jump process. Under mild assumptions on the transition rates, one derives a *master equation* (ME) governing the evolution of the probability distribution for the process. When the ME is autonomous, van Kampen proved that, with additional constraints on the (constant) transition rates, all probability distribution solutions of the ME converge to a unique stationary distribution in the long-time limit.

However, most biological processes are subject to nonstationary, external forces that are either unknown or difficult to model. In these cases the ME is necessarily nonautonomous, yet one still wants to understand the long-time behavior of the probability distribution solutions. In this talk we demonstrate how a variety of different constraints on the nonconstant transition rates ensure that the probability distribution solutions of the ME are globally asymptotically stable, thus extending van Kampen's theorem. By constructing counterexamples, we show that certain natural assumptions on the transition rates do not in general ensure that the probability distribution solutions of the associated ME are globally asymptotically stable. (Received July 21, 2009)

1051-60-39 **Hakima Bessaih*** (bessaih@uwyo.edu), Department of Mathematics,Dept. 3036, 1000 East University Avenue, Laramie, WY 82071, and **Franco Flandoli** and **Edriss S Titi**.
Long time behavior for stochastic shell phenomenological models of turbulence. Preliminary report.

In a recent paper, it has been proposed that the nonlinear deterministic shell model of turbulence and the passive scalar equation have the same scaling exponents of the structure functions. This relationship has been established through a coefficient λ. In this paper, we deal with the stochastic shell model of turbulence driven by an additive noise. We prove the continuous dependence of the solutions with respect to the parameter λ. We prove the existence of a finite dimensional random attractor for each value of λ and the property of upper semicontinuity of this random attractor. This property is proved by a pathwise argument. We hope that this result or the technique involved may contribute to understand the problem of $T \longrightarrow \infty$. (Received July 31, 2009)

1051-60-88 **Sivaditya Kaligotla** (kaligotl@usc.edu), Department of Mathematics, USC, 3620 S. Vermont Av. KAP 108, Los Angeles, CA 90089, and **Sergey Lototsky*** (lototsky@usc.edu), Department of Mathematics, USC, 3620 S. Vermont Av., KAP 108, Los Angeles, CA 90089. *A stochastic Burgers equation: Bringing together chaos expansion, embedding theorems, and Catalan numbers.*

A special stochastic perturbation of the Burgers equation is considered. The nature of the perturbation is such that the solution is not square-integrable, and the growth of the norms at different stochastic scales is described by the Catalan numbers. Many similar equations with quadratic nonlinearity exhibit the same behavior. (Received August 16, 2009)

62 ► Statistics

1051-62-87 **Grzegorz A Rempala*** (grempala@mcg.edu), 1469 Laney Walker Blvd, (Pavilion I) AE-1005, Augusta, GA 30912. *Algebraic Statistical Model for Inferring Biochemical Reactions Network.*

Algebraic statistical model is a set of polynomial equations mapping the set of parameters into a probability simplex. The idea of such model is useful for finding MLEs via direct inspection (with algebraic-geometric methods) of all zeros of the score equations and has been applied for instance to certain comparative genomics

problems as well as to developing extensions of the Fisher exact test in contingency tables. The talk shall present yet another application of algebraic statistical models which is related to statistical inference for biochemical reactions and possibly also useful in discovering genetic networks. (Received August 16, 2009)

65 ► Numerical analysis

1051-65-49 **Beatrice Riviere*** (riviere@rice.edu), 6100 Main Street MS-134, Houston, TX 77005. *Numerical Methods for Solving the Miscible Displacement Problem.*

The miscible displacement of a solvent with a resident fluid occurs in tertiary oil recovery processes. The resulting mathematical model is a system containing an elliptic equation for the fluid pressure coupled with a convection dominated parabolic equation for the concentration of the solvent.

This talk presents high order schemes for solving the coupled pressure and concentration equations. The underlying discretization techniques employ the finite element method, the mixed element method and the discontinuous Galerkin method. Convergence results are obtained, under minimal regularity assumptions. (Received August 05, 2009)

1051-65-51 **Qin Sheng*** (Qin_Sheng@baylor.edu), Department of Mathematics, CASPER, Baylor University, Waco, TX 76798-7328, **Shekhar Guha**, Air Force Research Laboratory, 2977 Hobson Way, Wright Patterson AFB, Dayton, OH 45433-7702, and **Leonel Gonzalez**, Air Force Research Laboratory, 2977 Hobson Way, Wright Patterson AFB, Dayton, OH 45433-7702. *Adaptive splitting finite difference methods for solving singular equations.* Preliminary report.

Different splitting methods have been playing an important role in the numerical solution of nonsingular differential equation problems due to their remarkable efficiency, simplicity and flexibility in computations as compared with their peers. Although the numerical strategy is still in its infancy for solving singular differential equation problems arising from many applications, explorations of the next generation decomposition schemes associated with various kinds of adaptations can be found in many recent work. In the talk, key explorations will be given to two particularly interesting issues, that is, direct solutions of degenerate singular reaction-diffusion equations and nonlinear optical wave equations. Simulated results will also be given. (Received August 06, 2009)

1051-65-194 **Weiming Cao*** (wcao@math.utsa.edu), One UTSA Circle, San Antonio, TX 78249, and **Borries Demeler**, San Antonio, TX 78249. *Adaptive Finite Element Methods for Analytic Ultracentrifugation Analysis.*

Analytic ultracentrifugation analysis (AUC) is a commonly used tool in biochemstry and biology to determine various stoichiometries of the molecules in solutions. The ultracentrifugation experiments can be modeled by a system of advection-diffusion-reaction equations (the Lamm equations), and AUC is essentially an inverse problem to identify the coefficients in these equations. Therefore, efficient and accurate solution of these equations is critical to the resolution and reliablity of AUC. In this talk, we shall present our recent results on the development of the adaptive space-time finite element methods for solving the Lamm equations. Various systems involving ideal/non-ideal, interacting/non-interacting species are considered. (Received August 24, 2009)

1051-65-197 **Jianzhong Su*** (su@uta.edu), Department of Mathematics, University of Texas at Arlington, Arlington, TX 76019, and **Humberto Perez Gonzales**, **Michail Todorov**, **Hristo Kojouharov** and **Liping Tang**. *A mathematical model for foreign body reactions.* Preliminary report.

The foreign body reactions are commonly referred to the network of immune and inflammatory reactions of human or animals to foreign objects placed in tissues. They are basic biological processes, and are also highly relevant to bioengineering applications in implants, as fibrotic tissue formations surrounding medical implants have been found to substantially reduce the effectiveness of devices. Despite of intensive research on determining the mechanisms governing such complex responses, few mechanistic mathematical models have been developed to study such foreign body reactions. This study focuses on a kinetics-based predictive tool in order to analyze outcomes of multiple interactive complex reactions of various cells/proteins and biochemical processes and to understand transient behavior during the entire period (up to several months). A computational model in two spatial dimensions is constructed to investigate the time dynamics as well as spatial variation of foreign body reaction kinetics. The simulation results have been consistent with experimental data and the model can facilitate quantitative insights for study of foreign body reaction process in general. (Received August 25, 2009)

1051-65-239 **Shekhar Guha***, Materials and Manufacturing Directorate, AFRL, WPAFB, OH 45433, **Leonel Gonzalez**, Materials and Manufacturing Directorate, AFRL, WPAFB, OH 45433, and **Qin Sheng** (qin_sheng@baylor.edu), Department of Mathematics, Baylor University, One Bear Place, Waco, TX 76798-7328. *Comparison of Transform Method and Local One-Dimensional Method in Description of Tightly Focused Light Propagation Through Nonlinear Optical Materials.* Preliminary report.

Light propagation is described by Maxwell's wave equation which can be solved using many different techniques. Readily available fast Fourier Transform (FFT) software makes the transform method an attractive way to solve the equation. An alternative technique is the local one dimension (LOD) method in which the wave equation is cast in the finite difference form and propagation in the two transverse dimensions are solved one at a time. This method is attractive because of the simplicity in programming and it doesn't need a pre-packaged transform program. For light propagation in cases of tight focusing, especially when nonlinear optical effects in materials are included, both methods run into computational challenges. In this work we will describe some of the challenges and compare the two schemes in their ability to tackle them. (Received August 25, 2009)

70 ► Mechanics of particles and systems

1051-70-155 **Barbara Shipman*** (bshipman@uta.edu), Department of Mathematics, Box 19408, Arlington, TX 76019-0408. *Toda flows on homogeneous spaces.*

This talk will explain how group actions on homogeneous spaces help in understanding the structure of iso-level sets associated with the completely integrable system known as the Toda lattice. Each version of the Toda lattice evolves on a space of matrices according to a hierarchy of iso-spectral flows in Lax form. Singularities in the flows are completed by embedding the system into a homogeneous space, where the flows generate group actions. The type of spectrum determines the group that arises from the flows, ranging from a diagonal torus when the eigenvalues are distinct to a unipotent group when all eigenvalues coincide. (Received August 23, 2009)

76 ► Fluid mechanics

1051-76-43 **Mallikarjunaiah S Muddamallappa** and **Dambaru Bhatta*** (bhattad@utpa.edu), Department of Mathematics, The University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539, and **Daniel N Riahi**. *On convective instability & transition to turbulence in a mushy layer.* Preliminary report.

The problem of nonlinear convective flow in a mushy layer with permeable mush-liquid interface is studied under operating conditions for an experiment. A Landau type nonlinear evolution equation for the amplitude of the stationary mode, which is based on the Landau theory and formulation for the Rayleigh number close to its critical value, is developed. Using numerical and analytical methods, the solutions to the evolution equation were calculated for both supercritical and subcritical conditions. The results including those about the types of transition to turbulence that can occur in such a flow system are discussed. (Received August 04, 2009)

1051-76-53 **Annick Pouquet*** (pouquet@ucar.edu), PO Box 3000, Boulder, CO 80307, and **Julien Baerenzung**, **Pablo Mininni** and **Duane Rosenberg**. *Combining rotation and helicity in turbulent flows and the emergence of strong and persistent cyclonic columnar vortices.*

Rotation, measured by the Rossby number Ro, is important in geophysics. When rapid, weak turbulence prevails but at high Reynolds number Re, this regime breaks down.

The effect of helicity, measuring departures from mirror symmetry, unclear without rotation, is significant at low *Ro*. Using direct numerical simulations with 1536^3 grid points, we show the occurence of long-lived laminar cyclonic vortices together with turbulent vortices, reminiscent of recent tornado observations but in a simpler physical context. The small-scale energy cascade (of spectrum $\sim k^e$ and transfer rate μ) is self-similar with no deviations from Gaussianity and dominated by the helicity cascade (of spectrum $\sim k^h$ and transfer rate ν). This points to the discovery of a new small parameter in rotating helical turbulence, $\sim \mu/\nu$. We also find that the spectral indices obey $e + h = -4$ when taking into account the inertial wave mediation of nonlinear transfer to small scales.

We then perform a parametric study, using a subgrid model with helical transport coefficients, up to Re$\sim 10^5$ and down to Ro $\sim$ 0.005. At fixed Re, strong rotation leads to this new regime, whereas one recovers the Kolmogorov law when increasing Re at fixed rotation rate. (Received August 07, 2009)

1051-76-60 **Lokenath Debnath*** (debnathl@utpa.edu), University of Texas-Pan American, Department of Mathematics, 1201 West University Drive, Edinburg, TX 78539-2999. *Fourier Transforms and Wavelet Transforms in Turbulence.*

Some problems in the study of turbulence will be presented. Turbulence based on the Euler equations and the Navier-Stokes equations will be discussed. Included are the Fourier and the wavelet transforms analysis of turbulent flows. (Received August 11, 2009)

1051-76-63 **Boris Levant**, Department of Computer Science & Applied Math, The Weizmann Institute of Science, 76100 Rehovot, Israel, **Fabio Ramos**, Department of Computer Science & Applied Math, The Weizmann Institute of Science, 76100 Rehovot, Israel, and **Edriss S. Titi*** (etiti@math.uci.edu), Department of Mathematics, The University of California, Irvine, CA 92697-3875. *On the Statistical Properties of the 3D Incompressible Navier-Stokes-Voigt Model.*

The Navier-Stokes-Voigt (NSV) model of viscoelastic incompressible fluid has been recently proposed as a regularization of the 3D Navier-Stokes equations for the purpose of direct numerical simulations. In this talk I will present results concerning its statistical properties by employing phenomenological heuristic arguments, in combination with Sabra shell model simulations of the analogue of the NSV model. For large values of the regularizing parameter, compared to the Kolmogorov length scale, simulations exhibit multiscaling inertial range, and the dissipation range displaying low intermittency. These facts provide evidence that the NSV regularization may reduce the stiffness of direct numerical simulations of turbulent flows, with a small impact on the energy containing scales. (Received August 11, 2009)

1051-76-90 **Eleftherios Gkioulekas*** (gkioulekase@utpa.edu), University of Texas-Pan American, Department of Mathematics, 1201 West University Drive, Edinburg, TX 78539-2999. *Dissipation range and anomalous sinks in steady two-dimensional turbulence.*

In my talk, I will discuss a new theoretical framework for understanding the robustness (or lack thereof) of the cascades of two-dimensional Navier-Stokes turbulence. The mathematical framework underlying our analysis is the infinite system of balance equations that govern the generalized unfused structure functions, first introduced by L'vov and Procaccia. As a point of departure we use a revised version of the system of hypotheses that was proposed by Frisch for three-dimensional turbulence. We show that both the enstrophy cascade and the inverse energy cascade are local in the sense of non-perturbative statistical locality. We also investigated the stability conditions for both cascades. We have shown that statistical stability with respect to forcing applies unconditionally for the inverse energy cascade. For the enstrophy cascade, statistical stability requires large-scale dissipation and a vanishing downscale energy dissipation. Finally, we have shown that the anomalous sink hypothesis follows as a consequence of our hypotheses. (Received August 17, 2009)

1051-76-102 **mogens v melander*** (melander@smu.edu), Dept of Mathematics, SMU, Dallas, TX 75256. *The question of universal scaling coefficients for inertial range structure functions.*

In the inertial range of homogeneous isotropic turbulence with large scale forcing the structure functions are statistical moments that depend parametrically on a length scale l. For each moment, the scaling dependence with respect to l takes the form of a power law and is thus characterized by an exponent, a coefficient, and a virtual origin. The scaling exponent is generally believed to be a universal function of the moment order p. In contrast, the coefficient is not believed to be a universal function of p. Only when p is three or zero are universal values of the coefficient accepted. For other values of p one finds arguments in the literature that the coefficients can't be universal. One such agument against universality is due to Landau. Other arguments build on the fact that the large scales are governed by the forcing which is essentially arbitrary. Supposedly, universal coefficients are in conflict with arbitrariness at the large scales, or so the argument goes. By a counterexample we show that there need not be any such conflict. Hopefully, this will clear the way for the idea of universal scaling coefficients for the inertial range. (Received August 19, 2009)

1051-76-125 **Nusret Balci**, **Ciprian Foias** and **Michael S Jolly*** (msjolly@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405. *2-D Turbulence for Time-dependent Forces with Large Gaps in their Spectra.* Preliminary report.

We discuss the existence of both an inverse cascade of energy and a direct cascade of enstrophy for the 2-D Navier-Stokes equations driven at two widely separated scales. It is assumed that on average the bulk of the time-dependent force is at the smaller scales. (Received August 21, 2009)

1051-76-126 **Nusret Balci** (msjolly@indiana.edu), 4240 E. Penn Ct., Bloomington, IN 47408, **Ciprian Foias***, Texas A&M University, Department of Mathematics, Mailstop 3368, College Station, IN 77843, and **Michael S Jolly** (msjolly@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405. *On the Statistics of the Global Attractor of the 2-D Navier-Stokes Equations.*

We discuss rigorous estimates related to 2-D turbulence for time independent forcing at all scales. This blends previous work for time-dependent forces using finite time averages with other work using invariant measures for autonomous flows. (Received August 21, 2009)

1051-76-146 **N. Balci*** (nubalci@indiana.edu), Institute for Mathematics and its Application, University of Minnesota, 114 Lind Hall 207 Church Street S.E., Minneapolis, MN 55455, and **C. Foias** and **M. S. Jolly**. *Vertical Averages of the RBE.* Preliminary report.

We discuss the vertical spatial averages of the Rayleigh-Benard equations from the 2D turbulence point of view, and derive analogs of some fundamental relations in the mathematical theory guided by Kraichnan's heuristic/phenomenological theory of 2D turbulence, including bounds on the dissipation range, the 2D analog of Kolmogorov's dissipation law, and the wave numbers related to the cascade phenomena. We compare the results with the 2D periodic NSE with time-dependent general forcing. (Received August 23, 2009)

1051-76-178 **Igor Kukavica**, **Amjad Tuffaha*** (tuffaha@usc.edu) and **Mohammed Nabil Ziane**. *Strong Solutions to a System of Nonlinear Fluid-Structure Interactions.* Preliminary report.

We consider the existence of local-in-time strong solutions to a system of two partial differential equations arising in Fluid-Structure interactions and consisting of an incompressible Navier-Stokes equation as well as an elastic equation with velocity and stress matching boundary conditions at the interface in between the two domains where each of the two equations is defined. We discuss existence results for different types of initial data and differences between domains with flat boundaries versus non-flat boundaries. (Received August 24, 2009)

1051-76-180 **Radu Dascaliuc*** (rd5bw@virginia.edu), Department of Mathematics, University of Virginia, Cherlottesville, VA 22904. *On energy cascades in 2D flows.*

We rigorously show that in a flow modeled by 2D space-periodic Navier-Stokes equations, an energy cascade can exist only on a very narrow band on wavenumbers. (Received August 24, 2009)

1051-76-227 **Roman Shvydkoy*** (shvydkoy@math.uic.edu), MSCS, M/C249, 851 S. Morgan St., Chicago, IL 60302. *On the Onsager conjecture for two dimensional stational Euler equations.* Preliminary report.

In this talk we will describe an attempt to construct a stationary solution to the Euler equations in 2D with Onsager-critical smoothness, which does not satisfy the energy balance relation. (Received August 25, 2009)

1051-76-228 **John C. Bowman*** (bowman@math.ualberta.ca), Department of Mathematical Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *Casimir Cascades in Two-Dimensional Turbulence.* Preliminary report.

It is well known that, in addition to energy and enstrophy, the nonlinearity of 2D turbulence conserves the global integral of an arbitrary C^1 function of the scalar vorticity field. However, the direction of transfer of such quantities in wavenumber space remains unclear. Numerical investigations of this problem are hampered by the fact that pseudospectral simulations, which necessarily truncate the wavenumber domain, do not conserve global integrals of arbitrary powers of the vorticity. A fundamental question is whether, in addition to the *rugged* quadratic energy and enstrophy invariants (which do survive spectral truncation), the higher order invariants also play an underlying role in the turbulent cascade.

Polyakov's minimal conformal field theory model has suggested that the higher-order Casimir invariants cascade to large scales, while Eyink suggests that they might instead cascade to small scales. We develop estimates for the degree of nonconservation of the Casimir invariants and demonstrate, using sufficiently well-resolved simulations, that the fourth power of the vorticity cascades to small scales. We also attempt to measure the decay rate of Casimir invariants in the presence of viscosity and compare to earlier work of Câteau *et al.* (Received August 25, 2009)

1051-76-238 **Milton C. Lopes Filho** (mlopes@ime.unicamp.br), Departamento de Matematica, IMECC, Universidade Estadual de Campinas – UNICAMP, Caixa Postal 6065, Campinas, SP 13083-970, Brazil, **Helena J. Nussenzveig Lopes*** (hlopes@ime.unicamp.br), Departamento de Matematica, IMECC, Universidade Estadual de Campinas – UNICAMP, Caixa Postal 6065, Campinas, SP 13083-970, Brazil, and **Steven Schochet** (schochet@post.tau.ac.il), School of Mathematical Sciences, Tel Aviv University, Ramat Aviv, 69978 Tel Aviv, Israel. *On the equivalence of the Birkhoff-Rott and Euler descriptions of vortex sheet evolution.*

We consider the evolution of a vortex sheet in two-dimensional incompressible and inviscid fluid flow, i.e., a curve on which vorticity is concentrated. This is a classical example of interface dynamics.

The vortex sheet evolution problem has been addressed, in the literature, by either explicitly propagating the interface, using the Birkhoff-Rott equations, or by embedding it in a weak solution of the Euler equations. In this talk we present a sharp criterion for the equivalence of these two descriptions of vortex sheet dynamics. (Received August 25, 2009)

1051-76-245 **Chao Xie*** (xie@math.ohio-state.edu), 231 W 18th Ave, Columbus, OH 43210. *Singularities in the unphysical complex plane for deep water waves.*

This work resolves some questions on singularities in deep water waves by tracking singularities in the unphysical domain and relating their close approach to the real axis with wave breaking.

The main result is the direct verification of Tanveer's result. A boundary integral technique is used to simulate deep water wave motion. A spectral procedure is used to form-fit the Fourier spectrum of the curvature of the wave profile to a prescribed asymptotic expression. The form-fit provides information on the power and location of the closest singularity to the real axis. The power of the singularity is -3/2 when the curvature is expressed as a function of the Lagrangian variable. This is associated with a pole singularity in the complex arclength plane, and is not an artifact of the parametrization. The singularity approaches the real axis when a plunging breaker occurs. For nonbreaking waves, the singularity wanders above some level in the unphysical plane. It is established that this singularity is theoretically equivalent to Tanveer's one-half power singularity. When the surface elevation is viewed as a function of horizontal distance, a square root type singularity arises that takes the form of a breaking wave when it reaches the real axis of the horizontal coordinate. (Received August 25, 2009)

1051-76-258 **M. Taylan Sengul*** (msengul@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405, and **Shouhong Wang**, Department of Mathematics, Indiana University, Bloomington, IN 47405. *Dynamic Transitions for the MHD Equations.*

In this talk, I shall present the dynamic stability and transitions for the basic solutions of the magnetohydrodynamic equations, using the recently developed dynamic transition theory. (Received August 25, 2009)

81 ► Quantum theory

1051-81-37 **Indranil Sen Gupta*** (sengupta@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. *Spectral analysis of the three dimensional Dicke Superradiance problem.*

Superradiance has been attracted the attention of many physicists and chemists since the pioneering work of Dicke (Phys. Rev., 93 , 99 , 1954) on spontaneous radiations. This problem is reduced to finding all the eigenfunctions of some integral equation. Slepian, Landau and Pollak (Prolate Spheroidal Wave Functions, Fourier Analysis and Uncertainity- I - V , Bell System technical journal) considered an integral equation related to the one-dimensional superradiance problem in a different context of communication theory and obtained prolate spheroidal functions as the eigenfunctions. In our work we will consider 3-dimensional superradiance problem and find a differential operator that commutes with the integral operator related to the problem. We find all the eigenfunctions of the differential operator and obtain a complete set of eigensolutions for the 3-dimensional superradiance problem. (Received August 26, 2009)

1051-81-136 **Guglielmo Fucci*** (Guglielmo_Fucci@Baylor.edu), Department of Mathematics, Baylor University, One Bear Place #97328, Waco, TX 76798-7328. *Non-Perturbative Electrodynamics in Curved Spacetime.*

In this talk we will present very recent results obtained in the ambit of quantum electrodynamics in curved spacetime. We utilize a newly developed non-perturbative heat kernel asymptotic expansion on homogeneous Abelian bundles over Riemannian manifolds in order to compute the one-loop effective action for scalar and

spinor fields in curved spacetime under the influence of a strong covariantly constant electromagnetic field. In this framework we derived, in particular, the gravitational corrections, up to linear terms in Riemannian curvature, to Schwinger's result for the creation of particles in an electromagnetic field. (Received August 21, 2009)

1051-81-141 **Lev Kaplan*** (lkaplan@tulane.edu), Department of Physics, Tulane University, New Orleans, LA 70118. *Quantum Vacuum Energy in Graphs and Billiards.*

The Vacuum (Casimir) energy in quantum field theory is a problem relevant both to new nanotechnology devices and to dark energy in cosmology. The crucial question is the dependence of the energy on the system geometry under study. Despite much progress since the first prediction of the Casimir effect in 1948 and its subsequent experimental verification in simple geometries, even the sign of the force in nontrivial situations is still a matter of controversy. Mathematically, vacuum energy fits squarely into the spectral theory of second-order self-adjoint elliptic linear differential operators. Specifically, one promising approach is based on the small-t asymptotics of the cylinder kernel $e^{-t\sqrt{H}}$, H being the self-adjoint operator in question. In contrast with the well-studied heat kernel e^{-tH}, the cylinder kernel depends in a non-local way on the geometry of the problem. We discuss some recent results by the Louisiana-Texas-Oklahoma collaboration on vacuum energy in model systems, including quantum graphs and two-dimensional manifolds with boundary. The results may shed light on general questions, including the relationship between vacuum energy and periodic or closed classical orbits, and the contribution to vacuum energy of boundaries, edges, and corners. (Received August 22, 2009)

1051-81-167 **Seung-Moon Hong*** (seungmoon.hong@utoledo.edu), Department of Mathematics, 2801 W. Bancroft Street, Toledo, OH 43606. *On symmetrization of 6j-symbols and Levin-Wen Hamiltonian.*

We will talk about spherical fusion categories and their 6j-symbols. More specifically the 6j-symbols in the well-known examples are invariant under the symmetry group of the tetrahedron. V. Turaev showed that a ribbon category with unimodality allows symmetrized 6j-symbols, and which implies that the state sum model on closed 3-manifold is invariant under the bistellar moves on triangulations. However this need not be the case in general. We define the mirror conjugate symmetry of 6j-symbols instead and show that 6j-symbols of any unitary spherical category can be normalized to have this property.

As an application, we discuss an exactly soluble model on a honeycomb lattice. For the Levin-Wen Hamiltonian on a honeycomb lattice, it was assumed that the 6j-symbols have tetrahedral symmetry and it was shown that the Hamiltonian is exactly soluble. Levin and Wen also asserted in the paper that the Hamiltonian is hermitian. We prove that the Levin-Wen Hamiltonian is exactly soluble and hermitian on a unitary spherical category. In the proof, the mirror conjugate symmetry plays an important role. (Received August 24, 2009)

82 ► Statistical mechanics, structure of matter

1051-82-40 **Ricardo Alonso**, Rice University, Department of Applied Mathematics, Houston, TX, **Emanuel Carneiro**, Institute for Advanced Study, School of Mathematics, Princeton, NJ , and **Irene M. Gamba*** (gamba@math.utexas.edu), The University of Texas at Austin, Department of Mathematics and ICES, Austin, TX 78712. *Convolution estimates for the Boltzmann Transport Equation and classical solutions and stability near Maxwellian data.*

We focus on the study of existence and uniqueness of distributional and classical solutions to the Cauchy Boltzmann problem case assuming S^{n-1}-integrability of the angular part of the collision kernel (Grad cut-off assumption) with data near Maxwellian distributions.

We will show convolution estimates of Young's inequality type for the case of hard potentials, Hardy-Littlewood-Sobolev type inequality for soft potentials [ACG]. The main technique is radial average symmetrization using classical tools of harmonic analysis. Then, using the Kaniel-Shinbrot iteration we present elementary proofs of existence for initial data near local Maxwellians [AG] to obtain globally bounded solutions for soft potentials. We also study the propagation of regularity using the convolution estimates estimate for the gain operator, and an L^p-stability result, with $1 < p < \infty$.

References

[ACG] R. Alonso, E Carneiro and I.M.Gamba, *Convolution inequalities for the Boltzmann collision operator*, submitted for publication (2009).

[AG] R. Alonso and I.M.Gamba, *Distributional and classical solutions to the Cauchy Boltzmann problem for soft potentials with integrable angular cross section*, submitted for publication (2009) (Received August 02, 2009)

83 ► Relativity and gravitational theory

1051-83-108 **Jennie D'Ambroise*** (dambroise@math.umass.edu), P.O. Box 192, Amherst, MA 01004. *Elliptic functions in cosmology.*

In general, Einstein's gravitational field equations of the theory of general relativity cannot be solved exactly. One case in which exact solutions are possible is the Friedmann-Lemaître-Robertson-Walker (FLRW) model, in which one assumes that on large scales our current universe is homogeneous and isotropic. We will show that the resulting equations have solutions in terms of elliptic functions, which are the simplest of non-elementary functions and are known to appear in many branches of physics. In particular we will write these solutions in terms of Jacobi or Weierstrass elliptic functions, and in some cases also show an equivalent expression in terms of theta functions. (Received August 20, 2009)

92 ► Biology and other natural sciences

1051-92-18 **M. Reed*** (reed@math.duke.edu), Department of Mathematics, Science Drive, Duke University, Durham, NC 27705, and **J. Best** and **H. F. Nijhout**. *Passive and Active Stabilization of Dopamine in the Striatum.*

Parkinson's disease is a neurodegenerative disorder associated with cell loss from the substantia nigra pars compacta (SNc). The dopaminergic cells of the SNc project to the striatum where the loss of dopaminergic tone is thought to be the main cause of Parkinsonism symptoms. Dopamine in the extracellular space in the striatum remains remarkably stable as SNc cells are lost, consistent with the observation that symptoms do not appear until cell loss is very advanced. A recent mathematical model of dopamine synthesis, release, and reuptake, constructed with J. Best and H. F. Nijhout, is used to investigate this phenomenon. (Received June 24, 2009)

1051-92-20 **Peter S. Kim*** (kim@math.utah.edu), University of Utah, Mathematics Department, 155 S 1400 E, Room 233, Salt Lake City, UT 84112-0090, and **Peter P. Lee** and **Doron Levy**. *Emergent dynamics governed by regulatory cells produce a robust primary T cell response.*

The current paradigm for primary T cell responses is that each effector T cell independently commits to a developmental program. This concept is based on experimental evidence that T cells respond robustly to a wide variety of stimulation levels and initial conditions.

Various mathematical models confirm the result that programmed responses generate dynamics that are insensitive to the nature of antigen stimulation. However, our models suggest that programmed responses do not explain the robustness of T cell dynamics to variations in precursor frequency. As an alternative, we present the hypothesis that a primary T cell response may also be governed by a feedback loop involving regulatory cells. To test these hypotheses, we formulate two mathematical models based on T cell developmental programs and one mathematical model based on negative feedback from adaptive regulatory T cells.

We conclude that T cell programs by themselves do not capture the robustness of T cell responses and propose an alternative mechanism in which the primary T cell response is governed by an emergent group dynamic and rather than individual cell behavior. (Received June 27, 2009)

1051-92-55 **Joseph Lucchetti** (jbl@math.ufl.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611, **Manojit Roy** (roym@ufl.edu), Department of Biology, University of Florida, Gainesville, FL 32611, and **Maia Martcheva*** (maia@math.ufl.edu), Department of Mathematics, 358 Little Hall, University of Florida, Gainesville, FL 32611. *Avian Influenza: Modeling, Analysis, and Data Fitting.*

Low Pathogenic Avian Influenza (LPAI) virus, which circulates in wild bird populations in mostly benign form, is suspected to have mutated into a highly pathogenic (HPAI) strain after transmission to the domestic birds. HPAI has recently garnered worldwide attention because of the "spillover" infection of this strain from domestic birds to humans - primarily those in poultry industry - causing significant human fatality and thus creating potentially favorable conditions for another flu pandemic. We use an ordinary differential equation model to describe this complex dynamics of the HPAI virus, which epidemiologically links a number of species in a multi-species community. We include the wild bird population as a periodic source feeding infection to the coupled

domestic bird-human system. We also account for mutation between the low and high pathogenic strains. We fit our model to the actual number of human avian influenza cases obtained from WHO, and estimate the relevant reproduction numbers and invasion reproduction numbers. We discuss outcomes of the competition of LPAI and HPAI. (Received August 08, 2009)

1051-92-74 **Emily Stone*** (stone@mso.umt.edu), Dept. of Mathematical Sciences, The University of Montana, 32 Campus Drive, Missoula, MT 59812, and **Josh Lawrence** (john.lawrence@mso.umt.edu), Center for Struc. & Func. Neuroscience, Dept. Biomedical and Pharm. Sciences, The University of Montana, Missoula, MT 59812. *Neuromodulation of Synaptic Depression: Discrete dynamical system models predict changes in short term plasticity.* Preliminary report.

Parvalbumin-positive (PV+) basket cells (BC), interneurons that provide inhibition to the perisomatic regions of principal cells, play a critical role in the generation of gamma oscillations both in vitro and in vivo. Bath application of the cholinergic agonist carbachol readily evokes hippocampal gamma oscillations, but how cholinergic neuromodulation alters the intrinsic and synaptic properties of hippocampal PV+BCs is poorly understood. Experiments in Dr. J. Lawrence's lab demonstrate that such cholinergic neuromodulation relieves synaptic depression of PV+BCs in the CA1 region of the hippocampus at gamma (around 50 HZ) but not theta (around 5 HZ) frequencies. Specifically, in paired whole cell recordings in mouse CA1 hippocampus, activation of presynaptic metabatropic acetylcholine receptors inhibits transmission between presynaptic PV+BCs and postsynaptic pyramidal cells, in a frequency specific manner. This talk documents the development and analysis of return map models of this phenomenon, what aspects are essential, and the implications for the type of cellular mechanisms potentially involved in the neuromodulation. (Received August 13, 2009)

1051-92-83 **Ardith W El-Kareh** and **Leslie B Jones*** (ljones@math.arizona.edu), 101 A Henry Circle, Ft. Huachuca, AZ 85613, and **Timothy W Secomb**. *Additive damage model for anti-cancer drug combinations.*

Mathematical models for cellular pharmacology of anticancer drugs used in combination provide information which can be used for the optimization and individualization of therapy, the development of criteria for synergy and antagonism, and the assessment of different possible choices of dose and schedule for drug administration. We present the additive damage model which incorporates mechanistic information about drug uptake and action. (Received August 18, 2009)

1051-92-140 **Anna Y Kuznetsova*** (anna.kuznetsova@utsa.edu), Dept Biol., UTSA, One UTSA circle, San Antonio, TX 78249, and **Alexey S Kuznetsov** (alexey@math.iupui.edu), Dept Math Sci, IUPUI, 402 N. Blackford St, Indianapolis, IN 46202. *Firing frequency regulation in a computational model of a midbrain dopaminergic neuron.*

Midbrain dopaminergic neurons fire spontaneously at low frequencies and elicit fast bursting in response to unpredicted reward, thus participating in reinforcement learning. Fast oscillations can not be induced by constant depolarization; instead the frequency is limited due to a bifurcation transition to a fixed point. In a conductance-based model, we show that frequency limitation is caused by the weakness of the spike-producing currents. A multicompartmental model was required to match the frequency limitation to experimental data showing robustness in schematic and reconstructed morphologies. The bifurcation transition was altered by the presence of a BK-type potassium current. The phase of the stimulus onset relative to the pacemaking oscillations explains experimental variability in measuring the transient frequency. Oscillatory mechanisms supporting slow and fast firing depends on different ionic currents. We simulated this difference by altering the contribution of different potassium currents. We compared bursts elicited by high-frequency electrical stimulation, glutamate iontophoresis, and dynamic clamp and the role of nonlinear and linear synaptic currents. Nonlinear NMDA synaptic current exclusively enhances intrinsic ionic currents avoiding frequency limitation. (Received August 22, 2009)

1051-92-172 **Jo Hoffacker*** (johoff@clemon.edu), O-110 Martin Hall, Box 340975, Clemson, SC 29634-0975. *When to Spray: A Time Scale Calculus Approach to Controlling the Impact of West Nile Virus.*

West Nile Virus made its initial appearance in the New York City metropolitan area in 1999 and was implicated in cases of human encephalitis and the extensive mortality in crows (Corvus species) and other avian species. Mosquitoes were determined to be the primary vectors and NYC's current policy on control strategies involved an eradication program that is dependent on the synchronicity of the summer mosquito population's increases with the occurrence of cases in humans. The purpose of this talk is to investigate whether this is the most effective control strategy because past mathematical models assumed discrete behavior that is modeled by

difference equations for a single summer season, was most important to the virus's development cycle. However, both surviving mosquito eggs and surviving migratory birds incubate the virus during the winter leading to a continuation of infections the following warmer spring and summer when the birds return and the eggs hatch. Additionally, the virulence of WNV has been observed to fluctuate with changes in temperature towards warmer conditions. (Received August 24, 2009)

1051-92-184 **Andrew Gillette*** (agillette@math.utexas.edu), Department of Mathematics, University of Texas at Austin, 1 University Station C1200, Austin, TX 78712, and **Alexander Rand** and **Chandrajit Bajaj**. *Multi-scale Modeling of Electric Activity of Spiny Dendrites in the Hippocampus.*

Multiple types of brain injury and disease, such as epilepsy and genetic disorders leading to mental retardation, have been observed in combination with significant changes in shape, distribution, and prevalence of abnormal composition of dendritic spines in the hippocampus. Simulating the effect of neuronal modification in a computational model requires an accurate representation of *in vivo* neuronal geometry as well as stable methods for modeling electrical activity in the brain. Such electrical activity is governed by electrodiffusion partial differential equations at nanometer scales and by simplified versions of Maxwell's equations at micron scales. We will present the framework of Discrete Exterior Calculus (DEC) analysis to formalize geometric and functional constraints implied by the two sets of governing equations. The DEC analysis additionally guides the construction of stable polynomial bases and Whitney interpolants to be used for a consistent and robust simulation of the relevant ionic currents and varying membrane voltage potentials. This approach helps elucidate the relevant coupling structure and function parameters between the multi-scale sets of governing equations along with the dependence of electric activity on the spiny nature of dendrites. (Received August 24, 2009)

1051-92-190 **Alexander Rand*** (arand@ices.utexas.edu), **Andrew Gillette** (agillette@math.utexas.edu) and **Chandrajit Bajaj** (bajaj@cs.utexas.edu). *Modeling Electrodynamic Field Effects for Networks of Neurons at Submicron Scales.* Preliminary report.

Seizures are abnormal bursts on synchronous brain activity. One mechanism behind intertwining neuronal processes is the electrical field effects through extracellular space. Mathematical models are developed to identify features of network connectivity and geometry which encourage synchronous behavior through field effects and are often omitted from reduced models. In order to perform simulations of these models in the associated complex domains, several mathematical constructions are important including dual Delaunay-Voronoi meshes and higher order Whitney forms. (Received August 24, 2009)

1051-92-213 **Janet A Best*** (jbest@math.ohio-state.edu), Department of Mathematics, 100 Mathematics Tower, Columbus, OH 43210, and **Badal S Joshi** and **Mark S Blumberg**. *Mathematical Analysis of Sleep-Wake Distributions.*

We have been studying the distribution of the lengths of wake bouts by experimentation and by mathematical models. The distribution is exponential for infants but gradually changes to a power law in the adult. Our model consists of three interacting cell populations whose firing times are given by Poisson processes with firing rates that are themselves stochastic processes. We study this doubly stochastic process by analyzing the bifurcation diagram for the system of ODES given by the expectations of the rates conditioned on the past, and show that its qualitative behavior explains the transition from infant to adultbout distributions. (Received August 25, 2009)

1051-92-226 **Ian Besse** and **Colleen Mitchell*** (mtchll@math.uiowa.edu), 225E MacLean Hall, Iowa City, IA 52242. *Regulation Of The Cardiac Action Potential Through Caveolar Current.* Preliminary report.

Cardiac caveolae are microdomains which serve as reservoirs of recruitable sodium ion channels. In response to stress, caveolae open exposing up to 40% more sodium channels to the extracellular space. This can cause marked changes in action potential morphology and conduction. We will present a three compartment model incorporating caveolar current into a Hodgkin-Huxley type cardiac model. Recent studies suggest that mutations in the structural proteins of caveolae can lead to a new form of Long QT syndrome. Simulations which incorporate dynamic opening of caveolae provide a new hypothesis for the way in which this mutation leads to the diseased state. (Received August 25, 2009)

1051-92-230 **Necibe Tuncer*** (tuncer@ufl.edu), 358 Little Hall, PO Box 118105, Gainesville, FL 32611, and **Maia Martcheva** (maia@ufl.edu), 358 Little Hall, PO Box 118105, Gainesville, FL 32611. *Two strain SIS model with diffusion.*

In this work, we consider a two-strain SIS model with diffusion and coefficients depending on space. One way to understand the role of spatial effects in epidemiology is to consider models with diffusion. Spatial dependence of the coefficients is necessary to account for transmissibility, recovery and other epidemiological characteristics that vary with location. We introduce the basic reproduction number, and invasion numbers for the SIS model and study the properties of the disease-free equilibrium and endemic equilibria. We show that although in the corresponding space-independent SIS model the two strains will exclude each other, nich-partitioning mechanisms in the diffusion model may allow for coexistence of the strains. Our two strain model is based on the single strain SIS model considered in L. J. S. Allen, B. M. Bolker, Y. You, A.L. Nevai, Asymptotic profiles of the steady states for an SIS epidemic reaction-diffusion model, Discrete and Continuous Dynamical Systems, 21, (2008) 1-20. (Received August 25, 2009)

1051-92-234 **Megan Owen*** (maowen@ncsu.edu) and **J. Scott Provan**. *A Fast Algorithm for Computing Geodesic Distances in Tree Space.*

In 2001, Billera, Holmes, and Vogtmann constructed a geometric space of phylogenetic trees, which has the same combinatorial structure as the tropical tree space (the tropical Grassmannian), but a different metric. In their space, there is a unique shortest path between any two points (trees), and the length of this path is called the geodesic distance between phylogenetic trees. However, the complexity of computing this distance is an open problem. In this talk, I will give a polynomial time algorithm for finding the geodesic distance. This algorithm starts with a simple initial path and moves through a series of successively shorter paths until the geodesic is attained. I will also discuss connections to the tropical tree space. (Received August 25, 2009)

93 ► Systems theory; control

1051-93-216 **John E Miller*** (John_Miller1@baylor.edu) and **Ian Gravagne**. *Lyapunov Stability of Non-diagonalizable Switched Linear Systems on Time Scales.*

We apply Lyapunov stability theory to switched linear systems on time scales. Switched linear systems consist of continuous dynamics coupled with instantaneous switching events. This coupling can be difficult to model on standard time domains ($\mathbb{R}$ and $\mathbb{Z}$), especially if the switching events are non-uniformly spaced. We first present the most general case, stability of non-diagonalizable systems with arbitrary switching. A constrained switching case follows. Several examples are given for both. (Received August 25, 2009)

1051-93-221 **Alice Alexander Ramos*** (alice.ramos@bethelcollege.edu), Bethel College, Dept. of Mathematics, 1001 Bethel Circle, Mishawaka, IN 46545. *Stability Analysis and Design of Dynamic Switched Systems Evolving on Time Scales.* Preliminary report.

We extend Lyapunov's Second (Direct) Method to the stability analysis of switched systems evolving on dynamic domains by developing and implementing a generalized common Lyapunov function approach for these systems. This leads to the formulation of two very different but closely related problems in analysis and design of dynamic switched systems and has applications to problems in bandwidth optimization, adaptive control, and μ-dynamics. (Received August 25, 2009)

1051-93-224 **John M Davis*** (John_M_Davis@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798. *Algebraic and Dynamic Lyapunov Equations on Time Scales.* Preliminary report.

We develop the time scale generalizations of the algebraic Lyapunov equation (which unifies the continuous time ALE and discrete time ALE) as well as the dynamic Lyapunov equation (which unifies the continuous time DLE and discrete time DLE). We explore how each of these equations plays an important role in stability arguments based Lyapunov's Second Method. (Received August 25, 2009)

00 ► General

1052-00-350 **James M Haley*** (kapucensko51@comcast.net), 259 Maple Avenue, Pittsburgh, PA 15218. *The Simplest Continuous Model of Financial Chaos and Noise.*

This paper identifies the necessary policy conditions to prove the existence of a strange attractor in a three dimensional model of financial markets that is consistent with a Keynesian framework. Specifically, a Sprott's nonlinear model perturbed by noise behaves chaotically for stock returns, interest rates, and inflation, if the Federal Reserve, the US central bank, implements a Taylor-like monetary policy. In this regime the Fed targets the federal funds rate, which controls interest rates, to vary directly with inflation expectations and real output. Often the Fed overreacts by setting interest rates either too high or too low, causing chaos to emerge in the financial markets. Instead, if the Fed targets zero inflation expectations and pegs the federal funds rate to equal its real expectation, the stock market will behave like a Langevin equation. In this case stock returns mean-revert. Then everyone, including central banks, can make more reliable financial forecasts. (Received September 01, 2009)

05 ► Combinatorics

1052-05-13 **Glenn Appleby*** (gappleby@scu.edu), Department of Mathematics and CS, Santa Clara University, Santa Clara, CA 95053, and **Tamsen Whitehead**. *Symmetries of Hives, Generalized Littlewood-Richardson Fillings, and Invariants of Matrix Pairs over Valuation Rings.* Preliminary report.

Work by Pak and Vallejo found linear bijections between Littlewood-Richardson fillings (LR fillings) of skew shapes and certain integer-valued hives. Hives are defined over $\mathbb{R}$, so these maps allow one to define "real-valued" LR fillings, though it's not clear that such fillings correspond to objects of interest. Our recent results supply one such interpretation, and show how to realize $\mathbb{R}$-valued LR fillings as invariants of pairs of full-rank matrices over rings with an $\mathbb{R}$-valuation (generalizing previous results with integer-valued LR fillings and matrices over discrete valuation rings), so that we have bijections between hives, matrix pairs, and generalized LR fillings. The S_3 triangle symmetries of hives now correspond to alternate algebraic representations of one matrix pair, and also define new linear bijections between six related families of LR fillings. Further, the involution LR fillings proving $c^{\lambda}_{\mu\nu} = c^{\lambda}_{\nu\mu}$ has been extended to give a new involution on hives. Lastly, natural matrix operations are interpreted in the hive and LR filling context to define infinite families of such objects with a common "combinatorical core." (Received April 27, 2009)

1052-05-31 **Doron Zeilberger*** (zeilberg@math.rutgers.edu). *A Eulogy for Jack Good.*

I.J. Good (1916-2009) passed away at 6:00pm, April 5, 20009, but his original contributions and influence will live for ever. (Received July 22, 2009)

1052-05-40 **Sami Assaf*** (sassaf@math.mit.edu), Massachusetts Institute of Technology, Department of Mathematics, Cambridge, MA 02139, and **Peter R. W. McNamara**. *A Pieri rule for skew shapes.*

The Pieri rule expresses the product of a Schur function and a single row Schur function in terms of Schur functions. We extend the classical Pieri rule by expressing the product of a skew Schur function and a single row Schur function in terms of skew Schur functions. Like the classical rule, our rule involves simple additions of boxes to the original skew shape. (Received August 03, 2009)

1052-05-57 **Arthur Berg*** (berg@ufl.edu), Division of Biostatistics, Cancer Institute, H069, 500 University Drive, P.O. Box 850, Hershey, PA 17033-0850. *A New Use of Group Representation Theory in Statistics.*

In this talk, I will show how the use of group representation theory and a familiar faithful group representation of the symmetric group on k elements, S_k, can be applied in a new way to statistics. The results can be used to analyze statistical data that is collected in a time course, like the daily returns of the S&P 500 or monthly

sunspot counts. In such data, it is useful to consider a weighted Fourier transform which results in an estimate of the so-called spectral density.

However, the mapping that takes the original data to its corresponding spectral density estimate is not invertible; there is a loss of information. An attempt to overcome this loss leads to an estimation of the polyspectrum, a multivariate function that also arises from a weighted Fourier transform. But a new issue is presented–the need to construct a "symmetric form" of a given k-variable function. After a formal connection is made with group representations, an optimal k-variable function arises that posses an idealized property of having minimal L_2 norm (an estimator with smallest variance) under a certain class of functions.

This work has been made possible through the helpful conversations and contributions of Jason Bandlow (Penn), John Hall (Harvard), and Gregg Musiker (MIT). (Received August 16, 2009)

1052-05-58 **Bruce E. Sagan*** (sagan@math.msu.edu), Department of Mathematics, East Lansing, MI 20912. *Probabilistic proofs of hook length formulas involving trees.*

Let T be a rooted tree on n vertices. We use T to stand for the vertex set of T. An *increasing labeling* of T is a bijection $\ell : T \to \{1, 2, \ldots, n\}$ such that $\ell(v) \leq \ell(w)$ for all descendents w of v. Let f^T be the number of increasing labelings. The *hooklength*, h_v, of a vertex v is the number of descendents of v. The hook length formula for trees states that

$$f^T = \frac{n!}{\prod_{v \in T} h_v}.$$

There is a similar formula for the number of standard Young tableaux of given shape. Greene, Nijenhuis, and Wilf gave a beautiful probabilistic proof of the tableau formula where the hooklenths enter in a very natural way.

Recently, Han discovered a formula with the interesting property that hooklengths appear as exponents. Specifically, let $\mathcal{B}(n)$ be the set of all n-vertex binary trees. Han proved algebraically that

$$\sum_{T \in \mathcal{B}(n)} \prod_{v \in T} \frac{1}{h_v 2^{h_v - 1}} = \frac{1}{n!}.$$

We show how to give a simple probabilistic proof of this equation as well as various generalizations. We also pose some open questions raised by this work. (Received August 16, 2009)

1052-05-59 **Jocelyn Quaintance*** (jquaint@math.wvu.edu), 1602 Lakeside Village, Morgantown, WV 26508, and **H. W. Gould**. *Annihilation Coefficients, Binomial Expansions and $q-$Analogs.* Preliminary report.

Let $\{A_n\}_{n=0}^{\infty}$ be an arbitrary sequence of natural numbers. We say $A(n, k; A)$ are the Convolution Annihilation Coefficients for $\{A_n\}_{n=0}^{\infty}$ if and only if

$$\sum_{k=0}^{n} A(n, k; A)(x - A_k)^{n-k} = x^n. \tag{1}$$

Similarly, we define $B(n, k; A)$ to be the Dot Product Annihilation Coefficients for $\{A_n\}_{n=0}^{\infty}$ if and only if

$$\sum_{k=0}^{n} B(n, k; A)(x - A_k)^{k} = x^n. \tag{2}$$

The main result of this paper is an explicit formula for $B(n, k; A)$, which depends on both k and $\{A_n\}_{n=0}^{\infty}$. This paper also discusses binomial and $q-$analogs of Equations (0.1) and (0.2). (Received August 17, 2009)

1052-05-64 **Ae Ja Yee** (yee@math.psu.edu), McAllister Bldg, University Park, PA 16802, and **Kagan Kursungoz*** (kursun@math.psu.edu), McAllister Bldg, University Park, PA 16802. *Alternating Permutations and kth Descents.* Preliminary report.

Yee and Huber (2009) gave new q-analogs of Euler's tangent and secant numbers using alternating permutations and half descents. In this talk, half descents will be generalized to kth descents. Generating functions involving both kth descents and inversions on certain class of permutations will be given. Proofs will be sketched as time allows. This is Joint work with Ae Ja Yee (Penn State). (Received August 29, 2009)

1052-05-67 **Gary Gordon*** (gordong@lafayette.edu), Math Dept, Lafayette College, Easton, PA 18042, and **Elizabeth McMahon**. *Counting facet derangements of hypercubes.*

We present some simple formulas and recursions for the number of derangements of the (n-1)-dimensional facets of a hypercube. We also consider the parity of these derangements, and compare with known results concerning the parity of (ordinary) derangements. (Received August 18, 2009)

1052-05-71 **Gregg Musiker*** (musiker@math.mit.edu), 77 Massachusetts Ave., MIT, Department of Mathematics, Office 2-336, Cambridge, MA 02139, and **Ralf Schiffler** and **Lauren Williams**. *Positivity results for cluster algebras.*

We give formulas for cluster variables with principal coefficients for cluster algebras coming from surfaces. In particular, this proves the positivity conjecture of Fomin and Zelevinsky for cluster algebras of classical types and most skew-symmetric cluster algebras of finite mutation type. (Received August 19, 2009)

1052-05-80 **Charles Buehrle*** (ceb405@lehigh.edu), Department of Mathematics, Lehigh University, Bethlehem, PA 18015. *A new construction of Kazhdan-Lusztig's representations of the Hecke algebra.*

We state vanishing results for Kazhdan-Lusztig immanants belonging to the quantum polynomial ring. Applying these results we find a new construction of Kazhdan-Lusztig's representation of the Hecke algebra without employing the Kazhdan-Lusztig preorder. (Received August 30, 2009)

1052-05-81 **T. Kyle Petersen** and **Luis Serrano*** (lserrano@umich.edu), 2082 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Cyclic sieving for longest reduced words in the hyperoctahedral group.*

We show that the set $R(w_0)$ of reduced expressions for the longest element in the hyperoctahedral group exhibits the cyclic sieving phenomenon. More specifically, $R(w_0)$ possesses a natural cyclic action given by moving the first letter of a word to the end, and we show that the orbit structure of this action is encoded by the generating function for the major index on $R(w_0)$. (Received August 20, 2009)

1052-05-117 **Thomas Lam** and **Pavlo Pylyavskyy*** (pavlo@umich.edu). *Total positivity in loop groups.*

We study infinite products of Chevalley generators in the formal loop group. We develop the formalism of infinite sequences of braid moves, called a braid limit. We relate this to a partial order, called the limit weak order, on infinite reduced words. The limit semigroup generated by Chevalley generators has a transfinite structure. We prove a form of unique factorization for its elements, in effect reducing their study to infinite products which have the order structure of the natural numbers. (Received August 24, 2009)

1052-05-121 **Justin J. Lambright***, Department of Mathematics, Lehigh University, Bethlehem, PA 18015. *A combinatorial interpretation of coefficients arising in the quantum polynomial ring.*

Let $(\ell_1, \ldots, \ell_n)$ and $(m_1, \ldots, m_n)$ be two weakly increasing sequences of positive integers. Then we can express the monomial $x_{\ell_{u_1},m_{v_1}} \cdots x_{\ell_{u_n},m_{v_n}}$ in terms of the natural basis of the quantum polynomial ring $A_n(q)$, which consists of monomials of the form $x_{\ell_1,m_{w_1}} \cdots x_{\ell_n,m_{w_n}}$ with w maximal in the double coset $W_I w W_J$. A combinatorial interpretation of the coefficients of the natural basis elements is given in terms of walks in the Bruhat order. (Received August 24, 2009)

1052-05-122 **Emmanuel Briand** (ebriand@us.es), **Rosa C Orellana*** (rosa.c.orellana@dartmouth.edu) and **Mercedes H. Rosas** (mrosas@us.es). *On the stability of the Kronecker product.*

In the late 1930's Murnaghan discovered the existence of a stabilization phenomenon for the Kronecker product of Schur functions. For n sufficiently large, the values of the Kronecker coefficients appearing in the product of two Schur functions of degree n do not depend on the first part of the indexing partitions, but only on the values of their remaining parts. We compute the exact value of n for which all the coefficients of a Kronecker product of Schur functions stabilize. We also compute two new bounds for the stabilization of a sequence of coefficients and show that they improve existing bounds of M. Brion and E. Vallejo. (Received August 24, 2009)

1052-05-162 **Shishuo Fu*** (fu@math.psu.edu). *A bijective proof of Bressoud's Conjecture related to the Rogers-Ramanujan Identities.*

The Rogers-Ramanujan Identities have many natural and significant generalizations. The generalization presented in this paper was first studied by D. Bressoud, by considering the partitions he named as "footed partition". A bijective proof to his conjecture is given and some examples are attached in the end. (Received August 26, 2009)

1052-05-182 **Saúl A. Blanco*** (sabr@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *The shortest path poset of a finite Coxeter group.*

We define a ranked poset using the shortest paths in the Bruhat graph of a finite Coxeter group W from the identity to the longest word of W, w_0. We show that this poset is the union of Boolean posets of rank

absolute length of w_0, $\ell_T(w_0)$. That is, any set of reflections $\{t_1, \ldots, t_{\ell_T(w_0)}\}$ so that $t_1 \cdots t_{\ell_T(w_0)} = w_0$ is fully commutative and describes a path in the Bruhat graph from e to w_0. This allows us to give a combinatorial interpretation of the lowest-degree terms in the complete **cd**-index of W. (Received August 27, 2009)

1052-05-185 **David Little*** (dlittle@math.psu.edu), Mathematics Department, Penn State University, University Park, PA 16802. *Some Fine Combinatorics.*

In 1988, N. J. Fine published a monograph entitled *Basic Hypergeometric Series and Applications* in which he proved a number of results concerning the series $F(a, b; t : q)$. In this talk, we present a new combinatorial interpretation for the series $F(a, b; t : q)$ and use Fine's work as a guide for proving the Rogers–Fine identity and many of its properties in this setting. (Received August 27, 2009)

1052-05-193 **Sergi Elizalde*** (sergi.elizalde@dartmouth.edu), Department of Mathematics, Dartmouth College, 6188 Kemeny Hall, Hanover, NH 03784. *Descent sets of cyclic permutations.*

The descent set of a sequence $a_1 a_2 \ldots$ is the set of indices i such that $a_i > a_{i+1}$. Consider the $n!$ cyclic permutations of $\{1, 2, \ldots, n+1\}$ written in one-line notation, and for each one of them remove the last entry $\pi(n+1)$. We show that the descent sets of these objects have the same distribution as the descent sets of permutations of $\{1, 2, \ldots, n\}$. We give a bijective proof of this fact, as well as an alternate derivation using work of Gessel and Reutenauer. (Received August 27, 2009)

1052-05-197 **William J Keith*** (wjk26@drexel.edu), Korman Center 206, 3141 Chestnut Street, Philadelphia, PA 19104. *Bijective proofs of two theorems on partitions with distinct evens.*

In his paper #271, on partitions in which the even parts are distinct, George Andrews stated two theorems on the excess of DE-partitions with even DE-rank or exceptional-parts statistics over those with odd. He requested combinatorial proof, which is herein provided. (Received August 28, 2009)

1052-05-209 **Brendon Rhoades*** (brhoades@mit.edu). *The Cluster Monomial and Dual Canonical Bases of* $\mathbb{Z}[x_{11}, \ldots, x_{33}]$.

The polynomial ring $\mathbb{Z}[x_{11}, \ldots, x_{33}]$ has a basis called the dual canonical basis whose quantization facilitates the study of representations of the quantum group $U_q(\mathfrak{sl}_3(\mathbb{C}))$. On the other hand, $\mathbb{Z}[x_{11}, \ldots, x_{33}]$ inherits a basis from the cluster monomial basis of a geometric model of the type D_4 cluster algebra. We prove that these two bases are equal. As a side effect, we obtain an explicit factorization of every dual canonical basis element of $\mathbb{Z}[x_{11}, \ldots, x_{33}]$ into irreducible polynomials. This extends work of Skandera and proves a conjecture of Fomin and Zelevinsky. (Received August 28, 2009)

1052-05-213 **Sylvie Corteel** and **Carla D Savage*** (savage@csc.ncsu.edu), Dept. of Computer Science, Box 8206, North Carolina State University, Raleigh, NC 27695-8206, and **Andrew V Sills**. *A new view of the little Göllnitz products.*

We give a combinatorial proof of the following theorem: The number of partitions of N into distinct parts in which odd-indexed (even-indexed) parts are even is equal to the number of partitions of N into parts congruent to 2,3,7 (mod 8) (1,5,6 (mod 8)). This provides a new view of the infinite products appearing in the little Göllnitz identities. We also show that a finite version of the little Göllnitz product counts lecture hall partitions in which in which odd-indexed (even-indexed) parts are even, giving an analog of the Lecture Hall Theorem of Bousquet-Mélou and Eriksson. (Received August 28, 2009)

1052-05-228 **Russ Woodroofe*** (russw@math.wustl.edu), Department of Mathematics, Campus Box 1146, Washington University, St. Louis, MO 63130. *Vertex decomposable graphs and obstructions to shellability.*

An obstruction to shellability is a non-shellable complex which has every proper subcomplex shellable. Billera and Myers showed that there is a unique obstruction to shellability in the family of order complexes of posets. Wachs showed that there are an infinite number of obstructions in general simplicial complexes, and conjectured that there is a finite number of any given dimension.

In this talk I will give a graph-theoretic classification of the obstructions to shellability in the family of flag complexes. In particular, there are infinitely many. As time allows, I will also discuss approaches to other related problems. (Received August 28, 2009)

1052-05-233 **Jason Bandlow*** (jbandlow@math.upenn.edu), Department of Mathematics, David Rittenhouse Laboratory, 209 South 33rd Street, Philadelphia, PA 19104-6395. *The expansion of Hall-Littlewood polynomials into dual Grothendieck polynomials.* Preliminary report.

A combinatorial expansion of the Hall-Littlewood polynomials into the Schur basis of symmetric functions was first given by Lascoux and Schützenberger, with their discovery of the charge statistic. A combinatorial expansion of stable Grassmannian Grothendieck polynomials into monomials was first given by Buch, using set-valued tableaux. The dual basis of the Grothendieck polynomials was given a combinatorial expansion into monomials by Lam and Pylyavsky using plane partitions. In this talk I will describe these combinatorial ideas and show how they can be extended and combined to give a nice expansion of Hall-Littlewood polynomials into the dual Grothendieck basis. (Received August 28, 2009)

1052-05-244 **J. Haglund*** (jhaglund@math.upenn.edu), 209 S. 33rd. St., Math. Dept., Univ. of Penn., Philadelphia, PA 19104-6395, and **K. Luoto**, **S. Mason** and **S. Van Willigenberg**. *Littlewood Richardson Rules, Quasisymmetric Funcions, and Demazure Characters.*

We show how the product of a Schur function and a Demazure Atom (called standard bases by Lascoux and Schutzenberger) is a positive sum of Atoms. We also show how this implies similar rules for the product of a Schur function and either a Demazure character or Quasisymmetric Schur function. Our results involve "inversion triples" which occur in the combinatorics of Macdonald polynomials, and imply the classical Littlewood-Richardson rule for the expansion of a product of Schur functions in the Schur basis. (Received August 28, 2009)

1052-05-245 **Ian Goulden*** (ipgoulden@uwaterloo.ca), 200 University Ave. W., Waterloo, Ontario N2L3G1, Canada, and **William Slofstra**. *Annular embeddings of permutations for arbitrary genus.*

In the symmetric group on a set of size $2n$, let $\mathcal{P}_{2n}$ denote the conjugacy class of involutions with no fixed points (equivalently, we refer to these as "pairings", since each disjoint cycle has length 2). Harer and Zagier explicitly determined the distribution of the number of disjoint cycles in the product of a fixed cycle of length $2n$ and the elements of $\mathcal{P}_{2n}$. Their famous result has been reproved many times, primarily because it can be interpreted as the genus distribution for 2-cell embeddings in an orientable surface, of a graph with a single vertex attached to n loops. In this paper we give a new formula for the cycle distribution when a fixed permutation with two cycles (say the lengths are p, q, where $p + q = 2n$) is multiplied by the elements of $\mathcal{P}_{2n}$. It can be interpreted as the genus distribution for 2-cell embeddings in an orientable surface, of a graph with two vertices, of degrees p and q. In terms of these graphs, the formula involves a parameter that allows us to specify, separately, the number of edges between the two vertices and the number of loops at each of the vertices. (Received August 28, 2009)

1052-05-248 **Pisanski Tomaž***, University of Ljubljana, FMF and IMFM, Jadranska 19, 1111 Ljubljana, Slovenia, and **Alen Orbanić**, **Daniel Pellicer**, **Thomas W Tucker** and **Arjana Žitnik**. *Edge-transitive tessellations with non-negative Euler characteristic.*

Graver and Watkins classified edge-transitive maps on closed surfaces into fourteen types. In this note we study these types for 3-connected maps in surfaces of non-negative Euler characteristic, including the Euclidean and hyperbolic plane. We revisit both finite and infinite one-ended edge-transitive maps. For the finite ones we give precise description that enables us to enumerate them up to a given number of edges. The automorphism group of an edge-transitive map may have one, two, or four orbits when acting on the set of flags. Some more general questions concerning k-orbit maps will be discussed. (Received August 29, 2009)

1052-05-251 **Gregory S. Warrington*** (gswarrin@uvm.edu), Department of Mathematics and Statistics, University of Vermont, 16 Colchester Ave., Burlington, VT 05405, and **Nicholas A. Loehr**. *Infinitely many new partition statistics.*

Traditionally, the generating function $1/((1-tq)(1-tq^2)(1-tq^3)\ldots)$ enumerates partitions by area (the power of q) and number of parts (power of t). We give an infinite number of new interpretations for the power of t. That these new statistics are equidistributed with the length of a partition is proven via explicit bijections. These bijections involve various combinatorial constructions such as oriented trees and Eulerian tours on directed multigraphs. This is joint work with Nick Loehr. (Received August 29, 2009)

1052-05-253 **Drew Armstrong*** (armstrong@math.miami.edu), University of Miami, Department of Mathematics, 1365 Memorial Drive, Ungar 529, Coral Gables, FL 33146. *Shi arrangements and diagonal harmonics.* Preliminary report.

We define two statistics on the chambers of a Shi hyperplane arrangement, and conjecture that these encode the bigraded Hilbert series of the ring of diagonal harmonics. We prove that our conjecture is equivalent to a conjecture of Haglund and Loehr involving statistics on labeled lattice paths. We discuss versions of these statistics for extended Shi arrangements and the bounded chambers of these arrangements. (Received August 29, 2009)

1052-05-279 **James A. Sellers*** (sellersj@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Infinite Families of Divisibility Properties Modulo 4 for Non–Squashing Partitions into Distinct Parts.*

In 2005, Sloane and Sellers defined a function $b(n)$ which denotes the number of non-squashing partitions of n into distinct parts. In their 2005 paper, Sloane and Sellers also proved various congruence properties modulo 2 satisfied by $b(n)$. In this note, we extend their results by proving two infinite families of congruence properties modulo 4 for $b(n)$. In particular, we prove that for all $k \geq 3$ and all $n \geq 0$,

$$b(2^{2k+1}n + 2^{2k-2}) \equiv 0 \pmod 4 \quad \text{and}$$
$$b(2^{2k+1}n + 3 \cdot 2^{2k-2} + 1) \equiv 0 \pmod 4.$$

This is joint work with Michael Hirschhorn (UNSW, Australia) and Øystein Rødseth (University of Bergen, Norway). (Received August 30, 2009)

1052-05-292 **David M. Jackson*** (dmjackson@math.uwaterloo.ca), **Achim Kempf** and **Alejandro Morales**. *A combinatorial Legendre Transform.*

A combinatorial Legendre transform associated with Feynman diagrams will be described, and some of its properties reported. This is joint work with Achim Kempf and Alejandro Morales. (Received August 31, 2009)

1052-05-312 **Curtis Greene*** (cgreene@haverford.edu), Dept of Mathematics, Haverford College, 370 Lancaster Avenue, Haveford, PA 18940. *Inequalities for symmetric polynomials.* Preliminary report.

If f and g are symmetric polynomials with real coefficients, we say that f is less than or equal to g if f(X) is less than or equal to g(X) for all nonnegative substitutions of the variables X. This defines a partial order on the set of all symmetric polynomials. In joint work with A. Cuttler and M. Skandera (to appear in the Europ. Journal of Combinatorics) we studied the restriction of this partial order classical families such as the elementary, power sum, complete homogeneous, monomial, and Schur polynomials. Many of the results obtained can be viewed as generalizations of Muirhead's Inequalities. We will report progress on some conjectures that remained unproved in that work, and, in addition, give a complete characterization of all homogeneous symmetric function inequalities of degree three. The latter is joint work with M. Skandera, J. Kroll, J. Lima, and R. Xu. (Received August 31, 2009)

1052-05-323 **Jennifer Morse*** (morsej@math.drexel.edu), Math Department, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104. *Affine tableaux approach to K-theory.*

A family of tableaux connected to the affine symmetric group plays a natural role in affine Schubert calculus and in the theory of Macdonald polynomials similar to that of Young tableaux in classical Schubert calculus.

Our study of K-theory of affine Grassmannians led us to the discovery that combinatorics in this setting involves certain "affine set-valued tableaux". In particular, these tableaux characterize dual affine Grothendieck polynomials and define the associated Pieri rules. (Received August 31, 2009)

1052-05-329 **Heiko Todt*** (hut113@psu.edu), 240 Toftrees Ave #101, State College, PA 16803. *Asymptotic formulas for partitions with distinct parts.*

I will show how a method by Donald Newman for an asymptotic result for integer partitions can be extended to various generating functions for partitions with distinct parts. (Received September 01, 2009)

1052-05-344 **Solomon Adegoke Osifodunrin*** (asa_osifodunrin@yahoo.com), Department of Mathematics, Computer Science, and Statistics, Bloomsburg University of Pennsylvania, Bloomsburg, PA 17815. *On the existence of a class of* (v, k, λ) *difference sets with* $k < 350$, $n = k - \lambda = m^2, m = 8, 9, 11, 14$ *and* $v = 0 \pmod{68}$.

In 2005, Ken Smith and his under graduate student, Strom Borman showed that (204, 29, 4) difference sets do not exist by exploring factor groups of order 68. Based on this result, we investigate (v, k, λ) difference sets satisfying $k < 350, n = k - \lambda = m^2, m = 8, 9, 11, 14$ and $v = 0 \pmod{68}$. Using number theory and representation theory,

it turns out that most of the groups of v do not admit the respective difference sets. (Received September 01, 2009)

11 ► Number theory

1052-11-5 **Robertc C Vaughan*** (rvaughan@math.psu.edu), Mathematics Department, Penn State University, McAllister Building, University Park, PA 16802. *Diophantine approximation to curves and surfaces.*

The metrical theory of diophantine approximation has a long and distinguished history, beginning with Khinchin's celebrated theorem that almost no, or almost all, real numbers α have infinitely many rational approximations of the form $|\alpha - a/q| \le q^{-1}\psi(q)$, with $\psi(q)$ a positive decreasing function, according as

$$\sum_{q=1}^{\infty} \psi(q)$$

converges or diverges. There are many variants of this question and there have been a number of recent developments. In this talk we will give an historical overview and describe some of the recent developments. (Received August 27, 2009)

1052-11-17 **Ricardo P Conceicao*** (rconceic@math.utexas.edu), The University of Texas at Austin, Department of Mathematics., 1 University Station C1200, Austin, TX 78712. *Twists of elliptic curves with a large set of integral points over function fields.*

We will explicitly construct quadratic and cubic twists of supersingular elliptic curves with arbitrarily many integral points defined over $\mathbb{F}_q(t)$.

If time permits, we will also provide three different applications of these constructions. First they will be used to show that the conjecture of Lang-Vojta concerning the behavior of integral points in varieties of log-general type cannot be readily transported to the function field case. As a second application, we will show that these constructions provide examples of elliptic curves with an explicit large set of independent points. Finally, we will use them to construct quadratic and cubic function fields over $\mathbb{F}_q$ with class group of large m-rank, for m dividing $q+1$. (Received May 21, 2009)

1052-11-22 **C S Franze***, Department of Mathematics, Central Michigan University, Pearce Hall 214, Mount Pleasant, MI 48859. *Sifting Limits for Selberg's $\Lambda^2\Lambda^-$ Sieve.* Preliminary report.

Selberg outlined the details of his $\Lambda^2\Lambda^-$ sieve in his collected papers. He asserted that for sufficiently large sieve dimensions κ, the sifting limit is $2\kappa + \frac{19}{36} + o(1)$. In contrast, the higher dimensional sieve developed by Diamond, Halberstam, and Richert has a sifting limit that is asymptotically 2.44κ. While it is clear that Selberg's sieve is superior for sufficiently large κ, it is unknown as to how these sieves compare in small to moderately sized dimensions. To this end, I present some computations of the sifting limits for the $\Lambda^2\Lambda^-$ sieve. The computations suggest that the asymptotics for the sifting limits of the $\Lambda^2\Lambda^-$ sieve are achieved quite quickly. (Received July 06, 2009)

1052-11-29 **Kevin Ford*** (ford@math.uiuc.edu), Deptartment of Mathematics, University of Illinois at Urbana-Champaign, 1409 West Green St., Urbana, IL 61801, **Florian Luca** (fluca@matmor.unam.mx), Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, C.P. 58089 Morelia, Mexico, and **Carl Pomerance** (carl.pomerance@dartmouth.edu), Department of Mathematics, Dartmouth College, Hanover, NH 03755. *Common values of the arithmetic functions ϕ and σ.*

In 1958, Paul Erdős conjectured that there are infinitely many solutions of the equation $\phi(a) = \sigma(b)$, where ϕ is the Euler totient function, and σ is the sum-of-divisors function. We prove this conjecture, and moreover show that there is some constant $c > 0$ and infinitely many n so that $\phi(a) = n$ has more than n^c solutions and $\sigma(b) = n$ has more than n^c solutions. Our results depend on results about primes in arithmetic progressions, and recent bounds for prime chains due to Ford, Konyagin and Luca. (Received July 18, 2009)

1052-11-35 **Julia Wolf*** (julia.wolf@cantab.net). *Counting solutions to linear systems modulo N - an introduction to local quadratic Fourier analysis.*

Quadratic Fourier analysis was introduced by Gowers in his analytic proof of Szemeredi's theorem in 1998, and played a crucial role in Green and Tao's proof of the existence of long arithmetic progressions in the primes in 2004. We shall discuss recent formulations of quadratic Fourier-type decompositions that allow us to count the

number of solutions to certain systems of linear equations in the integers modulo N. This talk covers joint work with Tim Gowers. (Received July 31, 2009)

1052-11-37 **Roger C Baker*** (baker@math.byu.edu), Department of Mathematics, Brigham Young University, Provo, UT 84602. *Asymptotic formulas for ternary quadratic forms.* Preliminary report.

Let Q be an indefinite quadratic form in three variables with integer coefficients. How many solutions of Q(x)=m are present in a cube with side P tending to infinity? We usually make the assumption that P is of order of size square root of m, in the case where m tends to infinity. For the homogeneous case m = 0, this assumption is irrelevant. A search of the literature reveals a satisfactory answer only in the homogeneous case (Heath-Brown, 1996). What happens in the homogeneous case if we require all coordinates of x to be square-free? I report on this, and also on progress in the inhomogeneous case. (Received July 31, 2009)

1052-11-41 **Sidney W. Graham*** (sidney.w.graham@cmich.edu), Department of Mathematics, Central Michigan University, Mt. Pleasant, MI. *The Ideal Sieve.* Preliminary report.

I will discuss a simplified sieving problem in which all the sifting primes p lie in the interval $z^\alpha < p \leq z^\beta$. For certain values of α and β, we can construct optimal upper and lower bound sieves. This is joint work with Hugh Montgomery. (Received August 04, 2009)

1052-11-51 **Yu-Ru Liu*** (yrliu@math.uwaterloo.ca), Department of Pure Mathematics, University of Waterloo, Waterloo, Ontario N2V 2S7, Canada. *Vinogradov's Mean Value Theorem in Function Fields.*

Let $\mathbb{F}_q[t]$ be the ring of polynomials over the finite field $\mathbb{F}_q$. In this talk, we will discuss a generalization of Vinogradov's mean value theorem in $\mathbb{F}_q[t]$. We will apply our result to study Waring's problem in function fields. This is a joint work with Trevor Wooley. (Received August 12, 2009)

1052-11-52 **Tsz Ho Chan*** (tchan@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152, and **Igor E. Shparlinski**. *Concentration of Points on Modular Hyperbolas and Exponential Curves.*

We are interested in the number of points (x, y) on the modular hyperbola $xy \equiv a (\mathrm{mod} p)$ that lie in a small square of side length H. Is it true that there are only $o(H)$ points when $H = o(p)$? We will answer this question using sum-product type estimates from additive combinatorics. Similar argument applies to the modular exponential curve $y \equiv ag^x (\mathrm{mod} p)$. This is joint work with Igor Shparlinski. (Received August 13, 2009)

1052-11-53 **Patrick X. Rault*** (rault@geneseo.edu), Assistant Professor of Mathematics, 326 C South Hall, State University of New York, Geneseo, NY 14454. *On uniform bounds for lattice points in intersections of hyperbolic plane regions.*

We will present upper bounds for the number of primitive lattice points in hyperbolic plane regions. Specifically, we study regions in the plane bounded by equations $|f(x, y)| = B$ and $|g(x, y)| = C$, where f and g are indefinite quadratic forms. Unlike Gauss' circle theorem and other related results, these hyperbolic regions are nonconvex and nonsmooth. The bound obtained may be made independent of the choice of hyperbolas as it is inversely proportional to a positive power of $R(f, g)$, the resultant, and $D(f)D(g)$, the discriminants. We will briefly discuss a corollary on counting rational points on plane curves, which improves on certain cases of a theorem of Heath-Brown. (Received August 13, 2009)

1052-11-55 **Maosheng Xiong*** (xiong@math.psu.edu), 210 McAllister BLD, Dept. Mathematics, Eberly College of Science, Penn State University, State College, PA 16802. *The fluctuations in the number of points on a family of curves over a finite field.*

Let p be a prime number, $\mathbb{F}_q$ a finite field of cardinality q with $q \equiv 1 \pmod{p}$. In this paper we study the fluctuations in the number of $\mathbb{F}_q$-points on the curve C_F, namely $\#C_F(\mathbb{F}_q)$, with affine model $C_F : Y^p = F(X)$, where F is drawn at random uniformly from the set of all irreducible polynomials $F \in \mathbb{F}_q[X]$ of degree d. For q fixed and $d \to \infty$, we find that the limiting distribution of $\#C_F(\mathbb{F}_q) - 1 - q$ is that of a sum of q i.i.d. random variables taking the values $-1, p-1$ with probabilities $\left(\frac{p-1}{p}, \frac{1}{p}\right)$ respectively. When both $d, q \to \infty$, we find that $\frac{\#C_F(\mathbb{F}_q)-1-q}{\sqrt{q(p-1)}}$ has a standard Gaussian distribution. (Received August 14, 2009)

1052-11-60 **Donald Richards*** (richards@stat.psu.edu), 326 Thomas Building, Penn State University, University Park, PA 16802. *Integrals of Characteristic Polynomials of Unitary Matrices, and an Application to the Riemann Zeta Function.*

Conrey, Rubenstein, and Snaith (*Comm. Math. Phys.* **267** (2006), 611–629) derived an asymptotic expansion for the average of even integral powers of the characteristic function of random matrices that are uniformly distributed on the group of $N \times N$ unitary matrices. In this paper, we derive an explicit formula for that integral, deduce the exact asymptotic rate as $N \to \infty$, verify that the leading coefficient in that expansion is non-zero, and relate this expansion to a conjecture about the Riemann zeta function. Moreover, we explain how these calculations are related to mathematical statistics and to the hypergeometric functions of Hermitian matrix argument. (Received August 17, 2009)

1052-11-70 **Pradipto Banerjee** (banerjep@mailbox.sc.edu) and **Michael Filaseta*** (filaseta@mailbox.sc.edu). *Missed it by that much.*

A conjecture of Pál Turán is that every polynomial with integer coefficients is near an irreducible polynomial with integer coefficients. More precisely, he conjectured that there is an absolute constant C such that if $f(x) = \sum_{j=0}^{n} a_j x^j \in \mathbb{Z}[x]$, then there is an irreducible polynomial $g(x) = \sum_{j=0}^{n} b_j x^j \in \mathbb{Z}[x]$ such that $\sum_{j=0}^{n} |a_j - b_j| \leq C$. In this talk, I will present some history behind this interesting conjecture and some recent progress on the subject. (Received August 18, 2009)

1052-11-83 **Guillermo Mantilla*** (mantilla@math.wisc.edu), Madison, WI. *On the Mordell-Weil rank of Jacobians of principal modular curves of prime power level.* Preliminary report.

In this talk we give a bound for the growth of Mordell-Weil ranks in towers of Jacobians of modular curves. In more detail, we will show the following result.

Let $p > 2$ be a prime, and let J_n be the Jacobian of the principal modular curve $X(p^{n+1})$. Let F be a number field with μ-invariant μ, and such that $J_0[p] \subseteq F$. We show that there exists a constant C, depending on F and p, such that

$$\mathrm{rank} J_n(F) \leq (\frac{2p}{p^2-1})[F:\mathbb{Q}] \dim J_n + C' p^{2n} + 2\mu n$$

for all n.

The proof of the theorem generalizes a technique used in an unpublished result of J. Ellenberg on Fermat curves. (Received August 20, 2009)

1052-11-91 **Andrew Yang*** (ayang@math.dartmouth.edu), Department of Mathematics, 27 North Main Street, 6188 Kemeny Hall, Hanover, NH 03755. *On the low-lying zeros of Dedekind zeta functions associated to cubic number fields.*

The Katz-Sarnak philosophy asserts that to any "naturally defined family" of L-functions, there should be an associated symmetry group which determines the distribution of the low-lying zeros of those L-functions. We consider the family of Dedekind zeta functions of cubic number fields, and we predict that the associated symmetry group is symplectic. To analyze the low-lying zeros of this family, we start by using (as is standard in these types of problems) a variant of the explicit formula used by Riemann to study the Riemann zeta function. This reduces the problem to understanding the distribution of how rational primes split in cubic fields of absolute discriminant X, as X tends to infinity. This can be analyzed by using the work of H. Davenport and H. Heilbronn on the asymptotics of the number of cubic fields as the absolute discriminant tends to infinity. The final ingredient is a recent result of K. Belabas, M. Bhargava, and C. Pomerance on power-saving error terms in the count of cubic fields considered by Davenport and Heilbronn. If time permits we will discuss the adjustments that can be made to this argument to prove a similar result for S_4 quartic number fields, using Bhargava's generalization of the work of Davenport and Heilbronn. (Received August 21, 2009)

1052-11-95 **Sharon Anne Garthwaite*** (sharon.garthwaite@bucknell.edu), 380 Olin Science Bldg, Lewisburg, PA 17837. *The Quadratic AGM in the context of Mock Modular Forms.*

In this talk we see how hypergeometric series related to the quadratic arithmetic-geometric mean arise as the p-adic limit of certain weakly holomorphic modular forms. The proof follows a method of Guerzhoy, Kent, and Ono involving mock modular forms. This is joint work with Matt Boylan. (Received August 21, 2009)

1052-11-97 **Jennifer Paulhus*** (paulhus@math.ksu.edu), Department of Mathematics, 138 Cardwell Hall, Kansas State University, Manhattan, KS 66506. *Decomposing Jacobian varieties using automorphism groups.*

Jacobian varieties which have many elliptic curves as factors in their decompositions have interesting applications to rank and torsion questions. Given a curve X with automorphism group G, idempotent relations in the group ring $Q[G]$ lead to decompositions of the Jacobian of X. In this talk we briefly explain the techniques involved and some recent results obtained from these techniques. (Received August 22, 2009)

1052-11-99 **Krishnaswami Alladi*** (alladik@ufl.edu), Department of Mathematics, University of Florida, 358 Little Hall, Gainesville, FL 32606. *COMBINATORIAL STUDY AND COMPARISON OF PARTIAL THETA IDENTITIES OF ANDREWS AND RAMANUJAN.*

We study a partial theta function identity of Andrews combinatorially and show that it has a partition interpretation like Euler's pentagonal numbers theorem but involving partitions into distinct parts with smallest part odd. Andrews' identity has the advantage that it has a free parameter which can keep track of the number of odd parts in the partition. Recently, I obtained a similar partition interpretation for a partial theta function identity of Ramanujan, also with a free parameter. The amazing thing is that even though the weights in the free parameter in the identities of Andrews and Ramanujan are different, the sums of these weights over the same set of partitions are identical and are non-vanishing only at the perfect squares. Our proof and analysis of Andrews' partial theta identity lends fresh light on certain classical q-series identities and yields some new weighted partition theorems as well. (Received August 23, 2009)

1052-11-111 **Youn-Seo Choi*** (y-choi2@kias.re.kr), KIAS Hoegiro 87(207-43 Cheongnyangni 2-dong), Dongdaemun-gu, Seoul, 130-722, South Korea. *understanding the mock theta functions through the basic bilateral hypergeometric series.*

In 1893, M. Lerch introduced an interesting function which is defined in the form of the bilateral series. Later, G. N. Watson studied the relation between this Lerch's function and Ramanujan's fifth order mock theta functions with Lerch's function. In this talk, we will see the relation between the basic bilateral hypergeometric series and the mock theta functions which were introduced by S. Ramanujan and others. (Received August 24, 2009)

1052-11-126 **Nigel Boston*** (boston@math.wisc.edu), Department of Mathematics, University of Wisconsin, Madison, WI 53706. *Heuristics on Pro-p Groups arising as Galois Groups.* Preliminary report.

In work with Ellenberg and Venkatesh, the speaker gave a heuristic for how often a given finite g-generator g-relator pro-p group arises as the Galois group of the maximal pro-p extension of Q unramified outside g random primes. In this talk we consider generalizations to infinite pro-p groups and to imaginary quadratic fields, which introduce new phenomena. (Received August 24, 2009)

1052-11-137 **Brandt Kronholm*** (jk174783@albany.edu), Earth Science and Mathematics 110, 1400 Washington Avenue, Albany, NY 12222. *Ramanujan Congruence Properties of the Restricted Partition Function $p(n, m)$.*

The restricted partition function p(n,m) enumerates the number of partitions of n into exactly m parts. The relationship between the unrestricted partition function $p(n)$ and $p(n, m)$ is clear:

$$p(n) = p(n, 1) + p(n, 2) + ... + p(n, n).$$

We are all familiar with Ramanujan's partition congruences for $p(n)$ and that Ken Ono (2000) proved that there are Ramanujan congruences for $p(n)$ for every prime $\ell > 3$. In 2005 the speaker showed that there are Ramanujan congruences for $p(n, m)$ for every prime $m = \ell \geq 3$. However, given our choice of prime ℓ for both $p(n)$ and $p(n, m)$, n is restricted to a very special form. For example, if $\ell = 5$, then we are guaranteed that $p(n) \equiv 0\,(mod\,5)$ when $n = 5k + 4$. We are likewise guaranteed for $\ell = 5$ that $p(n, 5) \equiv 0\,(mod\,5)$ when $n = 60k$ and $n = 60k - 5$.

In this talk we will discuss a Ramanujan-like congruence relation for $p(n, m)$ where for our choice of prime ℓ there is no restriction on n. (Received August 25, 2009)

1052-11-139 **Paul Pollack*** (pppollac@illinois.edu). *The distribution of sociable numbers.*

Let $s(n)$ denote the sum of the proper divisors of n, so that $s(n) = \sigma(n) - n$. Interest in the behavior of this arithmetic function can be traced back thousands of years to the early interest in perfect numbers. Let s_k denote the kth iterate of s. We call a number n *sociable* if $s_k(n) = n$ for some $k \geq 1$; the least such k is then referred to as the *order* of n. Thus the sociable numbers of order 1 are precisely the perfect numbers and those of order 2 are precisely the amicable numbers. In this talk we describe some recent results on the distribution of sociable

numbers. This is joint work with M. Kobayashi and C. Pomerance, both from Dartmouth College. (Received August 25, 2009)

1052-11-142 **Craig Valere Spencer*** (craigvspencer@gmail.com), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506. *The Manin conjecture for $x_0y_0 + \cdots + x_sy_s = 0$.*

In this talk, we will discuss how the classical circle method can be used to provide a new proof of the Manin conjecture for the variety $x_0y_0 + \cdots + x_sy_s = 0$ for $s \geq 2$. (Received August 25, 2009)

1052-11-143 **Paul Pollack*** (pppollac@illinois.edu). *Recent results on the distribution of irreducible polynomials over finite fields.*

The prime numbers are the source of many unsolved problems in classical number theory. Three well-known examples are the twin prime conjecture about prime pairs $\{p, p+2\}$, Euler's conjecture (popularized by Landau) that there are infinitely many primes of the form $n^2 + 1$, and the Goldbach conjecture concerning prime pairs $\{p, N-p\}$ where $N \geq 4$ is even. We report on what is known about problems of this shape if the ring of rational integers is replaced by the ring of (univariate) polynomials over a finite field. Some of this is joint work with Andreas Bender of the Korea Institute for Advanced Study. (Received August 25, 2009)

1052-11-144 **Craig Valere Spencer*** (craigvspencer@gmail.com), Mathematics Department, 138 Cardwell Hall, Manhattan, KS 66506. *Additive combinatorics in function fields.*

In this talk, we will discuss how the circle method can be used to study additive combinatorics in the function field setting. In particular, we will consider variants of Roth's theorem and questions concerning irreducible polynomials. Parts of this work are joint with Thái Hoàng Lê, Yu-Ru Liu, and Xiaomei Zhao. (Received August 25, 2009)

1052-11-149 **Leo Goldmakher*** (lgoldmak@math.toronto.edu), Department of Mathematics, University of Toronto, 40 St. George Street, Toronto, ON M5S 2E4, Canada. *Multiplicative mimicry and improvements of the Pólya-Vinogradov inequality.*

Ever since its discovery in 1918, the Pólya-Vinogradov inequality has stood as the strongest bound on long character sums. In 1977, inspired by work of Daboussi and Delange, Montgomery and Vaughan obtained non-trivial bounds on exponential sums with multiplicative coefficients; this allowed them, on the assumption of the Generalized Riemann Hypothesis, to improve the Pólya-Vinogradov theorem to a best-possible estimate. In a somewhat surprising recent development, Granville and Soundararajan improved both the Pólya-Vinogradov and the Montgomery-Vaughan inequalities (unconditionally and on the assumption of the GRH, respectively) for cubic characters. We will sketch how some refinements of their ideas, combined with work of Halász, Tenenbaum, Montgomery, and Vaughan, lead to new bounds on exponential sums with multiplicative coefficients. As a consequence, we obtain improvements of both the unconditional and GRH bounds of Granville-Soundararajan for cubic character sums. Our conditional bound is best possible. (Received August 25, 2009)

1052-11-150 **Jingjing Huang*** (huang@math.psu.edu), Penn State University Mathematics Dept., University Park, State College, PA 16802. *Binary Egyptian Fractions and Erdos-Straus-Schinzel Conjecture.*

The Erdös-Straus-Schinzel conjecture in the field of Egyptian fractions asserts that for any positive rational numbers $\frac{a}{n}$ with fixed numerator $a \geq 4$ can always be expressed as a sum of three unit fractions except for a finitely many counterexamples. This conjecture has been open for the last 60 years. We hardly know anything about it except for an upper bound for the possible counterexamples, with denominator up to a height N, which was established by R.C. Vaughan in 1970. In this talk, I will try to investigate the average of the number of solutions with binary terms, instead of 3. In this case, an asymptotic formula has been worked out for the L^1 mean of the number of solutions. Though this is a simplification of the original conjecture, still it may illustrate how to obtain a similar result for the original problem, in the later work. Actually, by assuming a certain type of Manin Conjecture, a conditional result can be established with respect to the Erdös-Straus-Schinzel conjecture. (Received August 25, 2009)

1052-11-152 **Alexander Berkovich*** (alexb@ufl.edu), University of Florida, Math. Department, Gainesville, FL. *Ternary quadratic forms and certain positivity conjectures.*

I show that many of Ramanujan's modular equations of degree 3 can be interpreted in terms of integral ternary quadratic forms. This way I establish that for any $n \in N$

$$\begin{aligned} &|\{n = x\frac{(x+1)}{2} + y^2 + z^2 : x, y, z \in Z\}| >= \\ &|\{n = x\frac{(x+1)}{2} + 3y^2 + 3z^2 : x, y, z \in Z\}| \end{aligned} \tag{1}$$

The above is just one among many similar "positive" results of this type. This talk is based on a recent joint work with Will Jaggy. (Received August 25, 2009)

1052-11-157 **Qingquan Wu*** (quwu@ucalgary.ca), 2500 University DR NW, Department of Math & Stat, University of Calgary, Calgary, AB T2N 1N4, Canada. *Explicit Construction of Integral Bases of Radical Function Fields.*

A construction to find an integral basis for a radical function field of equation $y^n = D$ (such that the characteristic does not divide n) is described, where the basis is given explicitly in terms of the squarefree factorization of D. Moreover, the P-signatures for such a function field are analyzed, and it is discussed when the signature can be written down knowing a few easily computable invariants of the function field.

These results are of interest for two reasons: First, radical function fields are a wide class of function fields. Second, explicit formulae giving a nice integral basis are important for many algorithms for function fields. In particular, the property that these bases are nicely constructed allows optimizations resulting in speed-ups. (Received August 26, 2009)

1052-11-163 **Laurent Moret-Bailly** and **Alexandra Shlapentokh*** (shlapentokha@ecu.edu), Department of Mathematics, East Carolina University, Greenville, NC 27858. *Diophantine Undecidability of Holomorphy Rings of Function Fields of Characteristic 0.*

Let K be a one-variable function field over a field of constants of characteristic 0. Let R be a holomorphy subring of K, not equal to K. We prove the following undecidability results for R: If K is recursive, then Hilbert's Tenth Problem is undecidable in R. In general, there exist $x_1, \ldots, x_n \in R$ such that there is no algorithm to tell whether a polynomial equation with coefficients in $\mathbb{Q}(x_1, \ldots, x_n)$ has solutions in R. (Received August 26, 2009)

1052-11-164 **Mitsuo Kobayashi*** (mitskobay@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *On the Density of Abundant Numbers.* Preliminary report.

Following terminology from antiquity, a natural number is said to be abundant if it is smaller than the sum of its proper divisors. Since Davenport, we know that the abundant numbers have a positive asymptotic density, and from Behrend we know that this density is between 0.24 and 0.32. Henri Cohen asked if it could be determined whether it is less than, equal to, or more than 1/4. This was settled by Deléglise when he computed that it is $0.247\ldots$. We will discuss recent improvements to the algorithm of Deléglise which allows us to discover the next decimal digit. (Received August 26, 2009)

1052-11-165 **Chris Hall*** (christopher.hall@uwyo.edu), Ross Hall 305, Dept 3036, 1000 E. University Ave, Laramie, WY 82071. *Gonality and Hilbert Irreducibility.*

Given a Galois extension of the function field $\mathbb{Q}(t)$ one can specialize t to an element of a number field K in order to obtain a Galois extension of K. While the specialized Galois group is allowed to be smaller in general, a typical argument using Hilbert Irreducibility allows one to conclude that 'most' specializations have the same Galois group. The main goal of our talk will be to review a modern approach to drawing this conclusion. The key ingredient will be Faltings' celebrated (big) theorem which implies that a curve over a number field F with large gonality has only finitely many rational points defined over some small extension K/F. If time permits, we will describe an application to the endomorphism rings of the members of a (sufficiently general) one-parameter family of abelian varieties over $\mathbb{Q}$. (Received August 26, 2009)

1052-11-173 **Scott T. Parsell*** (sparsell@wcupa.edu), Department of Mathematics, West Chester University, 25 University Avenue, West Chester, PA 19383, and **Trevor D. Wooley**. *Exceptional sets for diophantine inequalities.* Preliminary report.

We describe new upper bounds for the measure of the set of real numbers not closely approximated by a diagonal form with real coefficients. The arguments employ a version of the classical Davenport-Heilbronn method together with more recent technology related to slim exceptional sets in Waring's problem. (Received August 26, 2009)

1052-11-187 **Michael J. Mossinghoff*** (mimossinghoff@davidson.edu), Department of Mathematics, Davidson College, Davidson, NC 28035. *Turan's problem on the distance to an irreducible polynomial.*

More than 40 years ago, Turán asked if every integer polynomial is 'close' to an irreducible polynomial. More precisely, he asked if there exists an absolute constant C such that for every polynomial $f \in \mathbb{Z}[x]$ there exists an irreducible polynomial $g \in \mathbb{Z}[x]$ with $\deg(g) \leq \deg(f)$ and $L(f-g) \leq C$, where $L(\cdot)$ denotes the sum of the absolute values of the coefficients. This problem remains unsolved. We describe some algorithms used to

investigate this question, and show in particular that $C = 4$ suffices for monic polynomials with degree less than 35. We also describe how well our results fit the predictions of a heuristic model. (Received August 27, 2009)

1052-11-196 **Youness Lamzouri*** (lamzouri@dms.umontreal.ca), 1 Einstein Drive, Princeton, NJ 08540. *Distribution of values of L-functions at the edge of the critical strip.*

We prove several results on the distribution of values of L-functions at the edge of the critical strip, by constructing and studying a large class of random Euler products. Among new applications, we study famillies of symmetric power L-functions of holomorphic cusp forms in the level aspect (assuming the automorphy of these L-functions) at $s = 1$, functions in the Selberg class (in the height aspect), and the family of L-functions of quadratic twists of a fixed $GL(m)/\mathbb{Q}$-automorphic cusp form at $s = 1$. (Received August 28, 2009)

1052-11-202 **Peter Paule***, Research Institute for Symbolic Computation, (RISC), Johannes Kepler University Linz, A-4040 Linz, Austria, and **Silviu Radu**. *Partition Analysis and Partition Congruences.*

The talk is a continuation of a project report delivered at the AMS Spring 2009 Sectional Meeting at Raleigh (April 4-5). It begins with partition explorations made possible by Omega, the computer algebra implementation of MacMahon's Partition Analysis developed jointly with G.E. Andrews and A. Riese. Special focus will be put on directed graphs made up of chains of generalized hexagons. From generating functions of such objects one can build infinite families of modular forms giving rise to partition congruences conjectured by G.E. Andrews and the speaker. Proofs have been delivered by M.D. Hirschhorn and J.A. Sellers, and by S.H. Chan. The talk reports on recent joint work with S. Radu who with the help of computer algebra was able to discover and prove additional congruence relations. (Received August 28, 2009)

1052-11-203 **Anthony Weaver*** (anthonyweaver@mac.com) and **Cormac O'Sullivan**. *The largest non-genus of a cyclic group.*

There is a largest positive integer g such that no surface of genus g is an n-fold regular cover of another surface. What is g? The answer is easy if n is prime, not much harder if n is prime power, and NP-hard if n has a composite, square-free factor. We treat the simplest "hard" case: when n is a product of two distinct primes. The question in this case is a four-dimensional version of a famous old problem in elementary number theory: the linear Diophantine problem of Frobenius. We obtain bounds on g, and exact formulae for certain large (infinite) classes of prime pairs. The bounds are stated in terms of the quotient and remainder of the larger prime on division by the smaller. Surprisingly, they depend heavily on the sum of those two integers – in particular, on whether the sum is less or greater than the smaller prime. A slight specialization of the question is: what is the largest g such that no surface of genus g admits a cyclic group of automorphisms of order n? In most cases, the extra requirement of a group action (as opposed to a merely regular covering) makes no difference to the answer. (Received August 28, 2009)

1052-11-208 **Frank Garvan*** (fgarvan@ufl.edu), Math Department, University of Florida, 358 Little Hall, PO Box 118105, Gainesville, FL 32611-8105. *Biranks for partitions into 2 colors.* Preliminary report.

The number of 2-colored partitions of n is congruent to 0 mod 5 for n congruent to 2, 3, or 4 mod 5. In 2003, Hammond and Lewis gave a statistic called the birank which divides these partitions into 5 equal classes. We give two deeper analogs. One analog is in terms of Dyson's rank and the second uses the 5-core crank due to Garvan, Kim and Stanton. (Received August 28, 2009)

1052-11-211 **Steve M. Gonek*** (gonek@math.rochester.edu), Department of Mathematics, University of Rochester, Rochester, NY 14627, and **Andrew H. Ledoan**. *Zeros of partial sums of the Riemann zeta-function.*

We discuss the distribution of the zeros of partial sums of the Riemann zeta-function, $\sum_{n \le X} n^{-s}$, estimating the number of zeros up to height T, the number of zeros to the right of a given vertical line, and other aspects of their horizontal distribution. (Received August 28, 2009)

1052-11-224 **Douglas Ulmer*** (ulmer@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332. *Elliptic curves of high rank and explicit points over function fields.*

We consider elliptic curves over function fields such as $K = \mathbf{F}_p(t)$, the rational function field over the field of p elements. Using cohomological techniques, it can be shown that there are many elliptic curves E over K with analytic rank (order of vanishing of $L(E, s)$ at $s = 1$) arbitrarily large. In many cases (but far from all) it can also be shown that the Birch and Swinnerton-Dyer conjecture holds and so the rank of the Mordell-Weil group

$E(K)$ is also large. In a still smaller collection of cases, generators for Mordell-Weil can be made quite explicit. It turns out that in at least one simple but interesting case, explicit points can be written down which lead to an essentially technology-free proof of the existence of elliptic curves over K of high rank. The goal of this talk is to explain this example and suggest some applications. (Received August 28, 2009)

1052-11-237 **Stephen C Milne*** (milne@math.ohio-state.edu), Department of Mathematics, The Ohio State University, 231 West 18-th Avenue, Columbus, OH 43210-1174, and **Sheldon L Degenhardt**. *A nonterminating q-Dougall summation theorem for hypergeometric series in $U(n)$, with applications.* Preliminary report.

In this talk we extend important classical one-variable summations and transformations of Bailey to multiple basic hypergeometric series very-well-poised on unitary groups $U(n+1)$. In particular, we derive multivariable generalizations of Bailey's 3-term transformation formula for ${}_8\phi_7$ series, and Bailey's nonterminating q-Dougall summation formula. As pointed out by Michael Schlosser, our nonterminating $U(n+1)$ q-Dougall summation formula yields a natural multivariable extension of Jacobi's classical identity for eighth powers of theta functions. All of this work is a consequence of the nonterminating $U(n+1)$ q-Whipple transformation formula of Milne and Newcomb. (Received August 28, 2009)

1052-11-259 **Matthew Papanikolas*** (map@math.tamu.edu), Department of Mathematics, Texas A&M University, College Station, TX 77843. *Special values of Goss L-functions for Dirichlet characters.* Preliminary report.

We will discuss special values of Goss L-functions and their relations to many prominent quantities in function field arithmetic. Let $\mathbf{F}_q[\theta]$ be a polynomial ring over the finite field with q elements, and let $\chi : \mathbf{F}_q[\theta] \to \overline{\mathbf{F}}_q$ be a Dirichlet character. For a positive integer n, special values of the Goss L-series for χ are defined by the series

$$L(n,\chi) = \sum_{a \in \mathbf{F}_q[\theta],\ \text{monic}} \frac{\chi(a)}{a^n},$$

which converges in the Laurent series field $\overline{\mathbf{F}}_q((1/\theta))$. In 1990 Anderson and Thakur considered the case of Carlitz-Goss zeta values, and showed that these values can be expressed as coordinates of logarithms on tensor powers of the Carlitz module. In 1996, Anderson considered additional characters and showed that $L(1,\chi)$ can be expressed in terms of logarithms of special points on the Carlitz module itself. We will show how to extend Anderson's log-algebraicity methods to tensor powers of the Carlitz module. Using this we find new formulas, which are explicitly related to the Carlitz period and Carlitz polylogarithms, for special values of Goss L-functions at all positive integers. (Received August 30, 2009)

1052-11-280 **Y.-R. Liu**, **C. V. Spencer** and **X. Zhao*** (x8zhao@math.uwaterloo.ca), Department of Pure Mathematics, Faculty of Mathematics, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada. *A generalization of Meshulam's theorem on subsets of finite abelian groups with no 3-term arithmetic progression.*

Let $G \simeq \mathbb{Z}/k_1\mathbb{Z} \oplus \cdots \oplus \mathbb{Z}/k_N\mathbb{Z}$ be a finite abelian group with $k_i | k_{i-1}$ $(2 \le i \le N)$. For a matrix $Y = \left(a_{i,j}\right) \in \mathbb{Z}^{R \times S}$ satisfying $a_{i,1} + \cdots + a_{i,S} = 0$ $(1 \le i \le R)$, let $D_Y(G)$ denote the maximal cardinality of a set $A \subseteq G$ for which the equations $a_{i,1}x_1 + \cdots + a_{i,S}x_S = 0$ $(1 \le i \le R)$ are never satisfied simultaneously by distinct elements $x_1, \ldots, x_S \in A$. Under certain assumptions on Y and G, we prove an upper bound of the form $D_Y(G) \le C|G|/N^\gamma$ for positive constants C and γ. (Received August 30, 2009)

1052-11-302 **Lisa Berger*** (lbrgr@math.sunysb.edu), Stony Brook University, Mathematics Department, Stony Brook, NY 11794-3651. *Surfaces dominated by products of curves and ranks of abelian varieties.*

We will discuss a recent construction of surfaces dominated by products of curves, with the property that they remain DPC in towers of field extensions. We describe recent and current work which utilizes this construction to study ranks of elliptic curves and higher dimensional abelian varieties in towers of function field extensions. (Received August 31, 2009)

1052-11-309 **Kirsten Eisentraeger***, Department of Mathematics, The Pennsylvania State University, University Park, PA 16802. *Hilbert's Tenth Problem for function fields over algebraically closed fields.*

Let K be the function field of a variety of dimension at least 2 over an algebraically closed field of odd characteristic. We show that Hilbert's Tenth Problem for K is undecidable. (Received August 31, 2009)

1052-11-315 **Alina Carmen Cojocaru*** (cojocaru@math.uic.edu), 851 S Morgan Str, 322 SEO, University of Illinois at Chicago, Chicago, IL 60607, and **Arpad Toth** (toth@cs.elte.hu), Eotos Lorand University, Department of Analysis, Mathematical Institute, Pazmany Peter setany, Budapest, Hungary. *Reductions of elliptic curves of global function fields.*

Let E be an elliptic curve defined over $F_q(t)$. We will discuss questions related to the cyclicity of E modulo P, as P varies over primes of good reductions for E. (Received August 31, 2009)

1052-11-326 **Mihran Papikian*** (papikian@math.psu.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802. *On the arithmetic of modular curves of $\mathcal{D}$-elliptic sheaves.*

Modular curves of $\mathcal{D}$-elliptic sheaves are the function field analogues of Shimura curves. We study the existence of rational points on modular curves of $\mathcal{D}$-elliptic sheaves over local fields and the structure of fundamental domains of these curves in the Bruhat-Tits tree. We discuss some applications which include finding presentations for arithmetic groups arising from quaternion algebras over function fields and finding the equations of modular curves of $\mathcal{D}$-elliptic sheaves. (Received August 31, 2009)

1052-11-327 **Bianca L Viray*** (bviray@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, Berkeley, CA 94609. *Failure of the Hasse principle for Enriques surfaces.* Preliminary report.

Most counterexamples to the Hasse principle can be explained by an algebraic Brauer– Manin obstruction. We define some of the other possible obstructions and exhibit an Enriques surface where the failure of the Hasse principle is not explained by an algebraic Brauer–Manin obstruction. If time permits we will explain how the transcendental part of the Brauer group can be thought of as a generalization of the Tate-Shafarevich group. (Received September 02, 2009)

12 ► Field theory and polynomials

1052-12-75 **Jan Minac*** (minac@uwo.ca), University of Western Ontario, Dept. of Math., Middlesex College, London, Ontario N6A 5B7, Canada. *Tiny, spectacular Galois jewels in the midst of mysterious giants.* Preliminary report.

Abstract:

Absolute Galois groups of fields are mysterious, grotesquely large, serious and intimidating giants. However if you look carefully you will see on their giant fingers, tiny, spectacular Galois groups of exponents at most p times p (for each prime number p) and of nilpotence index at most 2. Surprisingly these gems reveal a lot about their owners and their corresponding base fields.

This is a report on my joint work with Sunil Chebolu and Ido Efrat. (Received August 19, 2009)

13 ► Commutative rings and algebras

1052-13-20 **Laura Ghezzi*** (lghezzi@citytech.cuny.edu), Department of Mathematics, New York City College of Technology, CUNY, Brooklyn, NY 11201. *Cohen-Macaulayness and the vanishing of Hilbert coefficients.*

A conjecture on the vanishing of the first Hilbert coefficient $e_1(Q)$ is solved affirmatively, where Q is a parameter ideal in a Noetherian local ring. The invariance of $e_1(Q)$ for parameter ideals Q and its relationship to Buchsbaum rings are studied. This is joint work with S. Goto, J. Hong, K. Ozeki, T.T. Phuong, and W.V. Vasconcelos. (Received July 04, 2009)

1052-13-23 **Wolmer Vasconcelos*** (vasconce@math.rutgers.edu), Department of Mathematics - Hill Center, Rutgers University, 110 Frelinghuysen Rd, Piscataway, NJ 08854. *What is – and what is not – a Cohen-Macaulay ring.*

Let $\mathbf{F}$ be a field and $\mathbf{f} = \{f_1, \ldots, f_m\}$ a set of polynomials of $\mathbf{F}[x_1, \ldots, x_d]$. For a diversity of reasons–algebraic, geometric and/or computational–it is of interest to understand the zero set $V(\mathbf{f})$ (in $\mathbf{F}$ or in one of its extensions). A common pathway to this goal is the examination of the ring $\mathbf{A} = \mathbf{F}[x_1, \ldots, x_d]/(\mathbf{f})$.

There are many structures attached to $\mathbf{A}$–Jacobian ideals, modules of differentials, chain complexes, local cohomology modules, dualities, among others. Their usefulness are greatly enhanced in the presence of the condition known as the Cohen-Macaulayness of $\mathbf{A}$. We will discuss this condition, its major examples, and the role it has played in the development of commutative and homological algebra.

Finally, we will discuss methods, some of recent vintage, to quickly ascertain whether some of these rings are Cohen-Macaulay or not.

We thank Laura Ghezzi, Shiro Goto and Jooyoun Hong for many discussions related to topics in this talk. (Received August 27, 2009)

1052-13-28 **Irena Peeva***, Math. Dept., Cornell Univ., Ithaca, NY 14853, and **Eran Nevo**. *Powers of edge ideals.*

Edge ideals are monomial ideals defined by simple graphs. A lot of work has been done on relating the homological properties of an edge ideal to the combinatorial properties of the defining graph. This talk will discuss some cases when the minimal free resolution of a power of an edge ideal is linear. (Received July 14, 2009)

1052-13-73 **Kuei-Nuan Lin*** (link@purdue.edu). ***Rees Algebras of diagonal ideals.***.

Let X be an m by n matrix of variables over a field k. R and S are rings defined by the minors of X. We consider the diagonal ideal $\mathbb{D}$, the kernel of the diagonal map. By the work of Simis-Ulrich, we know the defining equations of special fiber of $\mathbb{D}$. When $R = S$, the special fiber is known as a homogeneous coordinate ring of secant variety of the determinantal variety $\mathcal{Z}(\mathrm{Spec}(R))$. Some of the cases show that the fiber ring is $k[X]$. It is nature to ask whether $\mathbb{D}$ is an ideal of linear type, which means that the natural map from the symmetric algebra of $\mathbb{D}$, $\mathrm{Sym}(\mathbb{D})$, onto the Rees algebra of $\mathbb{D}$, $\mathcal{R}(\mathbb{D})$, is an isomorphism. We aim at a more refined study of the ideal defining $\mathcal{R}(\mathbb{D})$. By knowing the defining equations, we can show that $\mathcal{R}(\mathbb{D})$ is Cohen-Macaulay and $\mathbb{D}$ is an ideal of linear type. (Received August 19, 2009)

1052-13-78 **Luchezar L. Avramov**, **Aldo Conca** and **Srikanth B Iyengar*** (iyengar@math.unl.edu), 305 Avery Hall, Department of Mathematics, Lincoln, NE 68588. *Free resolutions over Koszul algebras.*

For $R = Q/J$ with Q a commutative graded algebra over a field and $J \neq 0$, we relate the slopes of the minimal resolutions of R over Q and of $k = R/R_+$ over R. When Q and R are Koszul and $J_1 = 0$ we prove $\mathrm{Tor}_i^Q(R,k)_j = 0$ for $j > 2i \geq 0$, and also for $j = 2i$ when $i > \dim Q - \dim R$ and $\mathrm{pd}_Q R$ is finite. (Received September 01, 2009)

1052-13-88 **Brian Harbourne*** (bharbour@math.unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Powers versus symbolic powers of ideals.*

If I is an ideal in a polynomial ring $R = k[x_0, ..., x_n]$ over a field k, it is known by work of Ein-Lazarsfeld-Smith (using multiplier ideals) and Hochster-Huneke (using Frobenius powers and tight closure) that $I^{(m)} \subseteq I^r$ whenever $m \geq nr$ and it is known by work of Bocci-Harbourne (using algebraic geometric methods) that n is the least value of the coefficient c such that $m \geq cr$ implies $I^{(m)} \subseteq I^r$ for all ideals $I \subseteq R$. I will discuss recent questions, conjectures and results addressing the question of what values of a guarantee $I^{(m)} \subseteq I^r$ for all ideals $I \subseteq R$ given $m \geq nr - a$. (Received August 21, 2009)

1052-13-92 **Angela L Kohlhaas*** (akohlhaa@nd.edu), University of Notre Dame, 255 Hurley Hall, Notre Dame, IN 46556. *The core versus the adjoint of a monomial ideal.* Preliminary report.

Given an ideal I in a Noetherian ring R, the core of I is the intersection of all ideals contained in I with the same integral closure as I. The core naturally arises in the context of the Briançon-Skoda theorem as an ideal which contains the adjoint of a certain power of I. As the arbitrary-characteristic analog of the multiplier ideal, the adjoint is an important tool in the study of resolutions of singularities, and the question of when the core and the adjoint of a power of I are equal has been tied to a celebrated conjecture of Kawamata about the non-vanishing of sections of line bundles. By illustrating symmetry properties of the core of a monomial ideal in a polynomial ring, I will show that for certain classes of monomial ideals, this equality holds if and only if the core is integrally closed. (Received August 21, 2009)

1052-13-98 **Luchezar L Avramov*** (avramov@math.unl.edu), Deapartment of Mathematics, University of Nebraska, Lincoln, NE 68516. *Bass numbers of local rings: Questions, results, and the whole story in codepth* 3. Preliminary report.

The nth emphBass number mu_R^n of a commutative noetherian local ring R with maximal ideal $mathfrakm$ and residue field $k = R/mathfrakm$ is defined to be the rank of the k-vector space $mathrmExt_R^n(k,R)$. It is known that for $n > mathrmdepthR$ all Bass numbers vanish when R is Gorenstein, and that none of them does when R is not Gorenstein. The talk will survey open problems and known results concerning emphquantitative information on the sequence (mu_R^n). For rings satisfying $mathrmrank_k(mathfrakm/mathfrakm^2) - mathrmdepthRle3$

the sequence will be computed explicitly. The argument will be used as a platform for discussing a variety of general techniques, which may be applied in other cases as well. (Received August 25, 2009)

1052-13-103 **Andrew R Kustin***, Mathematics Department, University of South Carolina, Columbia, SC 29208. *Singularities of plane curves which are parameterized by homogeneous forms of small degree.*

Consider an ideal I of height two generated by three homogeneous forms of degree six in $R = k[x, y]$. On the one hand, we describe the degrees of the minimal generators of the defining ideal $\mathcal{A}$ of the Rees algebra $R[It]$. There are only a handful of possibilities. On the other hand, the ideal I gives rise to a parameterization of a curve $\mathcal{C}$ in the projective plane. The curve $\mathcal{C}$ has singularities and the multiplicities of these singularities are determined by the generator degrees of $\mathcal{A}$. This work has been carried out with Claudia Polini, Bernd Ulrich, and David Cox. (Received August 23, 2009)

1052-13-125 **Inês Bonacho dos Anjos Henriques*** (ihenriques@math.unl.edu), Department of Mathematics, 203 Avery Hall, P.O. Box 880130, Lincoln, NE 68588-0130, and **Liana M. Şega**, Department of Mathematics and Statistics, University of Missouri, Kansas City, MO 64110. *Cohomology over short Gorenstein local rings.*

We identify a class of local rings $(R, \mathfrak{m})$ with $\mathfrak{m}^4 = 0$, exhibiting the Koszul like property that $\mathrm{H}_R(-t)\,\mathrm{P}^R_M(t)$ is a polynomial in $\mathbb{Z}[t]$ for all finite R-modules M. This class includes generic graded Gorenstein algebras of socle degree 3. We show that minimal free resolutions of finite modules over such rings admit Koszul syzygy modules. (Received August 24, 2009)

1052-13-131 **Ri-Xiang Chen*** (rxc@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14850. *Macaulay's Theorem for Some Projective Monomial Curves.*

Gasharov, Horwitz and Peeva introduced the notion of a lex ideal in the toric ring. We will discuss whether Macaulay's Theorem holds for some special projective monomial curves. (Received August 24, 2009)

1052-13-134 **Timothy B.P. Clark*** (tbpclark@math.northwestern.edu), Mathematics Department, 2033 Sheridan Road, Evanston, IL 60208. *Poset resolutions of monomial ideals.*

Let P be a finite partially ordered set (poset) with set of atoms A and let k be a field. Considering certain open intervals of P, we utilize a construction of Tchernev to produce a sequence of k-vector spaces and vector space maps $\mathcal{D}(P)$. When a poset map $\eta : P \to \mathbb{Z}^n$ exists, the sequence $\mathcal{D}(P)$ is homogenized to approximate a free resolution $\mathcal{F}(\eta)$ of R/N where N is the monomial ideal in $k[x_1, \ldots, x_n]$ whose set of minimal generators is $\{x^{\eta(a)} : a \in A\}$. When $\mathcal{F}(\eta)$ is an exact complex of multigraded modules, we call it a *poset resolution* of R/N. We show that the poset which provided our original motivation, the lcm-lattice associated to N, supports the minimal free resolution for a class of ideals we call *lattice-linear*. This class of monomial ideals contains both the class of ideals with a linear resolution and the class of Scarf ideals. More generally, poset resolutions provide a common framework from which to view a number of (not necessarily minimal) resolutions previously constructed using distinct methods. Specifically, we show that both the Taylor resolution and Eliahou-Kervaire minimal resolution may be viewed as poset resolutions. (Received August 26, 2009)

1052-13-166 **Sonja Mapes*** (smapes@math.duke.edu), Mathematics Department, 117 Physics Bldg, Box 90320, Durham, NC 27708. *Cellular resolutions of monomial ideals and LCM lattices.*

In the study of cellular resolutions of monomial ideals it is often useful to consider the LCM lattice of the given monomial ideal. In particular, it is known that all ideals with isomorphic LCM lattices have isomorphic minimal resolutions. In this talk I will discuss how studying the parameter space of such lattices provides new insights into the structure of these resolutions. (Received August 26, 2009)

1052-13-168 **Susan E. Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, 601 University Dr., San Marcos, TX 78666. *Depth Bounds and Cohen-Macaulayness for Square-free Monomial Ideals.*

There is a natural one-to-one correspondence between square-free monomial ideals and simple hypergraphs, also called clutters. Using this correspondence, combinatorial properties of the hypergraph associated to an ideal can be used to determine algebraic properties of the ideal. In this talk, a lower bound will be given for $\operatorname{depth}(R/I^t)$ for $t \geq 1$ when I is the edge ideal of a tree. A similar bound will be given for small powers t when I is the edge ideal of a graph. For more general square-free monomial ideals, conditions will be given under which $\operatorname{depth}(R/I^t)$ is positive. A combinatorial condition on a hypergraph, which extends results of Herzog and Hibi for edge ideals of bipartite graphs, will be given under which $\operatorname{depth}(R/I)$ is maximal, or R/I is Cohen-Macaulay. (Received August 26, 2009)

1052-13-190 **Andrew Crabbe*** (amcrabbe@syr.edu), Syracuse University, Department of Mathematics, 215 Carnegie Bldg., Syracuse, NY 13244-1150, and **Silvia Saccon** (s-ssaccon1@math.unl.edu), University of Nebraska–Lincoln, Department of Mathematics, 203 Avery Hall, Lincoln, NE 68588–0130. *Ranks of indecomposable maximal Cohen-Macaulay modules.* Preliminary report.

Let R be a one-dimensional reduced Noetherian local ring of infinite Cohen-Macaulay type, and let $P_1,\dots, P_s$ be the minimal prime ideals of R. From work of Roger Wiegand and others, it is known that for every positive integer r there is an indecomposable maximal Cohen-Macaulay R-module M of constant rank r, i.e. $M_{P_i} \cong R_{P_i}^{(r)}$ for each i. In this talk we explore the following question: For which non-trivial s-tuples $(r_1,\dots,r_s)$ is there an indecomposable maximal Cohen-Macaulay R-module M such that $M_{P_i} \cong R_{P_i}^{(r_i)}$ for each i? Our main result is that if R/P_1 has infinite Cohen-Macaulay type, then a non-trivial s-tuple $(r_1,\dots,r_s)$ can be realized as the rank of an indecomposable maximal Cohen-Macaulay module whenever $r_1 \geq r_i$ for each i. (Received August 27, 2009)

1052-13-212 **Louiza Fouli**, New Mexico State University, Las Cruces, NM, **Janet Vassilev*** (jvassil@math.unm.edu), University of New Mexico, Albuquerque, NM , and **Adela Vraciu**, University of South Carolina, Columbia, SC. *The *-core of an ideal.*

Assume that $(R,\mathfrak{m})$ is a local Noetherian ring of characteristic $p>0$. In this setting, we will discuss the $*$-core of an ideal, I, and some instances where we know a formula for the $*$-core(I). (Received August 28, 2009)

1052-13-271 **Leila Khatami*** (l.khatami@neu.edu), Department of Mathematics, Northeastern University. *Commuting Nilpotent Matrices.*

Fix a nilpotent $n\times n$ matrix B over a field k and of Jordan partition P. Consider the centralizer $\mathcal{C}_B$ of B and its irreducible subvariety $\mathcal{N}_B$ of nilpotent matrices. There is a Jordan block partition $Q(P)$ of the generic matrix $A\in\mathcal{N}_B$, that is greater than any other Jordan partition occurring for elements of $\mathcal{N}_B$. R. Basili and A. Iarrobino show that the partition $Q(P)$ is determined by the Hilbert function of the ring $k[A,B]$ with A a generic element of $\mathcal{N}_B$. It is also shown, by T. Košir and P. Oblak, that $k[A,B]$ is Gorenstein for general enough A. From these results it follows that $Q(P)$ has parts differing pairwise by at least two. In this talk we review the basic facts and discuss a new approach to the study of $Q(P)$ developed in a joint work with R. Basili and A. Iarrobino. (Received August 30, 2009)

1052-13-282 **Jeff A Mermin*** (mermin@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Satoshi Murai**. *The lex-plus-powers conjecture holds for pure powers.*

Let $R=k[x_1,\dots,x_n]$ be a polynomial ring. Let $F=(f_1,\dots,f_r)$ be a homogeneous regular sequence with $\deg(f_i)=e_i$ and $e_1\leq\cdots\leq e_r$. Put $P=(x_1^{e_1},\dots,x_r^{e_r})$. The Lex-Plus-Powers conjecture asserts the following:

(1) Let I be any ideal containing F. Then there exists a lex ideal L such that the lex-plus-powers ideal $L+P$ has the same Hilbert function as I.

(2) The graded Betti numbers of $L+P$ are all greater than or equal to those of I.

Part (1), on its own, is the Eisenbud-Green-Harris conjecture. Both are open.

We prove the lex-plus-powers conjecture in the case that $F=P$. (Received August 31, 2009)

1052-13-294 **Diana White*** (diana.white@ucdenver.edu), Campus Box 170, 1250 14th St., PO Box 173364, Denver, CO 80217-3364, and **Sean Sather-Wagstaff** and **Tirdad Sharif**. *Iterating the construction of the Gorenstein projectives.*

The Gorenstein projectives arise naturally as cokernels of complete resolutions by free modules. In this talk, we investigate what happens if we iterate this construction. That is, we classify the cokernels of a complete resolution by Gorenstein projectives. (Received August 31, 2009)

1052-13-298 **Lars Winther Christensen*** (lars.w.christensen@ttu.edu), Department of Mathematics and Statistics, Broadway and Boston, M.S. 1042, Lubbock, TX 79409, and **Sean Sather-Wagstaff**. *A Cohen–Macaulay algebra has only finitely many semidualizing modules.*

Let R be a commutative noetherian local ring. A finitely generated R-module C is *semidualizing* if the natural homomorphism $R\to\operatorname{Hom}(C,C)$ is an isomorphism and $\operatorname{Ext}^{\geq 1}(C,C)=0$.

Vasconcelos asked whether the set of isomorphism classes of semidualizing R-modules is finite when R is Cohen–Macaulay and whether it has even cardinality when it contains more than one element.

I will present a positive answer to the first question for equicharacteristic rings and also discuss the second question. (Received August 31, 2009)

1052-13-301 **Dustin A. Cartwright*** (dustin@math.berkeley.edu), University of California, Berkeley, Department of Mathematics, 970 Evans Hall #3840, Berkeley, CA 94720-3840, and **Bernd Sturmfels**. *The Hilbert scheme of the diagonal in a product of projective spaces.*

The diagonal in a product of projective spaces is cut out by the ideal of 2×2-minors of a matrix of unknowns. The multigraded Hilbert scheme which classifies its degenerations has a unique Borel-fixed ideal. This Hilbert scheme is generally reducible, and its main component is a compactification of $PGL(d)^n/PGL(d)$. For $n = 2$ we recover the manifold of complete collineations. For projective lines we obtain a space of trees that is irreducible but singular. All ideals in our Hilbert scheme are radical. (Received September 01, 2009)

1052-13-320 **Lance Bryant*** (lebryant@ship.edu), 1871 Old Main Dr., Shippensburg, PA 17257. *Filtered Numerical Semigroups and Applications to One-Dimensional Rings.*

In this talk, filtrations in numerical semigroups will be considered. Applications are made to the study of one-dimensional Cohen-Macaulay local rings, particularly one-dimensional analytically irreducible Noetherian local domains. We are primarily interested in the Cohen-Macaulay and Gorenstein properties of associated graded rings of filtrations. (Received August 31, 2009)

1052-13-333 **S. D. Cutkosky**, **K. Dalili*** (dalilik@missouri.edu) and **O. Kashcheyeva**. *Asymptotic behavior of value semi-groups.*

Let v be a valuation dominating a noetherian local domain, let $S = \{v(r)|r \in R\}$ be its value semi-group and let G be its value group (the group obtained by appending inverses to S). The possible value groups G have been extensively studied and classified classically; the value semi-group S however is much less understood. In this talk we will briefly look at the known results classifying value groups and at some well known constraints on the value semi-groups. Then we will look at growth rate of the value semi-group and its asymptotic behavior to obtain new constraints on possible value semi-groups.

This is joint work with S. D. Cutkosky and O. Kashcheyeva. (Received September 01, 2009)

1052-13-337 **Jennifer Biermann*** (jbiermann@math.cornell.edu), 310 Malott Hall, Cornell University, Ithaca, NY 14853. *Reverse Lex Ideals.*

In this talk, I will introduce the notion of reverse lex ideals in a polynomial ring, and compare their properties to those of lex ideals. In particular I provide an analogue of Green's Theorem for reverse lex ideals. I also compare the Betti numbers of Borel and square-free Borel monomial ideals to those of reverse lex ideals. (Received September 01, 2009)

1052-13-338 **Thuy Pham*** (tpham@utsc.utoronto.ca), Department of Mathematics, University of Toronto, 40 St. George Street, Toronto, Ontario M5S 3G3, Canada, and **Wolmer V. Vasconcelos** (vasconce@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen road, Piscataway, NJ 08854. **On the computation of the jdeg of blowup algebras**.

For a graded algebra $\mathbf{A}$, its jdeg($\mathbf{A}$) is a global degree that can be used to study complexity of the normalization $\bar{\mathbf{A}}$. In this talk, we discuss methods to estimate jdeg using symmetric algebras and approximation complexes. This is joint work with Wolmer Vasconcelos. (Received September 01, 2009)

1052-13-340 **Jesse Burke*** (s-jburke13@math.unl.edu), 203 Avery Hall, Lincoln, NE 68588. *Vanishing of self-extensions over a complete intersection.*

Let R be a local complete intersection ring and M a finite R-module. Avramov and Buchweitz showed that M has finite projective dimension if $\operatorname{Ext}^{2n}_R(M, M) = 0$ for some $n \geq 1$. We generalize this result by showing that finiteness is not necessary. The proof is new and in particular makes use of Bousfield localization. (Received September 01, 2009)

1052-13-354 **Lars Winther Christensen** (lars.w.christensen@ttu.edu), Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042, and **W. Frank Moore*** (fmoore@gmail.com), Department of Mathematics, Cornell University, Ithaca, NY 14853. *On G-regular local rings and Golod homomorphisms.* Preliminary report.

A module G over a local ring $(R, \mathfrak{m}, k)$ is totally reflexive provided there is a complex of finitely generated free R-modules

$$\mathbf{F} = \ldots \longrightarrow F_{n+1} \xrightarrow{\partial_{n+1}} F_n \xrightarrow{\partial_n} F_{n-1} \longrightarrow \cdots$$

such that G is the cokernel of ∂_0 and $\operatorname{Hom}_R(\mathbf{F}, R)$ is exact. Such modules were first studied by Auslander and Bridger. A ring for which every totally reflexive module is free is called $\mathcal{G}$-regular.

Such rings have been studied in work of Takahashi and Yoshino, and have appeared implicitly in work of Christensen-Piepmeyer-Striuli-Takahashi. In this preliminary report, we unify many of the examples of $\mathcal{G}$-regular rings that exist in the literature by showing that if $\varphi\colon Q \to R$ is a Golod homomorphism, then under certain conditions R is $\mathcal{G}$-regular. (Received September 01, 2009)

1052-13-357 **Alberto Corso*** (corso@ms.uky.edu), Department of Mathematics, University of Kentucky, Lexington, KY 40506, and **Uwe Nagel**, **Sonja Petrovic** and **Cornelia Yuen**. *Determinantal equations defining the special fiber ring of certain ideals.* Preliminary report.

In a previous work, Corso and Nagel studied the algebraic properties of a class of monomial ideals arising from special bipartite graphs. These ideals, involving two distinct sets of variables, were dubbed Ferrers ideals. In particular, the special fiber ring of these ideals turned out to be defined by the two by two minors of a ladder. Using these equations we determine a special reduction of these ideals in a fashion that generalizes an old formula of Dedekind and Mertens about the relation of the contents of two polynomials and their product. Further, in some cases a specialization process produces an interesting class of monomial ideals generated in degree two. This class includes, for instance, (square-free) strongly stable ideals. We show that the equations defining the special fiber ring of these new specialized ideals are given by the two by two minors of a symmetric ladder, possibly with holes. This result extends some previous work of Conca and, later, Villarreal. (Received September 01, 2009)

14 ► Algebraic geometry

1052-14-27 **Emma Previato*** (ep@bu.edu), Deapartment of Mathematics and Statistics, Boston University, Boston, MA 02215-4211. *Riemann surfaces with automorphisms: Aspects of dynamics.*

Moduli of Riemann surfaces, and of vector bundles over a fixed Riemann surface, have become essential objects of mathematical physics in recent decades, prompting in turn new algebro-geometric questions and techniques. The talk will present different aspects of this story: Solitons of Ordinary Differential Operators with elliptic coefficients; Ultra- and Co-elliptic solitons; Calogero-Moser-Krichever Hamiltonian systems; Hitchin systems. Firstly we will explore a related property for the Riemann Surface, being an elliptic cover; out of this we construct (ultra- and co-)elliptic solitons (joint work with R.Y. Donagi, J.C. Eilbeck, V.Z. Enolskii), which are non-linear waves. Secondly, we will show that elliptic solitons 'split' the Jacobian, and focus on the Klein quartic, $x_0^3x_2 + x_2^3x_1 + x_1^3x_0 = 0$ to construct explicit flows on the Jacobian in terms of elliptic functions (joint work with V.Z. Enolskii and A. Perelomov). Lastly, we will write polynomial Hamiltonians for the Hitchin system (joint work with B. van Geemen, R.M. Fedorov) and their evolution equations in spaces of vector bundles over Riemann Surfaces of genus two with automorphisms (using joint work with T. Shaska and S. Wijesiri). Several projects will be proposed to the audience. (Received July 14, 2009)

1052-14-86 **Gabriel Bartolini*** (gabar@mai.liu.se), Matematiska institutionen, Linköpings universitet, SE-58183 Linköping, Sweden, and **Milagros Izquierdo**. *On the connectedness of the branch locus of the moduli space of Riemann Surfaces II.*

We used the equiparametric stratification described by Broughton (1990) to study the branch locus of the moduli space of Riemann surfaces of low genus, in particular its connectedness. On we also show that strata induced by actions of C2 and C3 belong to the same connected component for all genera. This is a joint wotk with Antonio F. Costa and Milagros Izquierdo (Received August 21, 2009)

1052-14-87 **S. Allen Broughton*** (brought@rose-hulman.edu) and **Christopher Judge**. *Flat Surfaces, Teichmueller Discs, Veech Groups, and the Veech Tessellation.* Preliminary report.

Flat surfaces were popularized as a tool in understanding the dynamics of a billiard ball on a polygonal table whose corner angles are rational multiples of π. However, the surfaces have become interesting in their own right and are powerful tools in the analysis of Teichmueller discs and Veech groups. A Teichmueller D disc may be thought of as a complex geodesic tangent curve in Teichmueller space through a given surface. The Veech group V is the subgroup of the mapping class group M that maps the disc to itself, and acts as linear fractional transformations on the disc. Normally, this is uninteresting unless D/V has finite area. In this case the image of D in the moduli space is a complex curve. In this talk, after introducing the main players, we will discuss an interesting tessellation on the Teichmueller disc D coming from flat surface analysis of the parametric family of surfaces defined by the disc. The automorphism group of the tesselation always contains the Veech group.

The authors present some conjectures that, in the finite area case, the inclusion is of finite index. This gives an alternate approach to computing Veech groups. (Received August 21, 2009)

1052-14-112 **Jürgen Wolfart*** (wolfart@math.uni-frankfurt.de), Math. Seminar der Goethe Universität, Postfach 111932, D-60054 Frankfurt a.M., Germany, and **G. A. Jones** and **M. Streit**. *Wilson's operations on regular dessins and cyclotomic fields of definition.*

Grothendieck's dessins d'enfants can be defined as bipartite graphs embedded into oriented compact surfaces and cutting them into simply connected cells. They determine a unique conformal structure on the surface, even as an algebraic curve defined over a number field. Recent joint work with G.A. Jones and M. Streit (to appear in the Proceedings of the LMS) shows that regularity and certain invariance properties under "Wilson operations" – well known in map theory – decode algebraic information about the curves hidden in the combinatorics of dessins. (Received August 24, 2009)

1052-14-116 **Gretchen L. Matthews** (gmatthe@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975, and **Justin D. Peachey*** (jpeache@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975. *Riemann-Roch spaces of the norm-trace function field.* Preliminary report.

The norm-trace function field over the finite field $\mathbf{F}_{q^r}$ is given by $\mathbf{F}_{q^r}(x,y)/\mathbf{F}_{q^r}$ where $N_{\mathbf{F}_{q^r}/\mathbf{F}_q}(x) = Tr_{\mathbf{F}_{q^r}/\mathbf{F}_q}(y)$, meaning the norm of x is equal to the trace of y with respect to the extension $\mathbf{F}_{q^r}/\mathbf{F}_q$. It is a generalization of the Hermitian function field over $\mathbf{F}_{q^2}$, which is obtained when $r = 2$. The norm-trace function field has $q^{2r-1}+1$ places of degree one, including q^{r-1} places P_{0b} and a single place at infinity P_∞. In this talk, we determine explicit bases for Riemann-Roch spaces $\mathcal{L}\left(a_0 P_\infty + a_1 P_{0b_1} + \cdots + a_m P_{0b_m}\right)$ where $1 \leq m \leq q^{r-1}$ and discuss some applications. (Received August 24, 2009)

1052-14-128 **Samar M ElHitti*** (selhitti@citytech.cuny.edu), 300 Jay street, Namm 602B, Brooklyn, NY 11201. *Formal prime ideals of infinite value and their algebraic resolution.*

Suppose that R is a local domain essentially of finite type over a field of characteristic 0, and ν a valuation of the quotient field of R which dominates R. The rank of such a valuation often increases upon extending the valuation to a valuation dominating $\hat{R}$, the completion of R. When the rank of ν is 1, Cutkosky and Ghezzi handle this phenomenon by resolving the prime ideal of infinite value, but give an example showing that when the rank is greater than 1, there is no natural ideal in $\hat{R}$ that leads to this obstruction. We extend their result on the resolution of prime ideals of infinite value to valuations of arbitrary rank. This paper is joint work with Dale Cutkosky. (Received August 24, 2009)

1052-14-155 **Jeremiah Heller*** (heller@math.northwestern.edu), Dept. Mathematics, 2033 Sheridan Road, Evanston, IL 60208. *Vanishing Theorems for Real Algebraic Cycles.*

We discuss recent joint work with M. Voineagu where we show that the reduced Lawson homology of a real algebraic variety vanishes in degrees larger than the dimension of the variety. These homology groups are defined via homotopy groups of some spaces of cycles on a real variety and are an interesting mix of topological and algebraic data, related for example to motivic cohomology and real morphic cohomology. We discuss a few applications and computations. (Received August 25, 2009)

1052-14-200 **Ernesto Girondo*** (ernesto.girondo@uam.es), Depto. de Matematicas, Campus de Cantoblanco, Universidad Autonoma de Madrid, 28049 Madrid, Spain, and **David Torres**. *Algebraic equations of genus 2 Riemann surfaces with a hyperelliptic uniform dessin.*

The determination of an algebraic model for the surface uniformized by a given Fuchsian group can be explicitly achieved only in very special situations. In the literature, most of the cases for which this problem has been solved correspond to quasiplatonic surfaces (i.e. surfaces with a regular dessin d'enfant).

We find equations for some (non-quasiplatonic) surfaces containing a hyperelliptic uniform dessin. The (elementary but sometimes lengthy) calculations leading to them are adapted to each particular case, and are based on the study of the corresponding uniform Belyĭ function. (Received August 28, 2009)

1052-14-218 **James S Wolper*** (wolpjame@isu.edu), 921 S. 8th Ave., Mail Stop 8085, Pocatello, ID 83209. *Automorphism Groups and Moduli Spaces of Vector Bundles.* Preliminary report.

Many theorems relate geometric properties of the Jacobian of a complex curve to the automorphism group of the curve. These properties involve subvarieties like the singular locus of the theta-divisor and various Brill-Noether loci. How can these theorems be extended to similar loci on the various moduli spaces of vector bundles over the curve?

This talk will describe examples of loci in the moduli spaces of vector bundles that depend on properties of the automorphism group of the curve. All of these example depend on known results about Jacobians. The talk will also discuss attempts to find new loci. (Received August 28, 2009)

1052-14-219 **Aaron Wootton*** (wootton@up.edu), 5000 North Willamette Blvd, Portland, OR 97217, and **J W Anderson**. *Bounding the Number of Group Actions on a Surface of Fixed Genus.* Preliminary report.

Let S be a closed oriented surface of genus $\sigma \geq 2$ and let N_σ denote the number of topologically distinct non-trivial finite group actions on S. For general σ, it is easy to determine upper and lower bounds for N_σ dependent upon σ, but such bounds are usually gross approximations. We consider the problem of refining such bounds. (Received August 28, 2009)

1052-14-332 **Jacques Hurtubise*** (jacques.hurtubise@mcgill.ca), Dept. Mathematics and Statistics, McGill University, 805 Sherbrooke St. W., Montreal, Quebec H2V 2W8, Canada. *Geometry of isomonodromic deformations.*

We consider the geometry behind the Hamiltonian structure of isomonodromy deformations of connections on vector bundles over Riemann surfaces. The main point is that one should think of an open set of the moduli of pairs (V, ∇) of vector bundles and connections as being obtained by "twists" supported over points of a fixed vector bundle V_0 with a fixed connection ∇_0; this gives two deformations, one, isomonodromic, of (V, ∇), and another induced from the isomonodromic deformation of (V_0, ∇_0). The difference between the two will be Hamiltonian. (Received September 01, 2009)

16 ► Associative rings and algebras

1052-16-273 **Manuel Lopez*** (malsma@rit.edu), School of Mathematical Sciences (COS), Rochester Institute of Technology, 1 Lomb Drive, Rochester, NY 14623. *How the Method of Finite Differences can show you the way to conjectures.*

The *method of finite differences* is well known for problems that yield to a polynomial solution. We will use this method in the more exotic problem of figuring out the i^{th} dimension of $\mathbb{Z}$-graded rings. Each $\mathbb{Z}$-graded ring will be a quotient ring of a polynomial ring $k[x_1, x_2, \ldots, x_n]$ where k is a field. The solution for this problem turns out to be a difference equation, not a polynomial. The resulting difference equation is readily computable. However the biggest divident of our approach is the availability of conjectures if one knows how to read the finite difference table. I'll point out the ones I have recognized, but other conjectures might still be there in plain sight. (Received August 30, 2009)

18 ► Category theory; homological algebra

1052-18-33 **Mark Hovey*** (mhovey@wesleyan.edu), Department of Mathematics, Wesleyan University, Middletown, CT 06459. *Watts' theorems and Brown representability for derived categories.*

Watts' theorem in algebra determines which functors from Mod R to Mod S are tensor products. We prove an analogous theorem for functors from the triangulated derived category D(R) to D(S). In particular, we partially salvage the failure of Brown representability for homology functors on D(R). (Received July 27, 2009)

1052-18-34 **Srikanth B. Iyengar*** (iyengar@unl.edu), 302.1 Avery Hall, Lincoln, NE 68588. *Stratifying derived categories associated to finite groups and to commutative rings.*

My lectures will be concerned with the general problem of describing/classifying the thick subcategories of the bounded derived category of a noetherian ring. I will report on recent progress, in the context of commutative rings and of group algebras of finite groups. This is based on joint work with various collaborators, including Luchezar Avramov, Dave Benson, and Henning Krause. (Received July 30, 2009)

1052-18-105 **J P May*** (may@math.uchicago.edu), Department of Mathematics, The University of Chicago, 1118 E. 58th Street, Chicago, IL 60637. *Six model structures for DG modules over DGA's.*

Let A be a differential graded algebra over a commutative ring R and let M(A) be the category of differential graded (left) A-modules. There are three obvious notions of weak equivalence in M(A): A-homotopy equivalence, R-homotopy equivalence, and quasi-isomorphism. These lead to three triangulated categories. There are (at least) six sensible model category structures on M(A), one, two, and three, respectively, for the three kinds of

weak equivalences just named. In one of them, the classical bar construction B(A,A,X) is a model theoretic cofibrant approximation of X. All of these model structures seem natural and interesting. There appear to be many other contexts in algebra and topology where such a sextet of interrelated model structures is present. (Received August 23, 2009)

1052-18-124 **Enxin Wu*** (ewu22@uwo.ca), Department of Mathematics, the University of Western Ontario, London, Ontario N6A 5B7, Canada. *A brief survey of A-infinity algebras and related triangulated structures.* Preliminary report.

I will talk about the definition of an A-infinity algebra, its basic properties, its derived category, and its relationship with a special class of triangulated categories. This is a survey talk based on Bernhard Keller's summary on A-infinity algebras, and some of the recent developments of the field. (Received August 24, 2009)

1052-18-341 **Tom Lada*** (lada@math.ncsu.edu). *An L-infinity algebra which is also an open closed homotopy algebra.* Preliminary report.

Recall L-infinity algebras are the objects acted upon by an L-infinity operad, and have strong connections to deformation theory and mathematical physics. More recently, open closed homotopy algebras (OCHAs) were introduced by Kajiura and Stasheff as the algebras over the 'Swiss-cheese' operad of Voronov, which blends the little disks and little intervals operads as suggested by Kontsevich's approach to deformation quantization. The talk will provide a general introduction to L-infinity algebras, along with some discussion of OCHAs, as a context for considering in some detail a specific example of both at once. (Received September 01, 2009)

19 ► K-theory

1052-19-194 **Bertrand J Guillou*** (bertg@illinois.edu). *The motivic fundamental group of the punctured projective line.*

We will discuss, following a suggestion of S. Bloch, the construction of certain motives associated to the projective line minus the points 0, 1, and infinity. In the end, this will reduce to the question of producing a cellular approximation of a certain dg-module over a dga, and we will see that the construction of this cell module is controlled by Massey products in the motivic cohomology of the ground field. The vanishing of these Massey products would give higher Steinberg relations in motivic cohomology and algebraic K-theory. (Received August 27, 2009)

20 ► Group theory and generalizations

1052-20-32 **Nir Avni***, Department of Mathematics, Harvard University, 1 Oxford St., Cambridge, MA 02138. *Commensurator Growth of Lattices.*

Let G be a group, and let A be a subgroup of G. Denote by C_n the set of elements in G such that the index of $g^{-1}Ag \cap A$ in A is n. The commensurator growth of the pair (A, G) is the asymptotic behavior of the sequence $|N_G(A)\backslash C_n|$. I will present several computations of commensurator growths for pairs (A, G) such that A is a lattice in G. (Received July 24, 2009)

1052-20-49 **Ming-hsuan Kang*** (kmsming@gmail.com), 2302 Plaza Drive, State College, PA 16801. *Zeta Functions of Complexes.*

We define and investigate the properties of the zeta functions on the complex, which arises from a finite quotient of the affine Bruhat-Tits building on a general linear group over a local function field. Briefly speaking, for each type of simplex of dimension k, we define a zeta function which counts the number of k-dimensional closed straight geodesics containing the simplex of that type.

Several important properties of zeta functions are concluded as follows. First, these zeta functions are rational functions and have closed-form expressions in terms of parahoric Hecke operators. Second, the alternating production of the zeta functions satisfies an identity which is involved in the Euler characteristic of the complex. Finally, we show that the Ramanujan property of complexes is equivalent to the condition on the absolute values of zeta functions' roots. (Received August 10, 2009)

1052-20-66 **Ilir Snopce*** (snopce@math.binghamton.edu), 191 Main Street Apt. 3R, Binghamton, NY 13905. *A question of Iwasawa.*

For a finitely generated pro-p group G, let $d(G)$ denote the minimal number of topological generators of G. For a positive integer n, Iwasawa raised the question of determining all pro-p groups G which satisfy the following condition:

$$d(H) - n = [G : H](d(G) - n)$$

for all open subgroups H of G.

In this talk I will answer the question of Iwasawa for pro-p groups of finite rank, provided $p > n + 1$. If time permits, I will state some results about the question of Iwasawa for pro-p groups of infinite rank. (Received August 18, 2009)

1052-20-69 **Emilio Bujalance**, **Francisco Javier Cirre** and **Marston Conder*** (m.conder@auckland.ac.nz), Mathematics Department, University of Auckland, Private Bag 92019, Auckland, 1023, New Zealand. *Extendability of group actions on non-orientable surfaces.*

Suppose the finite group G acts faithfully on some compact non-orientable surface S. Under what conditions does this action extend to a faithful action of some larger group on the same surface? This question will be considered, with particular attention to the case where the group G is cyclic. If such a cyclic group action is realised by means of a non-maximal NEC signature, then the action always extends, but in some other cases, the group G can be shown to be the full automorphism group of S. We can also find, for example, the largest cyclic group that is the full automorphism group of such a surface of given algebraic genus g, and the smallest algebraic genus of a non-orientable surface on which a given cyclic group C_n acts as the full automorphism group, or indeed the entire genus spectrum of such actions of C_n. (Received August 18, 2009)

1052-20-76 **Gareth A. Jones*** (G.A.Jones@maths.soton.ac.uk), School of Mathematics, University of Southampton, Highfield, Southampton, Hampshire SO17 1BJ, England. *Beauville surfaces and finite groups.*

Beauville surfaces are 2-dimensional complex algebraic varieties which are rigid in the sense of having no deformations. They can be constructed as quotients $(C_1 \times C_2)/G$ where C_1 and C_2 are compact Riemann surfaces of genus at least 2, with a group G acting as automorphisms of each so that it acts freely on $C_1 \times C_2$, and so that $C_i \to C_i/G$ is a covering of the Riemann sphere branched over three points (i.e. each C_i admits a regular dessin with automorphism group G). Bauer, Catanese and Grunewald have conjectured that every non-abelian finite simple group G, except A_5, acts in such a way. Extending their results and those of Fuertes and González-Diez, I shall verify this for the simple groups $L_2(q)$, the Suzuki groups $Sz(2^e)$, the Ree groups $R(3^e)$, and the quasi-simple groups $SL_2(q)$, $q > 5$. (Received August 20, 2009)

1052-20-77 **Michael A. Jackson*** (majackson@gcc.edu), Number 3130, 100 Campus Drive, Grove City, PA 16127. *Which $(2, 3, r)$ triangle groups give rise to the strong symmetric genus of some finite group?* Preliminary report.

The strong symmetric genus of a finite group G is the smallest genus of a closed orientable topological surface on which G acts faithfully as a group of orientation preserving symmetries. For many groups, the action is constructed by realizing G as the non-degenerate quotient of a (p, q, r) triangle group. In this talk, we will discuss which values of $r \geq 7$ have a group G where the strong symmetric genus of G is a result of G being a non-degenerate quotient of a $(2, 3, r)$ triangle group. (Received August 20, 2009)

1052-20-110 **Thomas Tucker*** (ttucker@colgate.edu), Math Department, Colgate University, Hamilton, NY 13346. *Seeing symmetries of surfaces in 3-space.*

It is shown that a surface of genus $g > 1$ can be embedded in 3-space with rotational symmetry of order n if and only if $g = cn - r$ where $-1 \leq r < n$ and $c > r$; these are the cyclic group actions on surfaces that one can "see". Orientation-preserving actions by the other spherical groups A_4, S_4, A_5 are also considered. In general, given a group G, one can ask for the spectrum of all g such that G acts on the surface of genus g (not necessarily as isometries of 3-space). An interesting class of groups would be those whose genus spectrum includes all sufficiently large g. (Received August 23, 2009)

1052-20-120 **Igor V. Erovenko*** (igor@uncg.edu), Department of Mathematics and Statistics, University of North Carolina at Greensboro, Greensboro, NC 27402, and **Nikolay Nikolov** and **B. Sury**. *Bounded generation and second bounded cohomology of wreath products.*

We show that the (standard restricted) wreath product of groups is boundedly generated if and only if the bottom group is boundedly generated and the top group is finite. We also establish a criterion for triviality of the singular part of second bounded cohomology of wreath products. (Received August 24, 2009)

1052-20-135 **Mark Sapir*** (markvs@gmail.com), Department of Mathematics, Vanderbilt University, Nashville, TN 37240. *Residual properties of 1-related groups.*

I will discuss the fact that most of 1-related groups with at least 3 generators are residually finite. This is a joint work with A. Borisov and I. Kozakova. (Received August 25, 2009)

1052-20-141 **Dave Witte Morris*** (Dave.Morris@uleth.ca), Department of Math and Computer Science, University of Lethbridge, Lethbridge, AB T1K 3M4, Canada. *Survey of invariant orders on arithmetic groups.*

At present, there are more questions than answers about the existence of invariant orders on an arithmetic subgroup Γ of a simple $\mathbb{Q}$-group.

Definition. An order relation $\prec$ on Γ is *left-invariant* if

$$x \prec y \implies ax \prec ay \qquad \text{for all } a, x, y \in \Gamma.$$

If, in addition, $x \prec y \implies xa \prec ya$, then we say that $\prec$ is *bi-invariant*.

It is easy to construct nontrivial partial orders on Γ that are left-invariant: choose any nonempty subset S of Γ that is closed under multiplication, but does not contain 1, and define

$$x \prec y \quad \iff \quad x^{-1}y \in S.$$

Free groups (and many other hyperbolic groups) provide examples of arithmetic groups with bi-invariant order relations that are *total,* rather than merely partial. This means

$$\forall x, y \in \Gamma, \text{ either } \; x \prec y \; \text{ or } \; x \succ y \; \text{ or } \; x = y.$$

In contrast, we would like to prove in most cases that there do *not* exist either

- a partial order that is bi-invariant, rather than merely left-invariant, or
- a left-invariant order that is total, rather than merely partial.

(Received August 25, 2009)

1052-20-146 **Andrei S. Rapinchuk*** (asr3x@virginia.edu), Universty of Virginia, Department of Mathematics, P.O. Box 400137, Charlottesville, VA 22901. *Groups with bounded generation.*

I will give a survey of results and conjectures related to the notion of groups with bounded generation. (Received August 25, 2009)

1052-20-154 **Peter Abramenko*** (pa8e@virginia.edu), Dept. of Mathematics, P.O. Box 400137, University of Virginia, Charlottesville, VA 22904. *Torsion elements in stabilizers of apartments.*

Let G be any Chevalley group (scheme) with associated Weyl group W, K any field and (B,N) the usual BN-pair in G(K). Then it can be proved (joint work with Matt Zaremsky) that there are elements w in W such that all representatives of w in N have finite order. This has the following consequence: Every subgroup of G(K) which stabilizes and acts chamber transitively on some apartment of the associated spherical building has torsion. A similar statement is true for the action on the affine building of G(K) if K is endowed with a discrete valuation. This leads to many examples of (torsionfree S-arithmetic) groups which act Weyl transitively but not strongly transitively on affine buildings. Previously those examples were only known in the tree case (joint work with Ken Brown). (Received August 25, 2009)

1052-20-179 **Coy L. May** (cmay@towson.edu), Towson, MD 21252, and **Jay Zimmerman*** (jzimmerman@towson.edu), Towson University, Department of Mathematics, Towson, MD 21252. *The 2-groups of odd strong symmetric genus.*

Let G be a finite group. The *strong symmetric genus* $\sigma^0(G)$ is the minimum genus of any Riemann surface on which G acts preserving orientation. We show that a 2-group G has strong symmetric genus congruent to 3 (mod 4) if and only if G is in one of 14 families of groups. A consequence of this classification is that almost all positive integers that are the genus of a 2-group are congruent to 1 (*mod* 4). (Received August 27, 2009)

1052-20-186 **Kevin Wortman*** (wortman@math.utah.edu). *Reducing Dehn functions of arithmetic groups to the Dehn functions of parabolic groups.*

Young proved that SL(n,Z) has a quartic Dehn function if n>4.

I'll discuss a method for reducing the question of whether certain arithmetic groups have a polynomial Dehn function to a seemingly simpler question of whether certain loops in parabolic subgroups can be filled with polynomial disks in the ambient arithmetic group. The method applies to groups G(Z) where G is a simple Q-group of Q-rank at least 3 with Q-root system of type A_n, C_n, or D_n. (Received August 27, 2009)

1052-20-191 **Jane Piore Gilman*** (jgilman@nsf.gov), Matjhematics Department, Smith Hall, Rutgers Unversity, Newark,, NJ 07102, and **Linda Keen**. *Automorphisms of Pants and Tori: Primitives and Palindromes.*

Let F be the free group on two generators and let G be a faithful non-elementary representation of F in $PSL(2,\mathbb{C})$. We discuss the geometry and algebra of G in the case that G is Fuchsian and free. In particular we emphasize the role of primitive elements and palindromes in the action of the automorphism group of G by identifying it with a covering group of a quotient torus or pair of pants. (Received August 27, 2009)

1052-20-250 **D. V. Osin*** (denis.osin@gmail.com). *Rank gradient and torsion groups.*

I will talk about a new construction of finitely generated infinite residually finite torsion groups with positive rank gradient. Some applications to problems about cost and L^2-Betti numbers will also be discussed. (Received August 29, 2009)

1052-20-267 **Thomas Philip Wakefield*** (TomWakefield@gmail.com), Department of Mathematics and Statistics, Youngstown State University, One University Plaza, Youngstown, OH 44555. *Useful Generalizations in Arguments Verifying Huppert's Conjecture.* Preliminary report.

In the late 1990s, Bertram Huppert conjectured that if G is a finite group and H a finite nonabelian simple group such that the sets of character degrees of G and H are the same, then $G \cong H \times A$, where A is an abelian group.

Huppert verified the conjecture for many nonabelian simple groups, including many of the sporadic simple groups. His method of proof relies upon a five step procedure which ultimately requires properties of the character degrees and maximal subgroups of the simple group in question. We will examine modifications to Huppert's arguments that can be used to establish his conjecture for many other simple groups. (Received August 30, 2009)

1052-20-269 **Francesco Matucci*** (fm6w@virginia.edu), Department of Mathematics, 325 Kerchof Hall, Charlottesville, VA 22904, and **Martin Kassabov** (kassabov@math.cornell.edu), Department of Mathematics, 590 Malott Hall, Ithaca, NY 14853. *Bounding the residual finiteness of free groups.* Preliminary report.

We analyze the question of the minimal index of a normal subgroup in a free group which does not contain a given element. Recent work by BouRabee-McReynolds and Rivin give estimates for the index. By using results on the length of shortest identities in finite simple groups we recover and improve polynomial upper and lower bounds for the order of the quotient. The bounds can be improved further if we assume that the element lies in the lower central series. (Received August 30, 2009)

1052-20-322 **Lisa Carbone*** (carbonel@math.rutgers.edu). *The Haagerup property, Property (T) and the Baum-Connes conjecture for lattices in locally compact Kac-Moody groups.*

We discuss the construction and properties of lattices in symmetrizable locally compact affine or hyperbolic Kac-Moody groups. For example there is a dichotomy between nonuniform lattices in symmetrizable Kac-Moody groups of noncompact hyperbolic type, with certain ones satisfying the Haagerup property and hence the Baum-Connes conjecture with coefficients, and others satisfying Kazhdan's Property (T) and the Baum-Connes conjecture without coefficients. Kac-Moody groups with the Haagerup property act properly on simplicial trees and certain examples also contain infinite descending chains of cocompact lattices. (Received August 31, 2009)

22 ► Topological groups, Lie groups

1052-22-133 **Mark Colarusso*** (mcolarus@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556-4618, and **Sam Evens** (sevens@nd.edu), Department of Mathematics, 255 Hurley Hall, Notre Dame, IN 46556-4618. *Algebraic integrability of the Gelfand-Zeitlin system on* $\mathfrak{gl}(n,\mathbb{C})$.

The Gelfand-Zeitlin integrable system on $\mathfrak{gl}(n,\mathbb{C})$ was constructed by Kostant and Wallach. They showed that it integrates to an action of a complex Lie group $A \cong \mathbb{C}^{\frac{n(n-1)}{2}}$ on $\mathfrak{gl}(n,\mathbb{C})$. Orbits of the group A of maximal dimension $\frac{n(n-1)}{2}$ form the leaves of a polarization of an open, dense subvariety of a regular adjoint orbit. We call an element of $\mathfrak{gl}(n,\mathbb{C})$ *strongly regular* if its orbit under the action of A is $\frac{n(n-1)}{2}$ -dimensional. In this talk, we discuss joint work with Sam Evens in which we extend a result of Kostant and Wallach concerning the algebraic integrability of the Gelfand-Zeitlin system to the full locus of strongly regular elements. We use decomposition classes to stratify the strongly regular set by smooth subvarieties. For each stratum we construct an étale covering and use Poisson geometry to lift the Hamiltonian vector fields of the Gelfand-Zeitlin system to the covering and integrate them to an action of a connected, commutative algebraic group. (Received August 25, 2009)

1052-22-217 **Milen Yakimov*** (yakimov@math.lsu.edu), Department of Mathematics, LSU, Baton Rouge, LA 70803. *Weak splitting of surjective Poisson submersions.*

Many interesting Poisson structures on homogeneous spaces, e.g. flag varieties and double flag varieties arise as projections from Poisson structures on Heisenberg and Drinfeld doubles. We will describe a general idea of weak splittings of those, based on the notion of Poisson–Dirac submanifolds studied by Crainic, Fernandes, and Xu, and a theorem that this is always possible for large classes of reductive doubles. (Received August 28, 2009)

1052-22-300 **Samuel Evens*** (sevens@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46656. *Intersections of orbits on the flag variety.*

I will report on joint work with Jiang-Hua Lu concerning intersections of orbits of a real semisimple Lie group and a Borel subgroup on the complex flag variety. (Received August 31, 2009)

26 ► Real functions

1052-26-306 **Alexei Poltoratski**, **Barry Simon** and **Maxim Zinchenko*** (maxim.zinchenko@wmich.edu). *Absolute Continuity of a Measure on a Homogeneous Set.*

We give a criterion for pure absolute continuity of a measure in terms of its Hilbert transform. Explicitly, we prove that $\lim_{t\to\infty} t|E \cap \{x : |H_\mu(x)| > t\}| = 0$ if and only if $\mu_s(E) = 0$, where μ is a finite positive measure on $\mathbb{R}$, μ_s its singular part, H_μ its Hilbert transform, and $E \subset \mathbb{R}$ is a homogeneous set in the sense of Carleson. The result has applications in the spectral theory of Schödinger, Jacobi, and CMV operators. (Received August 31, 2009)

30 ► Functions of a complex variable

1052-30-45 **yaacov kopeliovich***, MEAG NY 540 Madison Avenue, New York, NY 10022. *Towards Thomae formula for general cyclic covers of the Sphere.* Preliminary report.

Let $f : X \mapsto CP^1$ be a cyclic cover of the sphere of degree N. Assume that X is ramified above m points, $\lambda_1 ... \lambda_m$. Let $\theta[e](z,\tau)$ be a g dimensional theta function attached to X and g is the genus of X. We show how an application of Riemann theorem on the theta divisor produces $e \in R^{2g}$ such that $\theta[e](0,\tau_X) \neq 0$ where τ_X is the period matrix of X. For these e we conjecture a formula that express $\theta[e](0,\tau_X)$ as a polynomial in $\lambda_1 ... \lambda_m$. We sketch the connection with representation theory of symmetric groups and its applications to compute dimensions of the theta functions given above in certain examples. (Received August 07, 2009)

1052-30-158 **Emilio Bujalance** and **Javier Cirre*** (jcirre@mat.uned.es). *A family of Riemann surfaces with orientation reversing automorphisms.*

We consider compact Riemann surfaces of even genus g with an orientation reversing automorphism f of order $2g$. A characterization of these surfaces by means of non-euclidean crystallographic groups is given. Most of these surfaces are asymmetric, that is, they admit no orientation reversing involution, and in fact this happens

if and only if f generates the full group of automorphisms of the surface. We give a defining algebraic equation depending on three real parameters for each such surface (asymmetric or not) and also a formula for the automorphism f. An important feature is that the group generated by f is the unique cyclic group of order $2g$ generated by an orientation reversing automorphism of the surface. The Teichmüller space of these surfaces is a three dimensional submanifold of the Teichmüller space of Riemann surfaces of genus g. (Received August 26, 2009)

1052-30-198 **Yolanda Fuertes**, **Gabino Gonzalez-Diez*** (gabino.gonzalez@uam.es), **Ruben A Hidalgo** and **Maximiliano Leyton**. *The full automorphism group of a family of generalized Fermat curves.* Preliminary report.

Describing the automorphism group of a Riemann surface S is in general a difficult problem. A case in which this group $Aut(S)$ can be understood is when one knows that there is a subgroup $H < Aut(S)$ such that

(1) H is unique, hence normal, in $Aut(S)$ so that there is an obvious homomorphism $Aut(S) \to Aut(S/H)$, where $Aut(S/H)$ stands for the group of automorphisms of S/H (as an orbifold).

(2) All elements of $Aut(S/H)$ lift to elements of $Aut(S)$ so that the sequence $1 \to H \to Aut(S) \to Aut(S/H) \to 1$ is exact.

(3) The quotient S/H is an orbifold of genus 0 with r branch values so that $Aut(S/H)$ is a subgroup of Möbius transformations preserving r points, hence isomorphic to a subgroup of the symmetric group S_r.

It then follows that $Aut(S)$ is an extension of H by a subgroup of S_r, the classical case being the hyperelliptic one.

Here we study a family of generalized Fermat curves in which the role of H is played by $\mathbb{Z}_k^n$ and S/H has genus 0 and $n+1$ branching values, all of order k. We show that when $k, n > 2$ all these curves satisfy (2) and (3) and that when $n = 3$ they also satisfy (1) and so $Aut(S)$ is an extension of H by a subgroup of S_4. (Received August 28, 2009)

1052-30-199 **Ernesto Girondo** and **David Torres*** (david.torres@uam.es), Depto. de Matematicas, Campus de Cantoblanco, Universidad Autonoma de Madrid, 28049 Madrid, Spain. *Genus 2 Belyĭ surfaces with a unicellular uniform dessin.*

A *dessin d'enfant* is a bipartite graph embedded in an oriented compact surface S and dividing it into topological discs, called the faces of the dessin. By work of Grothendieck we know that such a graph defines a Riemann surface structure on S, and that this surface is in fact isomorphic to an algebraic curve defined over a number field (Belyĭ's theorem). However this correspondence is not injective: different dessins d'enfant can give rise to isomorphic Riemann surfaces.

In this talk we will deal with the question of whether different genus 2 unicellular uniform dessins, i.e. one-faced graphs with all the black vertices – resp. white vertices – having the same valency, give rise to isomorphic Riemann surface structures. (Received August 28, 2009)

1052-30-205 **Ewa Kozlowska-Walania*** (retrakt@math.univ.gda.pl), ul. Wita Stwosza 57, 80-952 Gdansk, Poland. *Pairs of symmetries of Riemann surfaces.*

As it is known, symmetries of compact Riemann surfaces correspond to the real forms of smooth projective irreducible complex algebraic curves whose number of connected components equals the number of ovals of symmetries. Therefore, one can study topology of real forms of complex algebraic curves by means of Riemann surfaces and their symmetries, using theory of Fuchsian and non-euclidean crystallographic groups. We focus our attention on qualitative studies on Riemann surfaces of genus $g > 1$ having a pair of non-commuting symmetries. We recall the minimal, with one exception in any genus $g > 2$, lower bound for g, which guarantees the commutativity of the symmetries and we make its further study, leading to some more general results concerning non-commuting $(M - q)$- and $(M - q')$-symmetries with the product of order 2^n. Throughout we take into account the fixed-point free symmetries and give a "comparative analysis" to the case of symmetries with fixed points, filling this way some gaps existing in literature. (Received August 28, 2009)

32 ► Several complex variables and analytic spaces

1052-32-252 **Mirroslav T Yotov*** (yotovm@fiu.edu), Florida International University, University Park, DM 416, Miami, FL 33199. *Hyperbolic curves in compact complex parallelizable manifolds.*

We are presenting some results on existence of Riemann surfaces of hyperbolic type in semi-simple compact complex parallelizable manifolds. (Received August 29, 2009)

33 ► Special functions

1052-33-363 **Jeffery C DiFranco*** (difranco@seattleu.edu), Department of Mathematics, Seattle University, 901 12th Ave, P.O. Box 222000, Seattle, WA 98122. *Asymptotics of Tracy-Widom distributions for the largest detected eigenvalues of random matrices.*

The Tracy-Widom distribution functions appear in numerous areas of combinatorics and probability. In particular these functions are the limiting distributions of the largest eigenvalues of the GUE, GOE and GSE random matrix ensembles. These functions can be expressed in terms of an integrals starting at positive infinity of a Painlevé II function. Using the steepest descent method for Riemann-Hilbert problems we are able to represent these functions, in terms of integrals starting at negative infinity of the same Painlevé functions. This new representation will be suitable for calculating the asymptotics of the Tracy-Widom functions near negative infinity. I will discuss on-going work concerning the asymptotics for the Tracy-Widom distributions for the largest eigenvalue when each eigenvalue is detected with a certain probability $p \neq 1$. (Received September 02, 2009)

34 ► Ordinary differential equations

1052-34-89 **Anthony M Bloch*** (abloch@umich.edu), Dept. of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Dynamics of gradient flows, Hamiltonian flows and thermostats.*

In this talk I will discuss the qualitative behavior of various flows which have asymptotically stable equilibria. In particular, I will compare the behavior of gradient flows, so-called double bracket flows on adjoint orbits, and certain nonholonomic flows. In the double bracket setting I will discuss the special case which yields the integrable Toda flows. In the nonholonomic setting I will discuss both constraints which are linear and nonlinear in the velocities. The latter case occurs in the dynamics of thermostats. (Received August 21, 2009)

1052-34-232 **Matthias Lesch**, Department of Mathematics, University of Bonn, Endenicher Allee 60, 53115 Bonn, Germany, and **Boris Vertman*** (vertman@math.uni-bonn.de), Department of Mathematics, University of Bonn, Endenicher Allee 60, 53115 Bonn, Germany. *The regular-singular Sturm-Liouville operators and their zeta-determinants.*

Recent advances in the computation of zeta-determinants for Laplace-type operators with specific regular-singular potentials of model type and general boundary conditions at the singularity have been made by Klaus Kirsten, Paul Loya, and Jinsung Park. A formula for zeta-determinants for a general class of regular-singular potentials, however only for specific boundary conditions at the singular end, is due to Matthias Lesch.

This poses the question whether appropriate results can also be achieved for Sturm-Liouville operators with general regular-singular potentials and general boundary conditions. We answer this question affirmatively and provide a formula for the zeta-determinant in terms of the Wronski-determinant of the boundary value problem, generalizing the earlier results of Lesch and Kirsten-Loya-Park. (Received August 28, 2009)

35 ► Partial differential equations

1052-35-7 **Kevin R. Payne*** (kevin.payne@unimi.it), Dipartimento di Matematica, Universita' di Milano, Via Saldini, 50, 20133 Milano, Italy. *PDE of mixed type: The twin challenges of globalization and diversity.*

Partial Differential Equations (PDE) of mixed elliptic-hyperbolic type arise in particular but interesting contexts such as transonic fluid flow and isometric embeddings of Riemannian manifolds whose curvature changes sign. Such problems are difficult due in large measure to diversity; that is, the mixture of qualitative types competes with the fact that sharp PDE tools are often calibrated to the type of the equation.

The most interesting problems involve nonlinear equations, but progress on them remains inhibited due to a glaring lack of precise information on linear equations of mixed type. For example, even for linear equations, the question of what constitutes a well posed boundary value problem is particularly delicate as the desired regularity of solutions is crucial. For truly nonlinear problems, handling possible singularities or shocks is a main objective.

One often can reduce the question at hand to the presence of suitable a priori estimates. For mixed type equations, such estimates, even when locally available, need not be globalizable in a robust or clear-cut way. We will give a general overview of some of the interesting problems which involve mixed type PDE as well as some strategies for obtaining global information. (Received August 31, 2009)

1052-35-42 **Qiang Du** (qdu@math.psu.edu) and **Manlin Li*** (li_m@math.psu.edu). *ON THE STOCHASTIC IMMERSED BOUNDARY METHOD WITH AN IMPLICIT INTERFACE FORMULATION.*

In this paper, we present a consistent and rigorous derivation of some stochastic fluid-structure interaction models based on an implicit interface formulation of the stochastic immersed boundary method. Based on the fluctuation-dissipation theorem, we provide the proper form of the noise to be incorporated in some deterministic hydrodynamic fluid-structure interaction models in either the phase field or level-set framework so as to capture the fluctuation effect near equilibrium. (Received August 06, 2009)

1052-35-56 **Robert M Strain*** (strain@math.upenn.edu), Department of Mathematics, David Rittenhouse Lab., 209 South 33rd Street, Philadelphia, PA 19104. *Recent global results for the relativistic Boltzmann equation.*

We will discuss several recent results regarding the relativistic Boltzmann equation. The talk will start with a broad overview of relativistic Kinetic theory for non-specialists.

New results to be discussed include the previously open problem of stability of the Maxwellian equilibrium for the relativistic Boltzmann equation with soft interactions. The soft potentials are important for particles moving at relativistic speeds. We can also prove for the first time the global validity of the Newtonian Limit in the near Vacuum regime.

Additionally we can establish the rigorous connection between the Boltzmann equation and Relativistic Euler via a Hilbert Expansion, this is joint work with Jared Speck.

Furthermore, we consider the relativistic Boltzmann equation coupled with it's internally generated electric and magnetic forces. Despite its importance, no global in time solutions have been established so far for this Lorentz invariant model. We prove existence of the first global in time classical solutions. This project is joint work with Yan Guo. (Received August 15, 2009)

1052-35-62 **Nathaniel Eldredge*** (neldredge@math.cornell.edu), 593 Malott Hall, Department of Mathematics, Cornell University, Ithaca, NY 14853. *Hypoelliptic heat kernel inequalities on H-type groups.*

One area of interest in the study of heat kernels in the hypoelliptic setting is in trying to obtain estimates of various types, including gradient bounds and pointwise heat kernel estimates. These in turn are related to other functional inequalities such as logarithmic Sobolev inequalities. In recent years, results by Li and by Bakry et al have made progress in this area by establishing such estimates for the sublaplacian on the Heisenberg group. I will discuss extensions of these results to the class of H-type Lie groups which generalize the Heisenberg group, and some of the ideas involved in the proofs. (Received August 17, 2009)

1052-35-65 **Jacek Szmigielski*** (szmigiel@math.usask.ca), Saskatoon, SK S7N 5E6, Canada. *Explicit multipeakon solutions of Novikov's cubically nonlinear integrable Camassa–Holm type equation.*

Recently Vladimir Novikov found a new integrable analogue of the Camassa–Holm equation, admitting peaked soliton (peakon) solutions, which has nonlinear terms that are cubic, rather than quadratic. Using the matrix Lax pair found by Hone and Wang and a transformation of Liouville type, the associated spectral problem is shown to be related to a cubic string equation, which is dual in the sense of M.G. Krein to the cubic string that was previously found in the work of Lundmark and Szmigielski on the multipeakons of the Degasperis–Procesi equation. This fact allows one to give explicit formulas for the positions of peaks and their momenta. In this talk I will highlight three aspects of the problem: 1. distributional Lax pairs and limitations of Lax-pair integrability; 2. a combinatorial lemma (The Canada Day Theorem) which facilitates the presentation of the constants of motion; 3. an alternative solution to the associated inverse problem using the Cauchy biorthogonal polynomials introduced by Bertola, Gekhtman and Szmigielski.

This talk is largely based on joint work with A. Hone (Kent, UK) and H. Lundmark (Linköping, Sweden). (Received August 18, 2009)

1052-35-84 **Yisong Yang*** (yyang@math.poly.edu), Department of Mathematics, Polytechnic Institute of New York University, 6 Metrotech Center, Brooklyn, NY 11201. *Cosmological Charged Dust Solutions of the Coupled Einstein and Maxwell Equations.* Preliminary report.

It is well known that the coupled Einstein and Maxwell equations allow a static "N-blackhole" solution under an equal mass-charge condition due to the exact cancellation of gravitational attraction and Coulomb repulsion in order to ensure an equilibrium state. Such a solution is due to Hartle and Hawking. Here we consider the extension of the Hartle-Hawking solution to the continuous case modeling a space occupied by charged dust.

Under the equal mass-charge condition, we show that there is an infinite family of smooth solutions realizing asymptotically flat spaces. (Joint work with Joel Spruck) (Received August 21, 2009)

1052-35-93 **Rupert L. Frank*** (rlfrank@math.princeton.edu), Department of Mathematics, Fine Hall, Princeton University, Princeton, NJ 08544, and **Heinz Siedentop** and **Simone Warzel**. *The relativistic Scott correction.*

We consider relativistic many-particle operators which describe the electronic states of heavy atoms. Their ground state energy is investigated in the limit of large nuclear charge and velocity of light. We show that the leading quasi-classical behavior given by the Thomas-Fermi theory is raised by a subleading correction, the Scott correction. Our result is valid for the maximal range of coupling constants, including the critical one. (Received August 21, 2009)

1052-35-102 **Luca Capogna*** (lcapogna@uark.edu), Department of Mathematical sciences, University of Arkansas, 1 Dickson St., Fayetteville, AR 72701. *An analogue of the mean curvature flow in sub-Riemannian geometry.* Preliminary report.

The talk will address some analytic and geometric aspects of an evolution PDE that describes the motion of smooth hypersurfaces in Carnot groups along the gradient flow of the (sub-Riemannian) perimeter. (Received August 23, 2009)

1052-35-106 **Dehua Wang*** (dwang@math.pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *A triple shock pattern and transonic flows.*

The evolution of discontinuity and triple shock structure for a system of two-dimensional conservation laws will be presented first. Then the transonic flow problem will be discussed. (Received August 23, 2009)

1052-35-113 **Juan J Manfredi*** (manfredi@pitt.edu), 140 Thackeray Hall, 139 University Drive, Pittsbugh, PA 15260, and **Mikko Parviainen** and **Julio Daniel Rossi**. *Asymptotic mean value properties for p-harmonic functions and tug-of-war games with noise.*

We present a variant of the tug-of-war noise of Peres and Sheffield. This game has a well-defined value that approximates p-harmonic functions as the step size goes to zero. Asymptotic mean value properties are used to identify the differential equation (p-Laplace equation,$p \geq 2$) satisfied by the limits of value functions of tug-of-war games with noise. (Received August 24, 2009)

1052-35-130 **Yuji Kodama*** (kodama@math.ohio-state.edu), Department of Mathematics, 100 Math Tower, 231 West 18th Avenue, Columbus, OH 43210. *KP solitons and shallow water waves.*

I begin with a brief summary of the recent development of classification theorem of the KP solitons [Chakravarty and Kodama, 2008-9]. The theorem shows that each soliton solution can be parametrized by a unique derrangement of the permutation group. Then I will show several real experimental pictures of shallow water waves including Mach reflection observed as an obliquely interacting wave with a rigid wall. Expressing each derrangement (i.e. soliton solution) by a unique chord diagram, I will describe the time evolution of those waves. I will also discuss the differences of KP solitons from the waves in real experiments. (Received August 24, 2009)

1052-35-156 **Jared Speck*** (jspeck@math.princeton.edu), 8 Vineyard St., Cambridge, MA 02138. *The Global Nonlinear Stability of the Trivial Solution of the Einstein-Maxwell-Born-Infeld System.*

The Maxwell-Born-Infeld (MBI) system has some remarkable properties that distinguish it among all Lagrangian field theories of classical electromagnetism. Although it was first studied in the 1930's, the MBI system has recently experienced a revival because of some interesting new developments in several scientific communities. For example, the MBI system plays a leading role in Kiessling's quest for a well-defined theory of classical electromagnetism with point charges. On the other end of the spectrum, the MBI Lagrangian has connections to string theory. In this talk, we will introduce the MBI system's special properties and our main problem of interest, which involves the coupling of the MBI equations to Einstein's field equations; i.e., the Einstein-Maxwell-Born-Infeld (EMBI) system. We will then discuss our main result, which is a proof that the vacuum Minkowski-space solution of the EMBI system is globally stable. Mathematically, our main result is a small-data global existence result for a quasilinear system of wave equations that satisfies a weak version of the null-condition. This work is an extension of previous stability results of Lindblad-Rodnianski, Loizelet, Christodoulou-Klainerman, Zipser, Klainerman-Nicolò, and Chae-Huh. (Received August 25, 2009)

1052-35-174 **Xiaolong Han**, Department of Mathematics, Wayne State University, Detroit, MI 48202, and **Guozhen Lu*** (gzlu@math.wayne.edu), Department of Mathematics, Wayne State University, Detroit, MI 48202. *A geometric covering lemma and nodal sets of eigenfunctions.*

In this talk we describe some new geoemtric covering lemma which is akin to but quite different from the classical Besicovitch covering lemma in the Euclidean spaces. More precisely, we prove the following type of covering lemma:

Let $n \geq 2$ and $\delta > 0$ be small enough, then given any finite collection of balls $\{B_\alpha\}_{\alpha \in I}$ in $\mathbb{R}^n$, one can select a subcollection $B_1, \cdots, B_N$ such that

$$\bigcup_\alpha B_\alpha \subset \bigcup_{i=1}^N (1+\delta) B_i \tag{1}$$

and

$$\sum_{i=1}^N \chi_{B_i}(x) \leq c\delta^{-\frac{n}{2}} \log(\frac{1}{\delta}) \tag{2}$$

where c is a constant independent of δ. Such a covering lemma was first introduced by Chanillo and Muckenhoupt.

On the other hand, we apply this covering lemma to improve BMO and volume estimates of nodal sets for eigenfunctions u satisfying $\triangle u + \lambda u = 0$ on $n-$dimensional Riemannian manifolds when λ is large, based on the works of Donnelly and Fefferman, Chanillo and Muckenhoupt. We also improve the BMO estimates for the function $q = |\nabla u|^2 + \frac{\lambda}{n} u^2$. Our covering lemma sharpens substantially earlier results and is fairly close to the optimal one we can expect. (Received August 26, 2009)

1052-35-180 **Peiyong Wang*** (pywang@math.wayne.edu), 656 W.Kirby, 1150 FAB, Department of Mathematics, Wayne State University, Detroit, MI 48202. *On The Uniqueness Of A Solution Of A Two-Phase Free Boundary Problem.*

I will address the uniqueness problem of a two-phase elliptic free boundary problem arising from the phase transition problem subject to given boundary data. This is a joint work with Guozhen Lu. We show that in general the comparison principle between the sub- and super-solutions does not hold, and there is no uniqueness of either a viscosity solution or a minimizer of this free boundary problem by constructing counter-examples in various cases in any dimension. In one-dimension, a bifurcation phenomenon presents and the uniqueness problem has been completely analyzed. In fact, the critical case signifies the change from uniqueness to non-uniqueness of a solution of the free boundary problem. Non-uniqueness of a solution of the free boundary problem suggests different physical stationary states caused by different processes, such as melting of ice or solidification of water, even with the same prescribed boundary data. However, we prove that a uniqueness theorem is true for the initial-boundary value problem of an ε-evolutionary problem which is the smoothed two-phase parabolic free boundary problem. (Received August 27, 2009)

1052-35-201 **Yuxi Zheng*** (yzheng@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802, and **Zachary Robinson**. *The Pressure Gradient System.*

The pressure gradient system is a sub-system of the compressible Euler system. It can be obtained either through a flux splitting or an asymptotic expansion. In both derivations, the velocity field is treated as a small remnant of the original velocity of the Euler system. As such, the boundary conditions for the velocity do not necessarily follow the original ones and careful consideration is needed for the validity, integrity, and completeness of the model. We provide numerical simulations as well as basic characteristic analysis and physical considerations for the Riemann problems of the model to find out appropriate internal conditions at the origin. The study reveals subtle structures of the velocity. The numerics is done at higher resolutions than traditionally possible via the automated clawpack that contains adaptive mesh refinement (AMR) and message passing interface (MPI), for which we provide the Riemann solvers, where the Roe's approximation has the elegant 1/2 average in the model's original variables. (Received August 28, 2009)

1052-35-215 **Vasilisa Shramchenko*** (vasilisa.shramchenko@usherbrooke.ca), Département de mathématiques, Faculté des, Sciences, Université de Sherbrooke 2500 boul., de l'Université, Sherbrooke, Québec J1K 2R1, Canada, and **Dmitry Korotkin** (korotkin@crm.umontreal.ca). *Fuchsian Riemann-Hilbert problem associated to Frobenius manifolds.*

There are two (dual to each other) Riemann-Hilbert problems naturally associated to every semisimple Frobenius manifold. In the case of Frobenius structures on Hurwitz spaces, the corresponding Riemann-Hilbert problems turn out to be solvable in terms of meromorphic bidifferentials defined on the underlying Riemann surface. In

this talk, I will present solutions to one of these Riemann-Hilbert problems (the one with Fuchsian singularities) and discuss their properties and monodromy. (Received August 28, 2009)

1052-35-222 **Andras Vasy***, Department of Mathematics, Stanford University, 450 Serra Mall, Stanford, CA 94305-2125. *Wave propagation on asymptotically De Sitter and Anti-de Sitter spaces.* Preliminary report.

In this talk I describe the asymptotics of solutions of the wave equation on asymptotically De Sitter and Anti-de Sitter spaces. This is part of a larger program to analyze hyperbolic equations on non-product, non-compact manifolds, similarly to how various types of 'ends' have been studied for the Laplacian and other elliptic operators on Riemannian manifolds. Part of the talk is on current work in progress. (Received August 28, 2009)

1052-35-234 **M. A. Nivala*** (man9@amath.washington.edu) and **Bernard Deconinck**. *The stability of finite-genus solutions of the KdV equation.*

The stability of stationary periodic solutions of partial differential equations has been an area of increasing interest in the last decade. In this talk, we examine the orbital stability of the finite-genus solutions of period L of the KdV equation with respect to perturbations that are periodic of period NL, for any nonzero integer N. Our method relies heavily on the integrability of the KdV equation, specifically on its hierarchy of commuting flows. (Received August 28, 2009)

1052-35-238 **Svitlana Mayboroda*** (svitlana@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907. *Properties of the biharmonic functions: Hadamard's conjecture, regularity of the Green function and Wiener criterion.*

In 1908 Hadamard conjectured that the biharmonic Green function must be positive. Later on, several counterexamples to Hadamard's conjecture have been found and a variety of upper estimates were obtained in sufficiently smooth domains. However, the behavior of the Green function in general domains was not well-understood until recently.

In a joint work with V. Maz'ya we derive sharp pointwise estimates for the biharmonic and, more generally, polyharmonic Green function in arbitrary domains. Furthermore, we introduce the higher order capacity and establish an analogue of the Wiener criterion describing the precise correlation between the geometry of the domain and the regularity of the solutions to the polyharmonic equation. (Received August 28, 2009)

1052-35-239 **Gregory Verchota*** (gverchot@syr.edu), Department of Mathematics, Syracuse University, 215 Carnegie Hall, Syracuse, NY 13244. *Linear elliptic operators requiring indefinite terms in the quadratic Dirichlet form in order for a full coercive estimate to hold.*

Certain 4th order linear real constant coefficient elliptic differential operators $L = \sum_{|\alpha|=|\beta|=2} a_{\alpha\beta}\partial^{\alpha+\beta}$ are shown to satisfy a coercive integro–differential estimate

$$c\sum_{|\alpha|\le 2}\int_\Omega |\partial^\alpha u|^2 dX \le \sum_{|\alpha|=|\beta|=2}\int_\Omega a_{\alpha\beta}\partial^\alpha u\,\overline{\partial^\beta u}dX + c_0\int_\Omega |u|^2 dX,\ \ (c>0)$$

over the full Sobolev space $W^{2,2}(\Omega)$ only when the right side contains quadratic terms that are indefinite, in fact negative definite on an infinite dimensional subspace of $W^{2,2}(\Omega)$. These terms are shown to be necessary even when L, in addition, can be written as a sum of squares of homogeneous 2nd order operators $\sum p_j^2(\partial)$, so that L also has formally positive forms $\sum_j \int_\Omega |p_j(\partial)u|^2 dX$. In these cases all formally positive forms are shown to be noncoercive over $W^{2,2}(\Omega)$. (Received August 28, 2009)

1052-35-241 **Shahla Molahajloo*** (smollaha@mathstat.yorku.ca), Department of Mathematics, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada. *Pseudo-differential operators on the unit circle.*

We give the basic properties of pseudo-differential operators with symbols in $S^m_{1,0}(\mathbb{S}^1\times\mathbb{Z})$, $-\infty<m<\infty$, on $L^p(\mathbb{S}^1)$, $1<p<\infty$. Ellipticity is then defined and the equivalence of Fredholmness on $L^p(\mathbb{S}^1)$ and ellipticity is established. (Received August 28, 2009)

1052-35-243 **Gui-Qiang Chen** and **Mikhail Feldman*** (feldman@math.wisc.edu). *Shock reflection for potential flow.*

In this talk we discuss existence and regularity of global solutions to shock reflection for potential flow. Self-similar potential flow equation is a nonlinear equation of mixed elliptic-hyperbolic type. One of main issues in analysis of shock reflection is to study solution near sonic line, where the type of equation changes. (Received August 28, 2009)

1052-35-246 **Marcus A. Khuri*** (khuri@math.sunysb.edu), Department of Mathematics, Stony Brook University, Stony Brook, NY 11794. *Nonlinear Equations of Mixed Type in Differential Geometry.*

In Differential Geometry, mixed type equations most naturally arise in the context of the isometric embedding problem for Riemannian manifolds. Here we will report on recent progress and new techniques for studying the equations involved. This is joint work with Q. Han. (Received August 28, 2009)

1052-35-256 **Karen Yagdjian*** (yagdjian@utpa.edu), Department of Mathematics, University of Texas-Pan American, 1201 W. University Drive, Edinburg, TX 78541-2999. *Fundamental Solutions for Hyperbolic Operators with Variable Coefficients.*

The goal of this talk is to give a survey of a new approach in the construction of fundamental solutions for the partial differential operators with variable coefficients and of some resent results obtaining by that approach. More precisely, the integral transformation is suggested that transforms the family of the fundamental solutions of the Cauchy problem for the operator with the constant coefficients to the fundamental solutions for the operators with variable coefficients. The kernel of that transformation contains the Gauss's hypergeometric function. This approach was applied by the author and his coauthors, T.Kinoshita (University of Tsukuba) and A.Galstyan (University of Texas-Pan American), to investigate in the unified way several equations such as the linear and semilinear Tricomi and Tricomi-type equations, Gellerstedt equation, the wave equation in Einstein-de Sitter spacetime, the wave and the Klein-Gordon equations in the de Sitter and anti-de Sitter spacetimes. In particular, for all above mentioned equations, we have obtained among other results, the representation formulas for the initial-value problem, the $L_p - L_q$-estimates, local and global solutions for the semilinear equations, blow up phenomena, self-similar solutions. (Received August 29, 2009)

1052-35-257 **Fabrice Baudoin*** (fbaudoin@purdue.edu), Department of Mathematics, 150 North Grant Street, West Lafayette, IN 47906, and **Nicola Garofalo**, Department of Mathematics, 150 North Grant Street, West Lafayette, IN 47906. *Generalized Bochner formulas and Ricci lower bounds for sub-Riemannian manifolds of rank two.*

We define and study a new class of rank two sub-Riemannian manifolds encompassing as a particular case Riemannian manifolds, CR manifolds with vanishing Webster-Tanaka torsion and orthonormal bundles over Riemannian manifolds. These manifolds admit a canonical horizontal connection and a canonical sublaplacian. We construct on these manifolds an analogue of the Riemannian Ricci tensor and show Bochner's type formulas for the sublaplacian. As a consequence, it is possible to formulate on these spaces a sub-Riemannian analogue of the so-called curvature dimension inequality. Sub-Riemannian manifolds for which this inequality is satisfied are shown to share many common properties with Riemannian manifolds whose Ricci curvature is bounded from below. (Received August 29, 2009)

1052-35-258 **Antonella Marini** and **Thomas H. Otway*** (otway@yu.edu). *Nonlinear Hodge-Frobenius equations of mixed and degenerate type.*

A class of quasilinear elliptic-hyperbolic systems is studied. The class includes the continuity equation for a steady, compressible, ideal flow which is not irrotational but is completely integrable. Other choices of the generalized mass density function reduce the system to a variety of equations in geometric variational theory and classical field theory. A class of Bäcklund transformations which relate various common choices of mass density is introduced. Technical questions to be discusssed include the smoothness of solutions and the existence of a good linearization. (Received August 29, 2009)

1052-35-266 **Leonard Gross*** (gross@math.cornell.edu), Mathematics Department, Cornell University, Ithaca, NY 14853, and **Nelia Charalambous**. *The Yang-Mills heat equation on 3-manifolds with boundary.*

Let M be a compact Riemannian 3-manifold with boundary. We consider the product bundle $M \times k \to M$ where k is the Lie algebra of a compact connected Lie group.

Theorem: The Yang-Mills heat equation over M with twice differentiable initial data has a unique long time solution under Marini's (nonlinear) boundary condition: normal component of curvature =0 for all positive time.

We also prove a similar theorem for Dirichlet and Neumann boundary conditions for initial data with one derivative in $L^2(M)$.

The main tool is a gauge invariant Gaffney-Friedrichs inequality, which we use in combination with the Zwanziger-Donaldson-Sadun method of conversion of the Yang-Mills heat equation to a strictly parabolic equation. (Received August 30, 2009)

1052-35-276 **Peter D. Miller*** (millerpd@umich.edu), Department of Mathematics, University of Michigan, 530 Church St., Ann Arbor, MI 48109. *The Benjamin-Ono Equation in the Small Dispersion Limit.*

The Benjamin-Ono equation is a model for several physical phenomena, including gravity-driven internal waves in certain density-stratified fluids. It has the features of being a nonlocal equation (the dispersion term involves the Hilbert transform of the disturbance profile) and also of having a Lax pair and an associated inverse-scattering algorithm for the solution of the Cauchy initial-value problem. We will review known phenomena associated with this equation in the limit when the dispersive effects are nominally small, and compare with the better-known Korteweg-de Vries equation. Then we will present a new result (joint with Zhengjie Xu) establishing the zero-dispersion limit of the solution of the Benjamin-Ono Cauchy problem for certain initial data, in the topology of weak convergence. The proof relies on aspects of the method of moments from probability theory. (Received August 30, 2009)

1052-35-281 **Emma Previato*** (ep@bu.edu), Department of Mathematics and Statistics, Boston University, Boston, MA 02215-2411. *The operator Schwarzian derivative.*

This talk brings together two lines of work. The first (with M.J. Dupré and J.F. Glazebrook) regards a characterization of the τ function for Sato's Grassmannian via the curvature of a universal bundle, after L.J. Mason, M.A. Singer, N.M.J. Woodhouse and M.I. Zelikin. The second (with S. Matsutani) regards geometric solutions of dispersionless hierarchies, e.g., dKP: $v_{xt}+(vv_x)_x+v_{yy}=0$. The link explored is the following: the τ-function solution of KP is viewed as depending on sections of line bundles over a spectral curve, the τ-function of dKP depends on the moments of a uniformization of the curve. L.A. Takhtajan pointed out that solutions to integrable reductions of self-dual Yang-Mills can be modular functions, sections of a line bundle over moduli space, and advocated a relationship with the Grassmannian τ-function via the Krichever map. The idea would be to demonstrate this link via the operator Schwarzian derivative: dynamics on moduli spaces (Whitham's hierarchy) is related to dKP, as well as having a Schwarzian-derivative interpretation via accessory parameters, while the Grassmannian τ function can is the determinant of an operator cross-ratio and as such produces solutions to the Riccati equation via the Schwarzian derivative. (Received August 30, 2009)

1052-35-286 **V. Zharnitsky*** (vz@math.uiuc.edu). *Near-linear dynamics in KdV with periodic boundary conditions.*

It will be shown that in KdV equation with periodic boundary conditions, high frequency solutions evolve almost as the linear ones. On the real line such behavior could be attributed to the dispersive decay. While on the circle such dispersive decay is not possible, the dipersion manifests itself in averaging out nonlinearity over the high frequency solutions. This result is obtained by the normal form procedure. This is a joint work with M.B. Erdogan and N. Tzirakis. (Received August 31, 2009)

1052-35-307 **Dening Li*** (li@math.wvu.edu), Math Dept, 409B Armstrong Hall, West Virginia University, Morgantown, WV 26506. *Integro-differential equations for ocean wave study.*

An integro-differential formulation is introduced in the study of ocean wave. For this new model, some of thesurface wave properties are studied and compared with the usual 3-D model. Finally, the well-posedness of the new formulation isestablished. (Received August 31, 2009)

1052-35-308 **Antonio Sa Barreto***, Department of Mathematics, Purdue University, 150 N. University St., West Lafayette, IN 47907. *Topics in geometric scattering theory.*

We will discuss asymptotic properties of solutions to the wave equation on complete manifolds which, in a weak sense, are modeled by Euclidean or hyperbolic space near infinity. We then introduce the scattering operator and discuss some of its properties. We will end by stating some open problems in the field. (Received August 31, 2009)

1052-35-314 **Annalisa M Calini*** (calinia@cofc.edu), Department of Mathematics, Robert Scott Small Bldg, Room 339, 66 George St, Charleston, SC 29424, and **Thomas Ivey**. *From circles to cables: closed finite-gap solutions of the Vortex Filament Flow.*

I will discuss joint work with Thomas Ivey on algebro-geometric solutions of the Vortex Filament Flow (VFF). This integrable model of self-induced dynamics of a vortex filament in an ideal fluid is closely related to the cubic focussing nonlinear Schrödinger (NLS) equation. We adapt algebro-geometric techniques for constructing finite-gap NLS solutions, and use the theory of isoperiodic deformations to generate a family of closed VFF solutions of increasingly higher genus, and increasing topological complexity, via successive deformations of the associated Riemann surface. We prove that each step of a deformation process that begins with a circular filament generates a cable on the previous filament, and that the knot type of the resulting cable is determined

from the deformation scheme, and is invariant under the time evolution. If time allows, I will comment on our current work on stability of such solutions. (Received August 31, 2009)

1052-35-318 **Nhu Thang Nguyen** and **Ingo Witt*** (iwitt@uni-math.gwdg.de), University of Göttingen, Mathematical Institute, Bunsenstr. 3-5, 37073 Göttingen, Germany. *Symbolic parametrix construction for the strictly hyperbolic Cauchy problem.*

The solution u to the strictly hyperbolic homogeneous Cauchy problem $Pu = f \equiv 0$ on X and $\gamma_k u = g_k$ on X_0 for $0 \leq k < \mu$ can be written as $u = \sum_{k=1}^{\mu} E_k g_k$, where each E_k is a sum of Fourier integral operators. Furthermore, it is known that real-principal type operators admit parametrices the kernels of which are one-sided paired Lagrangian distributions. In this talk, by identifying the Lagrangian submanifolds of $T^*(X \times X) \setminus 0$, $T^*(X \times X_0) \setminus 0$, and so on that arise, e.g., in compositions and by identifying the principal symbols on these Lagrangian submanifolds of the operators involved, we put both constructions together and come up with a calculus in which the strictly hyperbolic, but now inhomogeneous Cauchy problem (i.e., the above problem, where $f \not\equiv 0$ is possible) appears as an operator with an invertible principal symbol which allows a parametrix within the calculus. (Received August 31, 2009)

1052-35-328 **Christopher W. Curtis*** (christopher.w.curtis@colorado.edu), Dept. of Applied Mathematics, 526 UCB, University of Colorado, Boulder, CO 80309-0526. *Spectral Stability of Soliton-Like Solutions to a Boussinesq Approximation.*

In this talk, a proof of the spectral stability of soliton-like solutions of a Boussinesq approximation of the Euler water wave problem will be discussed. Some associated numerical computations of spectral instability of other types of solutions will also be presented. (Received August 31, 2009)

1052-35-331 **Barbara Lee Keyfitz***, Department of Mathematics, The Ohio State University, 231 W 18th Avenue, Columbus, OH 43210. *Linear and Nonlinear Change of Type: A Review.*

This session explores recent progress in understanding systems of PDE that change type between elliptic and hyperbolic. As an introduction to the session, and to provide a reference to important work by contributors who could not attend or present their work, the speaker will give a brief history of the field, including some axes according to which research can be classified: model problems may have their origins in physics or geometry; the underlying problem may be steady or unsteady, linear or nonlinear; and the change of type may or may not be a manifestation of some well-known instability. In addition, research in the area is aimed at many possible outcomes, and uses a variety of interesting techniques. This talk will be a tutorial, intended to give some perspective to the rest of the session. (Received September 01, 2009)

1052-35-347 **Eun Heui Kim*** (ekim4@csulb.edu), California State University Long Beach, 1250 Bellflower Blvd, Department of Mathematics, Long Beach, CA 90840. *Transonic two dimensional Riemann problems.*

We present some recent results on transonic two dimensional Riemann problems which give rise free boundary and sonic boundary problems. (Received September 01, 2009)

1052-35-351 **Katarina Jegdic*** (jegdick@uhd.edu), One Main Street, University of Houston - Downtown, CMS Department, Houston, TX 77002, and **Barbara Lee Keyfitz** and **Suncica Canic**. *Transonic regular reflection for the isentropic gas dynamics equations.*

We consider a two-dimensional Riemann problem for the isentropic gas dynamics equations with the initial data chosen so that the solution results in regular reflection with a subsonic state behind the reflected shock. We study the problem near the reflection point and we ignore interaction of linear waves with reflected shocks and effects of vorticity. We write the problem in self-similar coordinates and we obtain a mixed type system and a free boundary problem for the reflected shock and a subsonic state behind the reflected shock. We rewrite this first order system using a second order equation for density and two first order equations for velocities, and we rewrite the jump conditions across the free boundary using an oblique derivative boundary condition for density, Dirichlet conditions for velocities and an ordinary differential equation for the position of the free boundary. We show existence of a local solution to this nonlinear free boundary problem using estimates for the solutions of the second order elliptic equations with mixed boundary conditions, compactness arguments and the Banach contraction principle. (Received September 01, 2009)

1052-35-359 **Constance M Schober*** (drschober@gmail.com), University of Central FLorida, Dept. of Mathematics, PO Box 161364, Orlando, FL 32816. *Rogue waves and Dissipation.*

We discuss rogue wave generation in deep water from the perspective of the focusing Nonlinear Schrödinger equation and some of its higher order generalizations (HONLS). For the HONLS equation two features emerge:

(a) a chaotic sea state appears to be an important mechanism for both generation and increased likelihood of rogue waves; (b) the extreme waves intermittently emerging from the chaotic background can be correlated with degenerate homoclinic orbits characterized by maximal coalescence of their spatial modes. The effects of wind and wave damping are examined and a statistical interpretation of rogue wave data is provided. (Received September 01, 2009)

1052-35-362 **Nedyu Popivanov*** (nedyu@fmi.uni-sofia.bg), Faculty of Mathematics and Informatics, "St. Kl. Ohridski" University of Sofia, 5, J.Bourchier Blvd PO Box 48, BG-1164 Sofia, Bulgaria, and **Rudolf Scherer** and **Todor Popov**. *Asymptotic expansions of singular solutions for 3+1-D Protter problems.*

Some boundary value problems for the wave equation (or for a class of weakly hyperbolic equations) in R⁴ are studied, which are multidimensional analogues of Darboux problems in the plane. Now, it is known that the multidimensional Protter problem is not well-posed, in contrast to the plane Darboux problem. For the wave equation an infinite number of necessary and sufficient conditions for the classical solvability is found. The Semi-Fredholm classical solvability of 3+1 –D Protter problem is proved. To avoid this infinite number of necessary conditions in the frame of classical solvability, the concept of generalized solutions with a possible strong singularity at one fixed point was introduced. The exact asymptotic singularity of the generalized solution is found. All these problems are connected to the multidimensional hyperbolic-elliptic Protter Problem, the statement of which is given in 1952. This is a joint work with Rudolf Scherer from University of Karlsruhe, Germany and Todor Popov, University of Sofia. (Received September 02, 2009)

37 ► Dynamical systems and ergodic theory

1052-37-12 **Maarten Bergvelt**, University of Illinois, Urbana, IL, **Michael Gekhtman**, University of Notre Dame, Notre Dame, IN , and **Alex Kasman*** (kasmana@cofc.edu), Department of Mathematics, College of Charleston, Charleston, SC 29424. *Spin Calogero Particles and Bispectral Solutions of the Matrix KP Hierarchy.*

The bispectrality of Lax operators for a non-commutative version of the KP hierarchy is shown to have dynamical significance for the spin generalization of the Calogero-Moser particle system. This not only generalizes a previous result by one of the authors regarding the commutative and spinless versions of these integrable systems but also provides new information about the scalar case as well. (Received April 18, 2009)

1052-37-38 **Michel L. Lapidus** (lapidus@math.ucr.edu), 900 Big Springs Rd, Surge Building, Department of Mathematics, Riverside, CA 92512, and **Robert G. Niemeyer*** (niemeyer@math.ucr.edu), 900 Big Springs Road, Surge Building, Department of Mathematics, Riverside, CA 92521. *Experimental and theoretical results on the Koch Snowflake billiard and its associated flat surface.*

In this talk, we attempt to define and understand the orbits of the Koch snowflake fractal billiard KS. This is a priori a very difficult problem because $\partial(KS)$, the snowflake curve boundary of KS, is nowhere differentiable, making it impossible to apply the usual law of reflection at any point of the boundary of the billiard table. Consequently, we view the prefractal billiards KS_n (naturally approximating KS from the inside) as rational polygonal billiards and examine the corresponding flat surfaces of KS_n, denoted by $\mathcal{S}_{KS_n}$. In order to develop a clearer picture of what may possibly be happening on the billiard KS, we simulate billiard trajectories on KS_n. As a result, we formulate conjectures about the existence and the geometric properties of periodic orbits of KS and detail a working plan on how to prove such conjectures using inverse limits, of which includes a Veech Dichotomy for the billiard KS. Moreover, we hypothesize that the billiard flow on KS will be clearly understood once we demonstrate the existence of a well-defined flow on a 'fractal flat surface' of infinite genus, denoted by $\mathcal{S}_{KS}$. (Received August 02, 2009)

1052-37-96 **Tamas Wiandt*** (tiwsma@rit.edu), 85 Lomb Memorial Dr, Rochester, NY 14623. *A Notion of Intensity of Attraction for Closed Relations.*

Certain aspects of attractors and attractor blocks for maps on locally compact metric spaces were investigated by R. McGehee. Among other notions, he introduced a notion of intensity of attraction, which was shown to be intimately connected to the persistence of attractors for small perturbations of the map in question. We give an overview of the possible extensions of his results to the case of closed relations on compact Hausdorff spaces. (Received August 22, 2009)

1052-37-178 **Luc Haine**, **Emil Horozov** and **Plamen Iliev***, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160. *Trigonometric Grassmannian, Calogero-Moser matrices and a difference W algebra.*

The trigonometric Grassmannian $\mathrm{Gr}^{\mathrm{trig}}$ parametrizes rank one solutions of a differential-difference bispectral problem. On the discrete side, the motion of the poles are connected to the rational Ruijsenaars-Schneider system, while on the continuous side the motion is related to the trigonometric Calogero-Moser system.

We discuss the construction of $\mathrm{Gr}^{\mathrm{trig}}$ and its parametrization in terms of trigonometric Calogero-Moser matrices. The τ-functions corresponding to subspaces $W \in \mathrm{Gr}^{\mathrm{trig}}$ belong to a module over a difference W-algebra, which is a central extension of the Lie algebra of difference operators with rational coefficients. This property can also be used to characterize the τ-functions from $\mathrm{Gr}^{\mathrm{trig}}$. (Received August 27, 2009)

1052-37-263 **Peter Topalov*** (p.topalov@neu.edu), Northeastern University, 360 Huntington Avenue, Boston, MA 02115, and **Kazuyoshi Kiyohara**. *On Liouville integrability of h-projectively equivalent Kahler metrics.* Preliminary report.

Under a non-degeneracy condition we classify the compact connected Kahler manifolds admitting pairs of holomorphically projectively equivalent metrics. Any such manifold is biholomorphically equivalent to $\mathbb{C}P^n$ and has completely integrable geodesic flow. (Received August 30, 2009)

1052-37-316 **Mark Levi***, Mathematics Department, Penn State, University Park, PA 16802, and **Sergei Tabachnikov** and **Robert Foote**. *Bike tracks, symplectic group and forced pendula.*

In this talk I will describe will describe a connection between the objects mentioned in the title. This talk is based on our joint work with Sergei Tabachnikov, Robert Foote and Warren Weckesser. (Received August 31, 2009)

39 ► Difference and functional equations

1052-39-9 **Yun Kang*** (yun.kang@asu.edu), **Dieter Armbruster** and **Yang Kuang**. *Dynamics of plant-herbivore models with monotone plant growth rate.*

The impact of monotone plant growth models in general plant-herbivore models on the dynamics of the plant-herbivore interaction is studied. It is shown that all monotone growth models generate a unique interior equilibrium. We investigate the uniform persistence of monotone growth models with a single nonzero equilibrium of the plant population. Such models lead to noise sensitive bursting which is identified as adynamical mechanism for almost periodic outbreaks of the herbivore infestation. Montone and non-monotone plant growth models are contrasted with respect to bistability and crises of chaotic attractors. (Received February 11, 2009)

1052-39-18 **Fei Xue*** (xue@hartford.edu), 200 Bloomfield Ave., West Hartford, CT 06117, and **Harry Gingold** (gingold@math.wvu.edu), Department of Mathematics, P.O. Box 6310, West Virginia University, Morgantown, WV 26506. *Asymptotic summation of linear difference system of equations.*

A new method for asymptotic summation of linear systems of difference equations is proposed and studied. It is based on the introduction of a certain summation equation that pinpoints sufficient conditions for asymptotic summation. These conditions serve as a framework from which new and old theorems follow. In particular the analog of the fundamental theorems of Levinson is shown to follow from it. This is a joint work by H. Gingold and F. Xue. (Received June 03, 2009)

1052-39-24 **Bernard P Brooks*** (bpbsma@rit.edu), 85 Lomb Memorial Dr, Rochester, NY 14623. *FIRST ORDER 4-DIMENSIONAL DISCRETE DYNAMIC LINEAR STABILITY CONDITIONS.*

Multidimensional difference equations are useful tools to model many SIR style systems. Unfortunately, often times in these discrete mathematical models there are too many parameters to directly calculate the stability of equilibrium. What is needed is a set of conditions on the parameters that equate to linear stability, that is, conditions on the Jacobian that equate to the 4 eigenvalues having magnitude less than 1. Linear stability conditions for a first order 4-dimensional discrete dynamic are derived in terms of the trace, sum of minors, sum of their minors, and the determinant of the Jacobian evaluated at the equilibrium. Thus a stability region in parameter space can be defined by the resulting set of inequalities. (Received July 12, 2009)

1052-39-26 **Harry Gingold*** (gingold@math.wvu.edu), WVU, Department of Mathematics, Armstrong Hall, Morgantown, WV 26506. *COMPACTIFICATION AND BLOW UP OF SOLUTIONS IN NONLINEAR FINITE DIFFERENCE SYSTEMS.* Preliminary report.

Abstract. Nonlinear systems of difference equations are studied via a new compactification method that distinguishes among different directions at infinity. This compactification transforms a polynomial system in , to a rational system inside the unit ball. On the unit ball, of the compactified system, a family of solutions that correspond to ideal solutions of the original polynomial equation in is defined. The compactification allows us to define critical points at infinity. The critical points at infinity lead to a nonlinear eigenvalue problem. If a critical point on the boundary of the compactified system is "hyperbolic", then the original system is expected to possess solutions that blow up. A naive expectation that the Jacobian, about a point y= of any polynomial difference system, solely depends on the highest degree non linear terms of , is shown to be false. (Received July 14, 2009)

1052-39-46 **Candace M. Kent*** (cmkent@vcu.edu), Virginia Commonwealth University, Department of Mathematics & Applied Math., Harris Hall,1015 Floyd Ave., P.O. Box 842014, Richmond, VA 23284-2014, **David M. Chan** (dmchan@vcu.edu), Virginia Commonwealth University, Department of Mathematics & Applied Math., Harris Hall,1015 Floyd Ave., P.O. Box 842014, Richmond, VA 23284-2014, and **Norma L. Ortiz-Robinson** (nlortiz@vcu.edu), Virginia Commonwealth University, Department of Mathematics & Applied Math., Harris Hall,1015 Floyd Ave., P.O. Box 842014, Richmond, VA 23284-2014. *Convergence Results on a Second-Order Rational Difference Equation with Quadratic Terms.*

We investigate the global behavior of the second-order difference equation $x_{n+1} = x_{n-1}((\alpha x_n + \beta x_{n-1})/(Ax_n + Bx_{n-1}))$, where initial conditions and all coefficients are positive. We find conditions on $A\,, B\,, \alpha\,, \beta$ under which the even and odd subsequences of a positive solution converge, one to zero and the other to a nonnegative number; as well as conditions where one of the subsequences diverges to infinity and the other either converges to a positive number or diverges to infinity. We also find initial conditions where the solution monotonically converges to zero and where it diverges to infinity. (Received August 07, 2009)

1052-39-72 **Nicholas A Battista*** (nab4047@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester, NY 14623, and **Michael A Radin** (michael.radin@rit.edu), School of Mathematical Sciences, 85 Lomb Memorial Drive, Rochester, NY 14623. *Monotonic and Periodic Character of solutions of the Rational Difference Equation* $x_{n+1} = \frac{A_n X_{n-1}}{1+X_n+X_{n-1}}$. Preliminary report.

We investigate the monotonic and periodic character of the nonnegative solutions of the rational difference equation

$$x_{n+1} = \frac{A_n X_{n-1}}{1 + X_n + X_{n-1}},\ n = 0, 1, \ldots,$$

where $\{A_n\}_{n=0}^{\infty}$ is a periodic sequence of positive real numbers. (Received August 19, 2009)

1052-39-104 **Mostafa Ghandehari*** (ghandeha@uta.edu), Civil Engineering, Box 19308, Univ. of Texas at Arlington, Arlington, TX 76019, and **Siamak Ardekani**. *The differential-difference equation for the car-following.* Preliminary report.

Velocities and spacings in the linear car-following model satisfy a differential-difference equation. After taking the Z-transform a linear first order ordinary differential equation is obtained. The solution of differential equation will give the Z-transform of the nth car in the platoon. the inverse Z transform will give analytic expressions for velocities and spacings of the n cars. (Received August 23, 2009)

1052-39-118 **A M Brett**, **E Camouzis**, **G Ladas** and **C D Lynd*** (chris_lynd@mail.uri.edu). *On the Boundedness Character of a Rational System.*

We investigate the boundedness character of solutions of the rational system

$$x_{n+1} = \frac{\alpha_1 + \beta_1 x_n}{B_1 x_n + y_n} \text{ and } y_{n+1} = \frac{\alpha_2 + \beta_2 x_n + \gamma_2 y_n}{A_2 + x_n}$$

with nonnegative parameters and with arbitrary nonnegative initial conditions such that the denominators are always positive. (Received August 24, 2009)

1052-39-176 **Elias Camouzis** and **Emmanouil Drymonis*** (mdrymonis@mail.uri.edu), University of Rhode Island, Department of Mathematics, Kingston, RI 02881-0816, and **Gerasimos Ladas**. *On the Global Character of a Rational System in the Plane.*

We investigate the global character of solutions of a rational system in the plane with positive parameters and with arbitrary nonnegative initial conditions such that the denominators are always positive. We show that every solution of the system is bounded and furthermore every solution converges to a (not necessarily prime) period-two solution. (Received August 27, 2009)

1052-39-221 **Timothy Sauer*** (tsauer@gmu.edu), Department of Mathematics, George Mason University, Fairfax, VA 22030. *Convergence of Max-Type and Rank-Type Equations.*

We present sufficient conditions for convergence of hyperbolic autonomous difference equations of max-type, and similar results for the rank-type case, along with several examples. Some conjectures will be offered for the nonhyperbolic case which generalize conjectures of G. Ladas. (Received August 28, 2009)

1052-39-360 **Richard T Guy*** (guyrt7@wfu.edu), Department of Mathematics, Winston-Salem, NC 27109, and **Kenneth S Berenhaut** (berenhks@wfu.edu), Department of Mathematics, Winston-Salem, NC 27109. *Some recent results on minimum-delay difference equations.*

In this talk we will consider equations of the form

$$y_n = \min(f(y_{n-k_1}, y_{n-m_1}), \ldots, f(y_{n-k_L}, y_{n-m_L})).$$

Conditions on f and $\{(k_i, m_i)\}$ which guarantee global asymptotic stability of positive solutions will be provided. Periodicities of solutions will also be considered. (Received September 02, 2009)

41 ► Approximations and expansions

1052-41-290 **Marco Bertola*** (bertola@mathstat.concordia.ca), 1455 de Maisonneuve St. W, Montreal, Quebec H3G 1M8, Canada, and **Alexander Tovbis**, University of Central Florida, Dept. of Math., 4000 Central Florida Blvd., Orlando, FL 32816-1364. *Universality in the profile of the nonlinear Schrödinger equation at the first breaking curve.*

We consider the zero-dispersion limit of the focusing nonlinear one-dimensional Schrödinger equation with smooth, decaying initial data. The space-time plane subdivides into regions with qualitatively different behavior, with the boundary between them consisting typically of collection of (*breaking curve(s)*). For small time and/or large distance, the asymptotics is ruled by modulation equations (Whitham equations) whereby the amplitude is a smooth function and the phase is fastly rotating at the scale of the dispersion parameter; for any time greater than the *time of gradient catastrophe*, there is a compact subset of the x-axis where the asymptotic solution develops fast, quasiperiodic behavior, and the amplitude becomes fastly oscillating at scales of order ϵ. We study the asymptotic behavior of the left and right edges of the interface between these two regions at any time after the gradient catastrophe. The main finding is that the first oscillations in the amplitude are of nonzero asymptotic size even as ϵ tends to zero, and display two separate natural scales; of order $\mathcal{O}(\epsilon)$ in the parallel direction to the breaking curve in the (x,t)-plane, and of order $\mathcal{O}(\epsilon \ln \epsilon)$ in a transversal direction. (Received August 31, 2009)

42 ► Fourier analysis

1052-42-74 **Emanuel Carneiro**, **Friedrich Littmann** and **Jeffrey D. Vaaler*** (vaaler@math.utexas.edu), 1 University Station, C1200, Austin, TX 78712. *Some Extremal Functions in Fourier Analysis.*

We will describe some recently discovered solutions to the Beurling-Selberg extremal problem for certain special functions. If $f(x)$ is a suitable real valued function of the real variable x, the problem we consider is to identify a real, entire function $F(z) = F(x+iy)$ such that $f(x) \leq F(x)$ for all real x, $F(z)$ has exponential type at most 2π, and the integral of $F(x) - f(x)$ along the real axis is minimized. Analogous problems for periodic functions $f(x)$ will also be considered. For certain special choices of $f(x)$, for example $f(x) = |x|^\beta$ with $\beta > 0$, or $f(x) = \exp\{-\pi x^2\}$, the solution to this extremal problem has applications in analytic number theory. (Received August 19, 2009)

44 ► Integral transforms, operational calculus

1052-44-310 **Alexander Tovbis***, Dept. of Mathematics, UCF, Orlando, FL 32816. *Abel transform as the semiclassical limit of the scattering transform for the focusing NLS.* Preliminary report.

The semiclassical limit of the focusing Nonlinear (cubic) Schrödinger Equation (NLS) corresponds to the singularly perturbed Zakharov Shabat (ZS) system that defines the direct and inverse scattering transforms (IST). We derive explicit expressions for the leading order terms of these transforms, which are called semiclassical limits of the direct and inverse scattering transforms. Thus, we establish an explicit connection between the decaying initial data of the form $q(x,0) = A(x)e^{iS(x)}$ and the leading order term of its scattering data. This connection is expressed in terms of an integral transform that can be viewed as a complexified version of an Abel type transform. Our technique is not based on the WKB analysys of the ZS system, but on the inversion of the modulation equations that solve the inverse scattering problem in the leading order. (Received August 31, 2009)

45 ► Integral equations

1052-45-287 **E. Walter Farkas*** (farkas@math.ethz.ch), Swiss Banking Institute, Plattenstrasse 14, 8032 Zurich, Switzerland. *On option pricing under Levy copula processes - analytical and numerical aspects.*

We consider the valuation of derivative contracts on baskets of risky assets whose prices are Levy-like Feller processes of tempered stable type. The dependence among the marginals' jump structure is parametrized by a Levy copula. For marginals of regular exponential Levy type, we show that the infinitesimal generator A of the resulting Levy copula process is a pseudo-differential operator whose principal symbol is a distribution of anisotropic homogeneity. We prove that the domains of the infinitesimal generators of these processes are certain anisotropic Sobolev spaces. Using a Garding inequality, we finally discuss a wavelet-based dimension-independent tensor product discretization for the efficient numerical solution of the associated parabolic Kolmogorov equation arising in valuation of derivative contracts under possibly stopped Levy copula processes. The talk is based on some joint work with N. Reich and Ch. Schwab from ETH Zurich. (Received August 31, 2009)

46 ► Functional analysis

1052-46-10 **Alexander A Katz** (katza@stjohns.edu), St. John's University, Dep. of Math & CS, 300 Howard Ave., DaSilva 314, Staten Island, NY 10301, and **Oleg Friedman*** (friedman001@yahoo.com), University of South Africa, Department of Mathematical Sciences, P.O.Box 392, Pretoria, 0003, South Africa. *On ideals in real locally C*- and locally JB-algebras.*

In the sequel various order theoretic and topological properties of ideals in real locally C*-agebras (projective limits of projective families of real C*-algebras) and in locally JB-algebras (projective limits of projective families of JB-algebras) are investigated. (Received April 10, 2009)

1052-46-11 **Alexander A Katz*** (katza@stjohns.edu), St. John's University, Dep. of Math & CS, 300 Howard Ave., DaSilva 314, Staten Island, NY 10301. *On the notion of $\Phi-$normed spaces.*

The notion of $\Phi-$normed topological vector space is investigated for which the topology is defined by a norm-like mapping from a cone of positive elements of a Tikhonov topological semifield $\mathbb{R}_+^{\triangle}$ into itself. We show that every locally convex space is $\Phi-$normed, and every $\Phi-$normed space is topologically isomorphic to an inductive limit of a family of locally convex spaces. (Received April 10, 2009)

1052-46-14 **Alexander A Katz** (katza@stjohns.edu), St. John's University, Dep. of Math & CS, 300 Howard Ave., DaSilva 314, Staten Island, NY 10301, and **Roman Kushnir*** (kushnir_roman@yahoo.com), University of South Africa, Department of Mathematical Sciences, P.O.Box 392, Pretoria, 0003, South Africa. *On the notion of a real Hilbert module over real locally C*-algebra.*

In the sequel we introduce a notion of a real Hilbert module over real locally C*-algebra and show that this generalization shares many basic properties of its complex counterpart. (Received May 03, 2009)

1052-46-262 **Todd Kemp*** (tkemp@math.mit.edu), 2-175 MIT, Cambridge, MA 02139. *Free heat kernel analysis and liberation.* Preliminary report.

The intersection of heat kernel analysis and random matrix theory is a "hot" new field. Consider the Euclidean heat kernel on R^{n^2}, written as the entries of an $n \times n$ Hermitian matrix. A lot of work has gone into understanding the "heat flow" of the eigenvalues of this matrix. Interestingly, as $n \to \infty$, this kernel has finite propagation speed.

In this lecture, I will discuss recent work in the unitary case: studying the flow of eigenvalues of a random matrix sampled from the heat kernel measure on the unitary group $U(n)$. Seen from a certain angle as $n \to \infty$, one can write down a (semi-linear) PDE that describes a kind of heat kernel that, once again, has finite propagation speed.

This is joint work with Benoit Collins. (Received August 30, 2009)

51 ► Geometry

1052-51-90 **Fabrice Baudoin** and **Nicola Garofalo*** (garofalo@math.purdue.edu), Department of Mathematics, 150 N. University Street, West Lafayette, IN 47907-2067. *Generalized Bochner formulas and Ricci lower bounds for sub-Riemannian manifolds of rank two.*

This talk describes recent joint work with Fabrice Baudoin. We introduce a new class of sub-Riemannian manifolds of rank two which encompasses Riemannian manifolds, CR manifolds with vanishing Webster-Tanaka torsion, orthonormal bundles over Riemannian manifolds, and graded nilpotent Lie groups of step two. These manifolds admit a canonical horizontal connection and a canonical sub-Laplacian. We construct on these manifolds an analogue of the Riemannian Ricci tensor and prove Bochner type formulas for the sub-Laplacian. As a consequence, it is possible to formulate on these spaces a sub-Riemannian analogue of the so-called curvature dimension inequality. Sub-Riemannian manifolds for which this inequality is satisfied are shown to share many properties in common with Riemannian manifolds whose Ricci curvature is bounded from below. (Received August 21, 2009)

53 ► Differential geometry

1052-53-16 **J. T. Cho**, CNU The Institute of Basic Sciences, Gwangju 500-757, South Korea, and **Ramesh Sharma*** (rsharma@newhaven.edu), 300 Boston Post Rd., West Haven, CT 06516. *Contact Metrics And Ricci Solitons.*

Assuming that the Ricci curvature of the standard contact metric of the unit tangent bundle of a manifold vanishes along the Reeb vector field, we show that the scalar curvature of the base manifold M is non-negative and vanishes if and only if M is flat. Under the same hypothesis, for $dim.M = 2$, we show that M is either flat, or has constant curvature 2. Next we show that a compact contact Ricci soliton with a potential vector field V collinear with the Reeb vector field, is Einstein. We also show that a homogeneous H-contact gradient Ricci soliton is either Ricci-flat or locally isometric to $E^{n+1} \times S^n(4)$. Finally we obtain conditions so that the horizontal and tangential lifts of a vector field on the base manifold may be potential vector fields of a Ricci soliton on the unit tangent bundle. (Received May 20, 2009)

1052-53-36 **Philippe Rukimbira***, DM 416, Florida International University, Department of Mathematics, Miami, FL 33199, and **Dathe Hamidou**, Universite Cheik Anta Diop, Dakar, Senegal. *Deformation of closed, nonsingular 1-forms into contact forms on T^2-bundles over S^1.*

If a closed 3-manifold M supports a closed, nonsingular, irrational 1-form which defoms linearly into contact forms, then M supports a K-contact form. On the 3-torus, a closed, nonsingular 1-form deforms linearly into contact forms if and only if it is a fibration 1-form. On any other 2-torus bundle over the circle, every closed, nonsingular 1-form deforms linearly into contact forms. (Received July 31, 2009)

1052-53-63 **Keiichi Kikuchi*** (kikuchi@jewel.ocn.ne.jp), 1-36-3-205, Izumihoncho, Komae, Tokyo 201-0003. *General Lie algebra extensions and extended Euler equations.*

In the first place, we deal with extensions of the Lie algebra of conformal Killing vector fields on a compact Riemannian manifold and lead some extended Euler equations which are concerned with the higher dimensional shallow water equation. In particular, we consider the Lie algebra extension of conformal Killing vector fields on a compact Einstein manifold. In the second place, we treat a one-dimensional general extension of the Lie algebra

of vector fields on the circle, which is equipped with a non-standard bracket and a non-trivial representation, and obtain a certain extended Euler equation related with an infinite dimensional analogue of Heisenberg algebra. (Received August 22, 2009)

1052-53-68 **David E. Blair***, Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027. *A complex geodesic flow.*

When one poses a question like, what is the complex analogue of the geodesic flow, many objections may arise in one's mind, e.g.

1) What is a complex geodesic?

2) The home of the classical geodesic flow is the unit tangent bundle and an important special case is when the base manifold is a compact Riemannian manifold of negative curvature; in this case the geodesic flow is an Anosov flow. In contact metric geometry the tangent sphere bundle is an important example and the characteristic vector field (Reeb vector field) of the contact structure is twice the geodesic flow. So what is the complex analogue of the unit tangent bundle?

3) Since there is no natural ordering of the complex numbers, how can one have a flow?

We will address these objections and discuss a complex geodesic flow for complex space forms. We will conclude with a discussion of the relation of this problem to complex contact geometry. (Received August 18, 2009)

1052-53-119 **Mehdi Lejmi*** (lejmi.mehdi@courrier.uqam.ca), Département de Mathématiques, UQÀM, C.P. 8888 Succ. Centre-ville, Montréal, Québec H3C 3P8, Canada. *Extremal almost-Kähler metrics.*

We generalize the notions of the Futaki invariant and extremal vector field of a compact Kähler manifold to the general almost-Kähler case and show the periodicity of the extremal vector field when the symplectic form represents an integral cohomology class modulo torsion. (Received August 24, 2009)

1052-53-172 **Megan M Kerr*** (mkerr@wellesley.edu), Dept of Mathematics, Wellesley College, 106 Central St, Wellesley, MA 02481, and **Andreas Kollross** (kollross@math.uni-augsburg.de), Mathematics Institute, University of Augsburg, Augsburg, Germany. *On a class of homogeneous spaces with nonnegative curvature.* Preliminary report.

For compact Lie groups $H \subset K \subset G$, we study the existence of G-invariant fibration metrics on G/H with nonnegative sectional curvature, with respect to the fibration $K/H \to G/H \to G/K$.

We start with a metric on G/H induced from the biinvariant metric on G, such that the map $G/H \to G/K$ is a Riemannian submersion. We consider the one-parameter family of metrics on G/H obtained by scaling up in the direction of the fibers. In this work we build on the work of L. Schwachhöfer and K. Tapp, to understand what conditions on $H \subset K \subset G$ guarantee that this parametrization of homogeneous metrics on G/H yields metrics of nonnegative curvature. (Received August 26, 2009)

1052-53-204 **Arlo Caine*** (arlo.caine@nd.edu). *Toric Poisson Structures.*

A real algebraic Poisson structure on smooth complex toric varieties is constructed. In the natural holomorphic coordinates, the Poisson structure is homogeneous quadratic and generalizes quadratic Poisson structures of elliptic type in the plane. The geometry of the symplectic foliation is characterized and it is shown that the action of the complex torus is Poisson, but no subgroup acts in a globally Hamiltonian way. However, each symplectic leaf is a completely integrable system as sub-tori of the compact torus act in a Hamitonian fashion on each leaf. The modular class is always non-trivial and, using work of Nakanishi on plane quadratic Poisson structures, the Poisson cohomology of the simplest toric variety can be computed. A local calculation shows a connection between the zero locus of the modular vector field relative to a Delzant symplectic form on complex projective space and the centroids of the faces of the Delzant moment simplex. (Received August 28, 2009)

1052-53-240 **Jedrzej Sniatycki*** (sniat@math.ucalgary.ca), Department of Mathemtics and Statistics, University of Calgary, Calgary, Alberta T2N 1N4, Canada. *Singular Reduction of Symmetries.*

Presence of symmetries in Hamiltonian systems simplifies the task of solving equations of motion. If the action of the symmetry group G on a symplectic manifold (P, ω) is free and proper the space P/G of G-orbits in P is a Poisson manifold and the orbit map $\rho : P \to P/G$ is a locally trival fibration.

If the action of G on P is proper but not free, the orbit space P/G is not a manifold but a smoothly stratified space. One can recover all the structure of P/G from the structure of the ring $C^\infty(P)^G$ of smooth G-invariant functions on P.

This approach is also applicable to other types of systems, e.g. dynamical systems with non-holonomic constraints, non-linear control systems or Dirac systems.
(Received August 28, 2009)

1052-53-272 **Aissa Wade*** (wade@math.psu.edu), McAllister Building, Penn State, University Park, State College, PA 16802. *Dirac structures and contact geometry.*

There are numerous applications in which the theory of Dirac structures can be employed. In particular, Dirac structures are used in generalized complex geometry. In this talk, we discuss their relationship to contact geometry. (Received August 30, 2009)

1052-53-278 **Gideon Maschler*** (gmaschler@clarku.edu), Department of Mathematics & Computer Science, Clark University, Worcester, MA 01606. *Distinguished metrics conformal to Kähler metrics.* Preliminary report.

Under what conditions is a Kähler metric g conformal to a distinguished Riemannian metric $\hat{g}$? We discuss positive, and partial negative answers to this question for various metric types, requiring $\hat{g}$ to be either Einstein, a gradient Ricci soliton or quasi-Einstein in the sense of Case, Shu and Wei. (Received August 30, 2009)

1052-53-296 **Brian Rolle*** (brollO02@math.ucr.edu), Department of Mathematics, Surge 202, 900 University Ave., Riverside, CA 92521, and **Y S Poon** and **D Grandini**. *Variations of Cohomological Spaces of Generalized Complex Structures.*

Generalized complex structures have been a subject of interest since they were discovered and their deformations have been previously studied. In this paper we study deformations of generalized complex structures which leave the perturbed differential Gerstenhaber algebra quasi-isomorphic to the original. In the case of nilmanifolds, we develop conditions for an infinitesimal deformation to be quasi-isomorphic. (Received August 31, 2009)

1052-53-305 **Weiyi Zhang*** (zhang393@math.umn.edu), Department of Mathematics, 206 Church St SE, University of Minnesota, Minneapolis, MN 55455. *A new cohomology decomposition of almost complex 4-manifolds.*

In this talk, I will introduce a new cohomology decomposition of second cohomology group of almost complex 4-manifolds. This can be viewed as a generalization of (real) Dolbeault docomposition for complex manifolds. I will calculate and estimate ranks of the subgroups in some cases and explain the relations with comparison of some symplectic cones.

This is a joint work with Tedi Draghici and Tian-Jun Li. (Received August 31, 2009)

1052-53-324 **Mark Levi** (levi@math.psu.edu), Department of Mathematics, Penn State, University Park, PA 16802, and **Sergei Tabachnikov*** (tabachni@math.psu.edu), Department of Mathematics, Penn State, University Park, PA 16802. *Tire tracks geometry and Menzin's conjecture.*

The model of a bicycle is a unit segment that can move in the plane so that it remains tangent to the trajectory of its rear endpoint (the rear wheel, fixed on the bicycle frame). The trajectory of the front wheel and the initial position of the bicycle uniquely determine its motion and its terminal position; the monodromy map sending the initial position to the terminal one arises. This mapping of a circle to a circle is a Moebius transformation. Moebius transformations belong to one of the three types: elliptic, parabolic and hyperbolic. I shall outline a proof of a 100 years old conjecture: if the front wheel track is an oval with area at least Pi then the respective monodromy is hyperbolic. I shall also discuss versions of this result for classical geometries of constant curvature. (Received August 31, 2009)

1052-53-336 **Andrzej Derdzinski*** (andrzej@math.ohio-state.edu), Department of Mathematics, The Ohio State University, Columbus, OH 43210, and **Gideon Maschler**. *Pairs of Kähler surface metrics with a real-holomorphic gradient eigenvector.* Preliminary report.

We consider the case of two Kähler metrics g, h on a compact complex surface M with the property that some fixed nontrivial real-holomorphic vector field v is both a g-gradient and an h-gradient, while, at points where v is nonzero, v constitutes an eigenvector of h treated, with the aid of g, as a bundle endomorphism of TM. We then say that h arises from g by a v-biconformal change, and call the v-biconformal change trivial if h is a constant multiple of g. Various examples of nontrivial v-biconformal changes are presented, and the metrics involved include: all nonflat compact Kähler-Einstein metrics on compact complex surfaces admitting nontrivial holomorphic vector fields; all non-Einstein compact Kähler-Ricci solitons in complex dimension 2; and the Chen-LeBrun-Weber conformally-Einstein metric on the two-point blow-up of the complex projective plane with the v-biconformal change found by LeBrun in 1995. (Received September 01, 2009)

1052-53-346 **Augustin Banyaga*** (banyaga@math.psu.edu), Augustin Banyags, Department of Mathematics, McAllister Blg, 303, University Park, PA 16802. *A Hofer-like topology and the group of strong symplectic homeomorphisms.* Preliminary report.

We define a natural (Hofer-like) topology on the space of symplectic isotopies of a closed symplectic manifold, which generalizes the hamiltonian topology of Oh-Muller on the space of hamiltonian isotopies. The induces topology on the identity component in the group of symplectic diffeomorphisms is a metric topology, coming from a Hofer-like metric. We use this topology to define the group of strong symplectic homeomorphisms, generalizing the group Hameo of symplectic homoeomorphisms of Oh-Muller. (Received September 01, 2009)

55 ► Algebraic topology

1052-55-25 **Kijti Rodtes*** (pmp06kr@sheffield.ac.uk), Department of Pure mathematics, School of Mathmatics and Statistics, Hicks Building, The University Of Sheffield, Sheffield, S3 7RH. *The connective K-theory of finite groups.* Preliminary report.

The connective real K-homology of a finite group G, $ko_*(BG)$, plays an important role in Gromov-Lawson-Rosenberg(GLR) conjecture. In order to calculate them, we can compute from $ku^*(BG)$ via Bockstein spectral sequence(BSS) followed by Greenlees spectral sequence or compute from $ku_*(BG)$ by using BSS. In this talk, we will show how to calculate $ku^*(BG)$ and $ku_*(BG)$, for finite groups especially on Semidihedral group(order16), by using the process developed by J.P.C. Greenlees and R.R.Bruner. (Received August 27, 2009)

1052-55-44 **Ido Efrat** and **Sunil Kumar Chebolu*** (schebol@ilstu.edu), Department of Mathematics, Illinois State University, Campus box 4520, Normal, IL 61761, and **Jan Minac**. *On the continuous cohomology of Bloch-Kato profinite groups.*

For prime power $q = p^d$ and a field F containing a root of unity of order q we show that the Galois cohomology ring $H^*(G_F, \mathbb{Z}/q)$ is determined by a quotient $G_F^{[3]}$ of the absolute Galois group G_F related to its descending q-central sequence. Conversely, we show that $G_F^{[3]}$ is determined by the lower cohomology of G_F. This is used to give new examples of profinite groups which do not occur as absolute Galois groups of fields. These results are proved more generally for arbitrary profinite groups satisfying some conditions on their cohomology rings. This is joint work with Efrat and Minac. (Received August 06, 2009)

1052-55-114 **Mehdi Khorami*** (mkhorami@wesleyan.edu), Middletown, CT 06457. *Twisted K-theory.*

Let X be a space equipped with a cohomology class τ in $H^3(X, Z)$. As we recall in this talk, we can use τ to define both the twisted complex K-theory of X and the twisted Spin^c cobordism of X. Hopkins and Hovey proved that the (untwisted) complex K-theory of X is related to the Spin^c bordism of X via an isomorphism of Conner-Floyd type. We investigate the analogous question for the twisted theories. (Received August 24, 2009)

1052-55-115 **Anna Marie Bohmann*** (bohmann@math.uchicago.edu), Department of Mathematics, 5734 S. University Ave, Chicago, IL 60637. *The S^1 Equivariant Generating Hypothesis.*

The Freyd generating hypothesis is a long-standing conjecture in stable homotopy theory. An analogous conjecture can be formulated in any triangulated category with a set of compact generators. Recently, Hovey, Lockridge, and Puninski characterized the rings in whose derived categories this conjecture holds. They showed in particular that the generating hypothesis holds in the derived category of a von Neumann regular ring. The rational Burnside ring of a compact Lie group is an example of such a ring. This might lead one to suspect that the generating hypothesis holds in the rational equivariant stable homotopy category of a compact Lie group. Starting from Greenlees's algebraic description of this category for the circle group, we show that this is not the case by exhibiting an explicit counterexample. (Received August 24, 2009)

1052-55-132 **William G Dwyer*** (dwyer.1@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *The many faces of the Bockstein.* Preliminary report.

This is joint work with J. Greenlees. We look at the problem of classifying differential graded algebras (DGAs) over the integers whose homology ring is isomorphic to an exterior algebra over $\mathbb{F}_p$ on one generator of degree -1. (The generator is a type of generalized Bockstein operator.) Two DGAs are (directly) equivalent if there is a DGA map between them inducing an isomorphism on homology. The conclusion is that, with one exception, equivalence classes of these DGAs correspond bijectively to totally ramified extensions of the field of p-adic rationals. (Received August 25, 2009)

1052-55-138 **Troy Winfree*** (winfree@math.rochester.edu). *Continuous homotopy fixed point spectra: finiteness properties and computations.*

Given a closed subgroup G of the Morava stabilizer group S_n, let E_n^{hG} denote the continuous homotopy fixed point spectrum of Devinatz and Hopkins. We examine the case $G = W\mathbb{F}_{p^n}^0$ via computations in the Bockstein spectral sequence $H_c^*((W\mathbb{F}_{p^n}^0)^{p^k}, \mathbb{F}_{p^n}[u^{\pm}]) \Rightarrow H_c^*((W\mathbb{F}_{p^n}^0)^{p^k}, \mathbb{F}_{p^n}[[u_{n-1}]][u^{\pm}])$. At the $n = 3$ level and for $k \geq 0$ all of the zero-line differentials can be computed. We discuss two consequences: first, that a proposed finiteness result which holds at the $n = 2$ level cannot be extended to higher n; second, letting $V(1)$ denote a finite spectrum with $BP_*V(1) = BP_*/\langle p, v_1\rangle$, that if $p > 3$ then $\pi_*(E_3^{h((W\mathbb{F}_{p^3}^0)^{p^k} \times \mathbb{F}_p^\times)} \wedge V(1))$ is of essentially finite rank. (Received August 25, 2009)

1052-55-145 **Julie Bergner*** (jbergner@math.ucr.edu). *Stable homotopy theories and derived Hall algebras.*

Homotopy-theoretic approaches have been useful in recent attempts to associate a version of the Hall algebra to a triangulated category. We'll describe how to obtain such an algebra when the triangulated category is the homotopy category of a stable homotopy theory and satisfies certain finiteness assumptions, then discuss how one might generalize beyond this finitary case. (Received August 25, 2009)

1052-55-160 **Scott M. Bailey*** (bailey@math.rochester.edu), Department of Mathematics, University of Rochester, RC Box 270138, Rochester, NY 14627. *On the Tate spectrum of* tmf *at the prime 2.*

The root invariant of Mahowald associates to every element α in the stable homotopy groups of spheres, another element $R(\alpha)$. Since its construction introduces indeterminacy, the root invariant is a coset in general. Ravenel and Mahowald conjectured that the root invariant of a v_n-periodic element is v_{n+1}-periodic. Furthermore, they continued to exhibit a relationship between elements that were themselves root invariants with their behavior in the EHP spectral sequence. In particular, $R(-)$ seems to provide an interesting connection between the unstable world and the chromatic view of the stable world. Although neither a proof, nor a precise statement, of this phenomenon exists there are computations establishing its plausibility. For example, the root invariant is closely related to that of the Tate spectrum, tE, of a spectrum E. Numerous authors have given examples of v_n-periodic cohomology theories (bo, $BP\langle 2\rangle$, Johnson-Wilson theories $E(n)$, etc.) which split into v_n-torsion after the Tate spectrum functor is applied. In this talk, I will define the Tate spectrum functor, and discuss a similar phenomenon of t(tmf) at the prime $p = 2$. (Received August 26, 2009)

1052-55-161 **Ragnarsson Kari*** (kragnars@math.depaul.edu), Department of Mathematical Sciences, 2320 N. Kenmore Avenue, Chicago, IL 60614. *Stable splittings of classifying spaces.*

Let S be a finite p-group. A long-standing question asks when a stable summand of BS is the p-completed classifying space of a finite group G that has S as Sylow subgroup. As the p-local stable homotopy type of BG is determined by its fusion system (the category with objects the subgroups of S and morphisms induced by conjugation in G) it makes sense to extend this question and ask when a stable summand of BS is the classifying spectrum of a (possibly exotic) fusion system on S. In this talk I will show how applying recent joint work with Radu Stancu gives a surprising, simple answer to this question. Specifically, a stable summand of BS is the classifying spectrum of a saturated fusion system if and only if the corresponding idempotent in the double Burnside ring of S satisfies a simple self-linearity equation, closely linked with Frobenius reciprocity. (Received August 26, 2009)

1052-55-167 **Kate Ponto*** (kponto1@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556. *Additivity of the Reidemeister trace.* Preliminary report.

One of the most important properties of the Euler characteristic is additivity: If A is a subspace of B, the Euler characteristic of B is the sum of the Euler characteristics of A and B/A. The corresponding additivity property is also fundamental to the Lefschetz number and the Reidemeister trace. I will describe how additivity of the Reidemeister trace follows from the definition of this invariant as the trace in a bicategory with shadows. (Received August 26, 2009)

1052-55-181 **Staic D Mihai*** (mstaic@indiana.edu), Bloomington, IN 47405. *Secondary Cohomology and k-invariants.*

For a triple (G, A, κ) (where G is a group, A is a G-module and $\kappa \in H^3(G, A)$), and a G-module B we introduce a new cohomology theory ${}_2H^n(G, A, \kappa; B)$ which we call the secondary cohomology. We give a construction that associates to a pointed topological space (X, x_0) an invariant ${}_2\kappa^4 \in {}_2H^4(\pi_1(X), \pi_2(X), \kappa^3; \pi_3(X))$. This construction can be seen a "3-type" generalization of the classical k-invariant. (Received August 27, 2009)

1052-55-207 **Barry John Walker*** (bjwalker@math.northwestern.edu), Northwestern University Dept. of Math., 2033 Sheridan Road, Evanston, IL 60208. *Elliptic Orientations.* Preliminary report.

Recently, Ando, Hopkins and Rezk were able to produce the String orientation of topological modular forms in a purely homotopical way. Using their ideas, one can classify the components of the space of E_∞ complex orientations of Morava height one theories. These methods involve understanding the theory of p-adic analysis on the p-adic integers. However, the current arguments are not sensitive to the Morava stabilizer group of higher height or the Hecke operators of Ando, Hopkins, Strickland and Rezk.

In this talk we will discuss the current situation for extending this work to height two Morava theories. We will present the method for attacking the problem and the ingredients. These methods ascend, on the surface at least, to any finite height. (Received August 28, 2009)

1052-55-210 **Jonathan Andrew Scott*** (j.a.scott3@csuohio.edu), Cleveland State University, Department of Mathematics, 2121 Euclid Ave, RT 1515, Cleveland, OH 44115-2214, and **Kathryn Hess**. *Strong homotopy morphisms via twisting cochains.*

As with the classical twisting cochains of Brown, twisting cochains have been defined from co-operads to operads, permitting the construction of "twisted composition products" and hence "standard constructions". The bar resolution for operads, and the Koszul resolution for quadratic operads, are two examples.

We will show how the standard construction associated to any twisting cochain supports a co-ring structure, and investigate the resulting morphisms that this co-ring defines.

This is joint work with Kathryn Hess (EPFL). (Received August 28, 2009)

1052-55-230 **Andre Joyal*** (joyal.andre@uqam.ca), UQAM, Montreal, Quebec H3C 3P8, Canada. *Homotopy factorisation systems in model categories and factorisation systems in quasi-categories.* Preliminary report.

We introduce a notion of homotopy factorisation system in a general model category which extends the notion introduced by Bousfield in localisation theory. We gives many new examples in homotopy theory and in higher category theory. We also introduce a notion of factorisation system in a quasi-category. We show that the two notions coincide if the quasi-category is the Dwyer-Kan localisation of a model category. (Received August 28, 2009)

1052-55-235 **Kate Ponto*** (kponto1@nd.edu), 255 Hurley Hall, Notre Dame, IN 46556. *Relative fixed point theory.*

If $f\colon X \to X$ is a continuous map and the Lefschetz number of f is not zero, then every map homotopic to f has a fixed point. If A is a subset of X and $f(A) \subset A$, there is a refinement of the Lefschetz number, the relative Lefschetz number, that gives more information about the location of the fixed points of f. I will describe the relative Lefschetz number and its refinement, the relative Reidemeister trace, using traces in bicategories with shadows. (Received August 28, 2009)

1052-55-242 **Mark Behrens*** (mbehrens@math.mit.edu), MIT Dept of Mathematics, 77 Massachusetts Ave, Room 2-273, Cambridge, MA 02139, and **Michael J Hopkins**. *On the relationship between EO_n and TAF.*

It is well know that for $p = 2$, the $K(1)$-localization of KO is EO_1, and for $p = 2, 3$, the $K(2)$-localization of TMF is EO_2. When does the $K(n)$-localization of TAF contain a factor of EO_n? We will provide a complete answer. (Received August 28, 2009)

1052-55-249 **Ewa Tyszkowska*** (ewa.tyszkowska@math.univ.gda.pl), Institute of Mathematics, University of Gdansk, Wita Stwosza 57, 80-952 Gdansk, Poland. *Application of theory of coverings in a study of Riemann surfaces.* Preliminary report.

Every covering of a topological space X is isomorphic with one obtained from the universal covering of X and an action of the fundamental group $\pi(X, x)$ on some set T. In particular, for any homomorphism of groups $\theta : \pi(X, x) \to G$ we can make G into a $\pi(X, x)$-set and obtain G-covering of X. We study the covering of X constructed from its universal covering and the action of $\pi(X, x)$ on the set F of fixed points of G focusing our attention on the case when G is an automorphism group of a Riemann surface. We show how to determine presentation of such a group G with central automorphism δ by considering the set of fixed points of δ. Furthermore, we apply theory of coverings to study Riemann surfaces. (Received August 29, 2009)

1052-55-254 **David Blanc** and **Simona Paoli*** (sup24@psu.edu), Department of Mathematics, Penn State Altoona, 3000 Ivyside Park, Altoona, PA 16601. *Two-track categories.*

Categories enriched in groupoids, also called track categories, are well known algebraic models for the first Postnikov truncation of simplicially enriched categories. An abelian track category can be thought of as a linear extension of its homotopy category. Such an extension is classified by an element of the third Baues-Wirsching cohomology group. This description was used by Baues and collaborators to make computations in the Adams spectral sequence and to understand the structure of stable secondary homotopy operations. In this talk we extend this program one dimension up, via a Baues-Wirsching type cohomology of track categories and notions of two-track category and two-track extension. This is joint work with David Blanc. (Received August 29, 2009)

1052-55-304 **William C. Kronholm*** (wkronho1@swarthmore.edu), Department of Mathematics and Statistics, Swarthmore College, 500 College Ave., Swarthmore, PA 19081. *A Freeness Theorem for $RO(\mathbb{Z}/2)$-graded Cohomology.*

The $RO(\mathbb{Z}/2)$-graed equivariant cohomology of a point with constant $\underline{\mathbb{Z}/2}$ Mackey functor coefficients is a complicated bigraded ring with many interesting modules. However, the modules which arise as the cohomology of Rep$(\mathbb{Z}/2)$-complexes are free as modules over the cohomology of a point. As a consequence, we are able to compute the cohomology rings of projective spaces and certain Grassmann manifolds in this equivariant setting. (Received August 31, 2009)

1052-55-339 **Andrew Salch*** (asalch@math.jhu.edu). *An introduction to a topological Langlands program.* Preliminary report.

The talk will function as an introduction to the circle of ideas currently operating under the title of topological Langlands program, with some emphasis on the speaker's recent contributions. (Received September 01, 2009)

1052-55-342 **Michael Hill** (mikehill@virginia.edu), **Michael Hopkins** (mjh@math.harvard.edu) and **Douglas Ravenel*** (doug+pi@math.rochester.edu). *On the non-existence of elements of Kervaire invariant one.*

A major point of this talk will be to frame, in mathematical perspective, the recent solution of this long-standing question. An overview of the argument will also be provided, including a discussion of the Detection, Gap, and Periodicity Theorems which form the main results of the recent preprint of the same title. (Received September 01, 2009)

1052-55-343 **Michael Hill*** (mikehill@virginia.edu), **Michael Hopkins** (mjh@math.harvard.edu) and **Douglas Ravenel** (doug+pi@math.rochester.edu). *Non-existence of Kervaire invariant one elements and a homotopy fixed point spectral sequence.*

In recent work, a certain homotopy fixed point spectral sequence was used to resolve the long-standing question of the existence of Kervaire invariant one elements of high degree. The talk will focus upon the relevant equivariant E-infinity ring spectrum and on using its homotopy fixed point spectral sequence to recover information from the Adams-Novikov spectral sequence. (Received September 01, 2009)

1052-55-348 **Timothy Simin*** (tsimin@psu.edu), 345 Business Bldg., University Park, PA 16802. *Perils of Factor Formation and Predicting Returns.*

I will discuss perils of factor formation and predicting returns. (Received September 01, 2009)

57 ► Manifolds and cell complexes

1052-57-21 **Douglas J LaFountain*** (DJL2@BUFFALO.EDU), 244 Mathematics Building, University at Buffalo, Buffalo, NY 14260. *Contact structures and the uniform thickness property.*

We relate a contact topological property of fibered knot types embedded in S^3 to isotopy classes of contact structures supported by open book decompositions associated to those knots. Specifically, we study the uniform thickness property (UTP); a knot type satisfies the UTP if any embedded solid torus representing that knot thickens outward in a uniform way with respect to the standard contact structure. The UTP is of interest in part because failure of the UTP can lead to knot types which are transversally non-simple, meaning their Legendrian and transversal isotopy classes fail to be classified by classical invariants.

We prove that for the class of iterated torus knots, a knot type fails the UTP if and only if its supported contact structure is the standard one. This result extends and builds upon the work of Etnyre-Honda and

Hedden. We then conjecture ways this relationship may extend to general fibered knots, as well as to bindings of open book decompositions of general contact 3-manifolds. (Received July 05, 2009)

1052-57-85 **Milagros Izquiedo*** (miizq@mai.liu.se), Department of MAthematics, Linköpings universitet, SE-58183 Linköping, Sweden, and **Antonio F. Costa** and **Gabriel Bartolini**. *On the connectedness of the branch locus of the moduli space of Riemann Surfaces I.*

We revisited the equiparametric stratification described by Broughton (1990). We use this stratification to show that, for a infinite number of genus the branch locus contains isolated strata of dimension 1, generalizing a result of Kulkarni (1991) for isolated points. This is a joint work with Gabriel Bartolini and Antonio F. Costa (Received August 21, 2009)

1052-57-169 **Brian A Munson*** (bmunson@wellesley.edu), Department of Mathematics, Wellesley College, 106 Central Street, Wellesley, MA 02481. *Derivatives of the identity functor and generalizations of Milnor's invariants.* Preliminary report.

We synthesize work of Koschorke on link maps and work of Johnson on the derivatives of the identity functor in homotopy theory. The result can be viewed in two ways: as a generalization of Koschorke's generalization of Milnor's invariants of link maps, and as a stable range description, in terms of bordism, of the cross effects of the identity functor in homotopy theory evaluated at spheres. We also show how generalized Milnor invariants fit into the framework of a multivariable manifold calculus of functors, as developed by the author and Volić, which is itself a generalization of the single variable version due to Weiss and Goodwillie. (Received August 26, 2009)

58 ► Global analysis, analysis on manifolds

1052-58-8 **Bruce Driver**, **Len Gross** and **Laurent Saloff-Coste*** (lsc@math.cornell.edu). *Subelliptic heat kernel measures and holomorphic functions on complex Lie groups.*

Consider the Hilbert space of holomorphic functions that are square integrable with respect to the canonical Gaussian measure and the Hilbert space of sequence (a_n) with norm given by $\|(a_n)\|^2 = \sum_0^\infty |a_n|^2/n!$ A version of a celebrated result of Segal and Bargmann states that the Taylor map $f \mapsto (a_n) = (f^{(n)}(0))$ is a unitary map between these two Hilbert spaces. We will discuss extensions of this result in the context of complex Lie groups when the role of Gauss measure is played by the choice of a subelliptic heat kernel measure. (Received August 24, 2009)

1052-58-43 **Chung-I Ho** (hoxxx090@math.umn.edu), 206 Church ST. SE, Mpls, MN 55455, and **Tian-Jun Li*** (tjli@math.umn.edu), 206 Church St. SE, Mpls, MN 55455. *Luttinger surgery and Kodaira dimension.*

We show that the Luttinger surgery along Lagrangain tori in symplectic four manifolds preserves the symplectic Kodaira dimension. (Received August 06, 2009)

1052-58-223 **Daniel Grieser***, Institut für Mathematik, Carl von Ossietzky Universität Oldenburg, D-26111 Oldenburg, Germany, and **Eugenie Hunsicker**. *Pseudodifferential calculus for multiply fibred cusps.* Preliminary report.

We present a pseudodifferential calculus generalizing the 'fibred cusp calculus' introduced by Mazzeo and Melrose and generalized by Vaillant to the case of multiply fibred boundaries and corresponding cusp differential operators. In the case of two fibrations these are locally of the form $P(x, y, z, w; x^3\partial_x, x^2\partial_y, x\partial_z, \partial_w)$. Such operators arise for example as Laplace operator on locally symmetric spaces of Q-rank one. We give conditions for Fredholmness and prove boundedness results on suitable Sobolev spaces. (Received August 28, 2009)

1052-58-226 **Pierre Albin***, Massachusetts Institute of Technology, Department of Mathematics, 77 Massachusetts Avenue, Cambridge, MA 02139-4307. *The signature package on Witt spaces.* Preliminary report.

I will report on joint work with Eric Leichtnam, Rafe Mazzeo, and Paolo Piazza on understanding the signature operator on a stratified manifold with C^*-algebra coefficients. This operator comes up naturally in the study of higher signatures of stratified manifolds.

Assuming the space is Witt we inductively construct a parametrix and prove the operator is Fredholm, extending results of Cheeger to the C^*-algebra context. I will also discuss work in progress identifying the index class of this operator with the 'symmetric signature' of the Witt space. (Received August 28, 2009)

1052-58-227 **David Borthwick*** (davidb@mathcs.emory.edu), Dept. of Mathematics and Computer Science, Emory University, Atlanta, GA 30322. *Sharp upper bounds for resonance counting in perturbations of hyperbolic space.*

For a class of "black box" perturbations P of the Laplacian on H^{n+1}, we derive an explicit constant B_P such that the resonance counting function satisfies $N_P(r) \leq B_P r^{n+1} + O(r^n \log r)$. This constant is sharp in the sense that for a single spherical obstacle in H^{n+1}, we have $N_p(r) \sim B_P r^{n+1}$. (Received August 28, 2009)

1052-58-231 **Bruno Colbois** and **Emily B. Dryden***, Department of Mathematics, Bucknell University, 380 Olin Science, Lewisburg, PA 17837, and **Ahmad El Soufi**. *Upper bounds for eigenvalues of submanifolds.*

The problem of finding upper bounds for eigenvalues of the Laplace operator has a rich history, beginning with Hersch's sharp upper bound on λ_1 for the sphere. In contrast, Colbois and Dodziuk showed that for manifolds of dimension three and higher, the eigenvalues can be unbounded unless additional geometric constraints are imposed. We discuss upper bounds on eigenvalues in the setting of compact submanifolds of Euclidean space. Our bounds depend on the dimension and volume of the submanifold and the order of the eigenvalue, plus a geometric constraint which measures the "volume concentration" of the submanifold. (Received August 31, 2009)

1052-58-285 **Chris Kottke***, Massachusetts Institute of Technology, Department of Mathematics, 77 Massachusetts Avenue, Cambridge, MA 02139-4307. *An Anghel-Callias index theorem and monopole charges.* Preliminary report.

I will discuss a class of index problems that generalize a result by Callias concerning the index of a spin Dirac operator coupled to a skew-adjoint vector potential $D \otimes 1 + i \otimes \Phi$ on an odd-dimensional Euclidean space. The index turns out to depend only on the Chern character of the potential Φ over the sphere at infinity. A generalization to odd-dimensional noncompact manifolds was obtained by N. Anghel.

The first result is a K-theory formulation of an Anghel-Callias-type index theorem, permitting generalization to arbitrary self-adjoint elliptic pseudodifferential operators in the scattering calculus of Melrose, coupled to skew-adjoint potentials with appropriate invertibility and commutativity conditions at infinity. The index is entirely determined by symbolic and topological data over the manifold at infinity. I will also discuss some work in progress concerning the index of such operators when the potential Φ is not invertible at infinity, but merely has constant rank.

Finally I will mention applications to the moduli space of SU(2) monopoles over a class of manifolds, where the index of the operator gives the dimension of the moduli. (Received August 31, 2009)

1052-58-295 **Gerard Misiolek***, Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Dependence on initial data for solutions of the Euler equations.*

I will discuss some properties of the data-to-solution map for the Euler equations of hydrodynamics in lagrangian and eulerian coordinates. (Received August 31, 2009)

1052-58-313 **Boris Khesin*** (khesin@math.toronto.edu), Dept. of Mathematics, Univ. of Toronto, Toronto, ON M5S 2E4, Canada, and **Serge Tabachnikov** (tabachni@math.psu.edu), Dept. of Mathematics, Penn State University, University Park, PA 16802. *Contact complete integrability.*

Complete integrability in a symplectic setting means the existence of a Lagrangian foliation preserved by the dynamic leaf-wise. We describe complete integrability in a contact setting as the existence of a co-Legendrian foliation with an invariant transverse measure. We present an example of contact complete integrability: a Poncelet-type theorem for null geodesics on an ellipsoid in a pseudo-Euclidean space. (Received August 31, 2009)

60 ► Probability theory and stochastic processes

1052-60-30 **Radu S Tunaru*** (r.tunaru@city.ac.uk), 106 Bunhill Row, London, London EC1Y 8TZ, England. *Constructing approximation algorithms for financial calculus from weak convergence results.*

We develop a technique to generate approximation algorithms for integral calculations encountered in financial calculus. While the proofs are probabilistic, the algorithms are deterministic in nature. The methods can be applied to one-dimensional and multi-dimensional problems in a unified manner. For the one-dimensional set-up it is proved that the approximation grid is a dense set in the set of real numbers. We show how to circumvent

some problems related to the central limit theorem for multinomial distributed vectors. The technique can be applied to a wide range of problems such as pricing European options, spread options, Asian options, calculating the greek parameters and to problems related to portfolio analysis. While the methods are developed with the financial applications set in mind, they can also be applied to other areas where calculations of integrals with rough integrands or high-dimensional integration are needed." (Received July 21, 2009)

1052-60-39 **Ionut Florescu*** (ifloresc@stevens.edu), Castle Point on the Hudson, Department of Mathematical Sciences, Stevens Institute of Technology, Hoboken, NJ 07030. *Stochastic volatility models: Parameter estimation for a reduced model.* Preliminary report.

In this talk I will present a filtering method suitable for parameter estimation in a stochastic model with a hidden factor. The input consists in discrete time observations of the main process. The methodology is quite general but in this talk I will focus on the situation when the hidden factor is a continuous time Markov chain with an unknown state space. I will exemplify the procedure using financial data from March 10 - March 18, 2008 as well as temperature data collected within the state of New York (East Plateau and Central Park). (Received August 03, 2009)

1052-60-47 **Marco Avellaneda*** (avellaneda@courant.nyu.edu), 251 Mercer Street, New York, NY 10012, and **Stanley Jian Zhang**. *Path-Dependence of Leveraged ETF Returns.*

It is well-known that leveraged exchange-traded funds (LETFs) don't reproduce the corresponding multiple of index returns over extended (quarterly or annual) investment horizons. In 2008, most leveraged ETFs underperformed the corresponding static strategies. In this paper, we study this phenomenon in detail. We give an exact formula linking the return of a leveraged fund with the corresponding multiple of the return of the unleveraged fund and its realized variance. This formula is tested empirically over quarterly horizons for 56 leveraged funds (44 double-leveraged, 12 triple-leveraged) using daily prices since January 2008 or since inception, according to the fund considered. The results indicate excellent agreement between the formula and the empirical data. The study also shows that leveraged funds can be used to replicate the returns of the underlying index, provided we use a dynamic rebalancing strategy. Empirically, we find that rebalancing frequencies required to achieve this goal are moderate, on the order of one week between rebalancings. Nevertheless, this need for dynamic rebalancing leads to the conclusion that leveraged ETFs as currently designed may be unsuitable for buy-and-hold investors. (Received August 07, 2009)

1052-60-48 **Paul M Feehan*** (feehan@rci.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. *Heston stochastic volatility model and degenerate parabolic partial differential equations.*

The partial differential equations associated to the Heston or CIR stochastic processes are well-known to be degenerate parabolic. We explain how these partial differential equations are related to the linearization of the porous medium equation in mathematical physics and present explicit solutions in terms of confluent hypergeometric functions. We use these explicit solutions to show how the choice of Sobolev space for the solution impacts uniqueness and explain how the Feller parameter value determines whether boundary conditions along the degeneracy locus are required for uniqueness of the solution to European-style option pricing problems. Examination of the existence, uniqueness, and regularity questions for the analogous American-style option pricing problems is ongoing joint work with Panagiota Daskalopoulos (Columbia University). (Received August 10, 2009)

1052-60-101 **Mang Wu*** (mwu@math.uconn.edu), 196 Auditorium Road, Unit 3009, Storrs, CT 06269. *A Brownian motion on the group Diff(S^1).*

The group Diff(S^1) of orientation preserving C^∞ diffeomorphisms of S^1 has been extensively studied for a long time. One of the goals of research has been to construct and study the properties of Brownian motion with values in this group. Several authors (P. Malliavin 1999, S. Fang 2002, H. Airault and P. Malliavin 2006) have constructed Brownian motion with values in the group Homeo(S^1), the group of homeomorphisms of S^1, which is larger than the group Diff(S^1). We will present another way to construct a Brownian motion with value in the group Diff(S^1). Our method is to solve a stochastic differential equation in a sequence of Sobolev spaces. (Received August 23, 2009)

1052-60-171 **Peter M Kotelenez*** (pxk4@cwru.edu), Case Western Reserve University, Department of Mathematics, Cleveland, OH 44106. *Correlated Brownian Motions and the Depletion Effect in Colloids [Based on joint work with Marshall Leitman (CWRU) and Jay Mann (CWRU)].*

We first review the model of correlated Brownian motions as derived from deterministic dynamics (Kotelenez 1995, 2005). We then describe the qualitative behavior of correlated Brownian motions at short distances. In particular, we obtain that at short distances and for random times two correlated Brownian motions are attracted to each other (K., Leitman and Mann 2008). This attractive behavior is in good agreement with the depletion phenomena, experimentally observed in colloids (Asakura and Oosawa (1954)). (Received August 26, 2009)

1052-60-188 **M Denker*** (denker@math.psu.edu). *Multivariate Averaging.*

The talk will consider averages of form

$$\frac{1}{n^2}\sum_{1\le i,k\le n} h(X_i, X_k),$$

where h is a bivariate function, and more generally for d-variate functions. We prove a.s. and weak convergence results when $X_n,\ n \ge 1$ is a stationary ergodic process. These results depend heavily on the properties of h. The results is joint work with M. Gordin and H. Dehling. (Received August 27, 2009)

1052-60-206 **Mark Freidlin*** (mif@math.umd.edu), Mark Freidlin, Department of Mathematics, University of Maryland, College Park, MD 20742. *Perturbation Theory for Multiattractor Dynamical Systems.*

We consider long time influence of deterministic and stochastic perturbations on dynamical systems with many attractors. Our main goal is to describe some non-trival deterministic effects caused by small noise as well as stochastisity caused by pure deterministic perturbations. In particular, we consider metastability and its modifications, stochastic resonance, phantom dynamics and histerasis as the results of stochastic perturbations. We also show how deterministic perturbations of a system with instabilities and ergodic components may lead to stochasticity. (Received August 28, 2009)

1052-60-216 **Wenbo V. Li*** (wli@math.udel.edu), 501 Ewing Hall, Newark, DE 19716. *Probability Estimates for Brownian Sheets.*

We first provide an overview on fundamental roles of small value probability (estimates of rare events that positive random variables take smaller values) in the theory of stochastic processes. As two important fields of study, we consider the small deviation probability (two-sided boundary crossing)

$$\log P\Big(\sup_{\mathbf{t}\in[0,T]^d} |W(\mathbf{t})| \le 1\Big), \quad \text{as} \quad T\to\infty$$

and the lower tail probability (one-sided boundary crossing)

$$\log P\Big(\sup_{\mathbf{t}\in[0,T]^d} W(\mathbf{t}) \le 1\Big), \quad \text{as} \quad T\to\infty$$

for Gaussian random fields. Here we focus on the illustrating example that $W(\mathbf{t})$ is a Brownian sheet (tensored Brownian motion or space-time noises) used in stochastic partial differential equations. (Received August 28, 2009)

1052-60-261 **Stanislav A Molchanov*** (smolchan@uncc.edu), Department of Mathematics and Statistics, UNCC, Charlotte, NC 28270. *Limit theorems for the reaction-diffusuion equations woth the applications to the ecology.*

We consider two classes of the branching processes with the diffusion (or similar contact processes). The first one represents the mathematical model of the plankton(supercritical population of the one-cell species with mitosis). Mathematically, we have to study in this case the FKPP(Fisher-Kolmogorov-Petrovskii-Piskunov)type differential-fuctional equations for the Laplace transform of space-time-masses particles distribution independent of the local density. We have analyzed the analytic properties of these equations. The second class of the models contains the critical reaction-diffusion processes with the non-trivial limiting distribution, stationary in space and time. We will formulate several qualitative results about the statistics of the limiting particles field. (Received August 30, 2009) (Received August 30, 2009)

1052-60-265 **Michael B Woodroofe*** (michaelw@umich.edu), Statistics Department, University of MIchigan, Ann Arbor, MI 48109, and **Dalibor Volny** and **Ou Zhao**. *A Central Limit theorem for Partial Sums of a Reversible Processes with Non-linear Growth of Variance.*

Kipnis and Varadhan showed that for an additive functional, S_n say, of a reversible Markov chain the condition $E(S_n^2)/n \to \kappa \in (0,\infty)$ implies the convergence of the conditional distribution of $S_n/\sqrt{E(S_n^2)}$, given the starting

point, to the standard normal distribution. We revisit this question under the weaker condition, $E(S_n^2) = n\ell(n)$, where ℓ is a slowly varying function. It is shown by example that the conditional distribution of $S_n/\sqrt{E(S_n^2)}$ need not converge to the standard normal distribution in this case; and sufficient conditions for convergence to a (possibly non-standard) normal distribution are developed. (Received August 30, 2009)

1052-60-268 **Maria Angelica Cueto** and **Jason R Morton***, Department of Mathematics, McAllister Building, University Park, PA 16802, and **Bernd Sturmfels**. *Geometry of the Restricted Boltzmann Machine.*

The restricted Boltzmann machine is a graphical model for binary random variables. Based on a complete bipartite graph separating hidden and observed variables, it is the binary analog to the factor analysis model. We study this graphical model from the perspectives of algebraic statistics and tropical geometry, starting with the observation that its Zariski closure is a Hadamard power of the first secant variety of the Segre variety of projective lines. We derive a dimension formula for the tropicalized model, and we use it to show that the restricted Boltzmann machine is identifiable in many cases. Our methods include coding theory and geometry of linear threshold functions. (Received August 30, 2009)

1052-60-270 **Peter J. Thomas*** (pjthomas@case.edu), 10900 Euclid Avenue, Cleveland, OH 44106. *On the periodically forced Ornstein Uhlenbeck process with reset.* Preliminary report.

We study a hybrid stochastic process combining an Ornstein Uhlenbeck process (OUP) with deterministic reset upon reaching a threshold. Between resets, the OUP obeys a stochastic differential equation with periodically varying drift coefficient. Such a system arises in a neuroscience context as a model for a nerve cell driven by a periodically varying transmembrane current, the "leaky integrate and fire" (LIF) model with periodic forcing and additive noise. In the absence of noise the periodically forced LIF model falls in the general class of deterministic circle maps, which can show a rich variety of asymptotic dynamical behaviors. In the presence of noise, however, numerical results suggest that the distribution of reset times relative to the periodic drive converges to a unique stationary distribution independent of initial conditions. To date there are few analytical results available in this direction. We derive a condition on the first passage time distribution for the periodically forced OU process that is necessary and sufficient to guarantee convergence of the distribution of reset times relative to the forcing. We conjecture that this condition is met by the LIF model in a certain parameter regime (suprathreshold injected currents with weak periodic modulation). (Received August 30, 2009)

1052-60-274 **Magda Peligrad***, Department of Mathematical Sciences, POBox 210025, Cincinnati, OH 45221-0025, and **Wei-Biao Wu**. *Central Limit Theorem for Fourier Transforms of Stationary Processes.*

We consider asymptotic behavior of Fourier transforms of stationary ergodic sequences with finite second moments. We establish the central limit theorem (CLT) for almost all frequencies and also the annealed CLT. The theorems hold for all regular sequences. Our results shed new light on the foundation of spectral analysis and on the asymptotic distribution of periodogram, and it provides a nice blend of harmonic analysis, theory of stationary processes and theory of martingales. (Received August 30, 2009)

1052-60-293 **Jinho Baik*** (baik@umich.edu), 530 Church Street, Ann Arbor, MI 48103. *Asymptotics of Tracy-Widom distribution functions.*

Tracy-Widom distribution functions describe certain universal fluctuations appearing in random matrix theory and other probability settings. These functions are expressed in terms of Painleve II equation, which is an integrable nonlinear ODE. We discuss the asymptotics of the Tracy-Widom distribution functions. (Received August 31, 2009)

1052-60-321 **Leonid Koralov*** (koralov@math.umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742. *Deterministic and stochastic perturbations of Hamiltonian systems.*

I'm going to discuss our joint work with D. Dolgopyat and M. Freidlin where we study deterministic and stochastic perturbations of Hamiltonian systems on a two-dimensional torus. Even in the case of purely deterministic perturbations, the long-time behavior of such systems can be stochastic, in a certain sense. The stochasticity is caused by the instabilities near the saddle point of the non-perturbed system as well as by the ergodic component of the Hamiltonian system on the torus. (Received August 31, 2009)

1052-60-325 **Tai Melcher*** (melcher@virginia.edu), University of Virginia, Department of Mathematics, Charlottesville, VA 22903. *Heat kernel analysis for semi-infinite Lie groups.*

We'll talk about heat kernel measure on a class of infinite dimensional Lie groups based on an abstract Wiener space. Heat kernel measure here will be defined as the law of a Brownian motion, constructed as the solution to a stochastic differential equation. We'll discuss results for the heat kernel measure, including a Cameron-Martin type quasi-invariance theorem and a logarithmic Sobolev inequality, as well as some potential applications. (Received August 31, 2009)

1052-60-335 **andrew clark*** (andrew.clark@thomsonreuters.com), 8034 dry creek circle, niwot, CO 80503. *The Use of Random Dynamical Systems in Computational Agent-Based Modeling.*

In this paper the author will show how a common continuous time description of stock prices – the Ornstein-Uhlenbeck process – can be modified so it exhibits the bifurcations, chaotic activity and other properties seen in stock prices when modeled via discrete time agent-based systems.

In particular this paper will use infinitesimal generators (IG) of diffusion processes to show that the onset of the initial observed bifurcation comes about from the addition of additive noise to the Ornstein-Uhlenbeck process. This additive noise is shown to be caused by the increasing number of non-fundamentalist traders in a market.

The different types of bifurcations seen in agent-based models are shown to be related to the type of noise added. And the appearance of chaos is hypothesized to arise due to the type of noise in the system.

Multiplicative noise processes are shown to give rise a mix of risk-aversion parameters, an important feature in both real world financial activity and agent-based modeling.

The paper will also recommend ways its various conjectures can be proven (or disproven) empirically. (Received September 01, 2009)

1052-60-345 **Wojbor A. Woyczynski*** (waw@case.edu), Department of Statistics, Case Western Reserve University, Cleveland, OH 44106. *Nonlinear nonlocal evolution equations driven by Levy diffusions.*

We consider nonlinear nonlocal evolution equations driven by Levy diffusions. Competition between the strength of the nonlocal diffusive terms and the nonlinear terms is studied. Both quasilinear and strongly nonlinear cases are considered. Propagation of chaos results and existence of the densities for "weak" solutions of such equations are discussed. (Received September 01, 2009)

1052-60-349 **Iddo Ben Ari*** (benari@math.uconn.edu), 196 Auditorium Rd Unit 3009, Storrs, CT 06269. *Perturbations to Perron Eigenvalue, Additive Functionals and Limit Theorems.*

We present an elementary probabilistic approach to study perturbations to the Perron eigenvalue for certain operators related to generators of Markov processes. From the probabilistic point of view, the method provides a very simple proof of central limit theorems for (the joint) distribution of additive functionals of some Markov processes. An example is the central limit theorem for diffusions with periodic coefficients, originally due to Bhattacharya. From the analytic point of view, the method provides a unified approach to several known results, mostly from the theory of (entry-wise) non-negative irreducible matrices. Work in progress. (Received September 01, 2009)

1052-60-364 **Rabi N Bhattacharya*** (rabi@math.arizona.edu), Department of Mathematics, The University of Arizona, 617 N Santa Rita Avenue, Tucson, AZ 85721. *Iteration of IID Monotone Maps.*

We explore conditions for the existence of steady states for Markov processes generated by iterations of IID monotone maps on Euclidean spaces. Also studied are speeds of convergence to the steady state in appropriate metrics. (Received September 02, 2009)

70 ► Mechanics of particles and systems

1052-70-220 **Cameron Lynch** (celynch2@ncsu.edu) and **Dmitry Zenkov*** (dvzenkov@ncsu.edu). *Stability of Relative Equilibria of Nonholonomic Integrators with Semidirect Symmetry.*

Nonholonomic integrators are discrete-time analogues of mechanical systems with velocity constraints. Conditions for partial asymptotic stability of relative equilibria of nonholonomic integrators with semidirect symmetry are established. For integrators obtained by discretization of continuous-time dynamics, stability conditions are compared to those of the associated continuous-time systems. The results are illustrated with a stability analysis of the discrete roller racer. (Received August 28, 2009)

1052-70-229 **Oscar E Fernandez*** (oscarum@umich.edu), 1300 E. Lafayette St., Apt. 308, Detroit, MI 48207, and **Anthony M Bloch**. *Explicitly Solvable Nonholonomic Systems.*

In this talk we discuss various nonholonomic mechanical systems whose solutions are explicitly obtainable. For a certain class, called conditionally variational, we relate the existence of an invariant measure density for the system to the existence of explicit solutions, and further consider when such systems may be mapped into a Hamiltonian system subject to certain initial conditions. We also discuss specific systems which do not possess invariant measures but are nonetheless integrable by quadratures. (Received August 28, 2009)

1052-70-311 **Tomoki Ohsawa*** (ohsawa@umich.edu), 530 Church St, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109, and **Anthony Michael Bloch** (abloch@umich.edu), 530 Church St, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Nonholonomic Hamilton–Jacobi Equation and Integrability.*

We discuss an extension of the Hamilton–Jacobi theory to nonholonomic mechanics with a particular interest in its application to exactly integrating the equations of motion. We give a nonholonomic version of the geometric Hamilton–Jacobi theorem with a geometric interpretation of the conditions arising from nonholonomic constraints. In particular, we build on previous works on nonholonomic Hamilton–Jacobi theory so that the conventional method of separation of variables applies to integrating equations of motion of some nonholonomic mechanical systems. We also show a way to apply our result to a system to which separation of variables does not apply. (Received August 31, 2009)

76 ► Fluid mechanics

1052-76-79 **John D. Carter*** (carterj1@seattleu.edu), 901 12th Ave, Seattle University, Mathematics Department, Seattle, WA 98122, and **Rodrigo Cienfuegos** (racienfu@ing.puc.cl), Depto. Ingenieria Hidraulica y Ambiental, Pontificia Universidad Catolica de Chile, Av. Vincuna Mackenna 4860-Macul, Santiago, Chile. *Periodic solutions of the Serre equations.*

The Serre equations are a pair of strongly nonlinear, weakly dispersive, Boussinesq-type partial differential equations. They model the evolution of the surface elevation and the depth-averaged horizontal velocity of an inviscid, irrotational, incompressible fluid on a horizontal bottom. We present a three-parameter family of periodic solutions of the Serre equations and examine their linear stability. We establish that waves with sufficiently small amplitude/steepness are stable while waves with sufficiently large amplitude/steepness are unstable. (Received August 20, 2009)

1052-76-127 **Philippe Guyenne*** (guyenne@math.udel.edu), Department of Mathematical Sciences, 501 Ewing Hall, University of Delaware, Newark, DE 19716. *Hamiltonian formulation for water waves on variable depth.*

We present a Hamiltonian formulation for water waves over a variable bottom based on potential flow theory. The problem is reduced to a lower-dimensional one involving boundary variables alone. This is accomplished by introducing the Dirichlet-Neumann operator which expresses the normal fluid velocity at the free surface in terms of the velocity potential there, and in terms of the surface and bottom variations. A Taylor series expansion of the Dirichlet-Neumann operator in homogeneous powers of the surface and bottom variations is proposed. This formulation has implications for the convenience of asymptotic calculations and direct numerical simulations of the Euler equations for water waves. We derive asymptotic models for long waves over a random bottom topography, and develop an efficient and accurate numerical method based on the fast Fourier transform to solve the Euler equations. Numerical applications will be presented. This is joint work with A. de Bouard, W. Craig, O. Diaz-Espinosa, D. P. Nicholls and C. Sulem. (Received August 24, 2009)

1052-76-140 **Benjamin Akers*** (akers@math.uic.edu). *Applications of perturbation series.*

Applications of perturbation series are presented, with historical perspective. Pertubation methods for roots of polynomials are compared with similar methods for water wave problems. The role of resonances in perturbation series is explored. Modern boundary perturbation methods for solving the water wave problem are motivated. (Received August 25, 2009)

1052-76-159 **Jeongwhan Choi*** (jchoi@korea.ac.kr), Sungbukgu Anamdong 5-1, Korea University, Department of Mathematics, Seoul, 136-701, South Korea, and **Shu-Ming Sun**, **Sung-Im Whang**, **Dal-Soo Lee** and **Sang-Ho Oh**. *Supercritical surface gravity waves generated by a positive forcing-theory and experiments.*

Forced surface waves on an incompressible, inviscid fluid in a two-dimensional channel with a small bump are studied. Near a nondimensional wave speed, called Foude number, a time-dependent force KdV equation (FKDV) is derived. The solutions of FKdV are studied both theoritically and numerically. Moreover, experiments are carried on corresponding to numerical solutions of FKdV. (Received August 26, 2009)

1052-76-175 **Vladimir I. Zakharov*** (zakharov@math.arizona.edu). *Free Surface Hydrodynamics in Conformal Variables: New Results.*

We study the potential flow of a deep 2-D fluid with free surface in the presence of gravity. The fluid domain is conformally mapped onto the lower half-plane of the complex variable $w = u + iv$. If Φ is the hydrodynamic potential, in Dyachenko variables $R(w,t) = 1/z'$, $V(w;t) = i\partial\Phi/\partial z$, the Euler equations take an unusual but very elegant form. These equations are suitable both for analytical and numerical study. Analytical in the lower half-plane functions $R(w,t)$ and $V(w,t)$ have moving singularities in the upper half-plane. Zeros of $R(w,t)$ in the upper half-plane are also important. We are interested in the "robust" singularities only, which preserve their type with time. We will formulate a variety of rigorous analytical results about the nature of these singularities and their relationship to constants of the motion.

In spite of the progress, central questions of the theory are still unanswered: (A) Can singularity of the surface occur in a framework of exact equations in a finite time? (B) Are Euler equations for potential flow of deep fluid with free surface an integrable system?

The most plausible answer on both questions is positive. (Received August 26, 2009)

1052-76-189 **T. R. Akylas*** (trakylas@mit.edu) and **Yeunwoo Cho**. *Resonantly Forced Gravity–Capillary Lumps on Deep Water.*

A theoretical study is made of the wave disturbance generated by a locally confined external pressure on the surface of deep water moving with speed V near the minimum gravity–capillary phase speed, c_{min}. According to linear inviscid theory, the response when V equals c_{min} is unbounded, and the interplay of nonlinear and damping effects is crucial close to this resonance. The analysis is based on an approximate model that combines the linear dispersion relation in the vicinity of c_{min} with quadratic nonlinearity as well as viscous damping. For V well below c_{min}, the transient response from rest approaches the small-amplitude steady state predicted by linear theory, but nonlinear effects come into play at a certain forcing speed, $c_{crit} < c_{min}$, that depends on the strength of the forcing. Past this critical speed, the response jumps to a finite-amplitude state comprising a gravity–capillary lump on the downstream side of the excitation. A time periodic state is also possible for a range of forcing speeds slightly below c_{min}. This latter state involves periodic shedding of lumps that get damped quickly as they propagate downstream. The predictions show good agreement with experiments conducted by J. H. Duncan and J. D. Diorio at Maryland. (Received August 27, 2009)

1052-76-195 **J. H. Duncan*** (duncan@umd.edu), Department of Mechanical Engineering, University of Maryland, College Park, MD 20815, and **J. D. Diorio**, Department of Mechanical Engineering, University of Maryland, College Park, MD 20815. *An Experimental Investigation of the Wave Pattern Generated by a Moving Pressure Source: Solitary Capillary-Gravity Waves.*

The wave pattern generated by a small pressure source moving across a water surface at speeds less than the minimum phase speed for linear gravity-capillary waves (c_{min} = 23 cm/s) was investigated experimentally. The resulting wave pattern was measured using cinematic shadowgraph and laser-induced fluorescence (LIF) techniques. The results show the existence of several distinct behavioral states. At low speeds, no wave behavior is observed and the pattern resembles the symmetric stationary condition. However, at a critical speed, but still below c_{min}, the pattern undergoes a sudden transition to an asymmetric state with a stationary, 2D solitary wave that forms behind the pressure source. This solitary wave is elongated in the cross-stream relative to the stream-wise direction and resembles gravity-capillary "lumps" observed in previous numerical calculations. As the translation speed approaches c_{min}, another time-dependent behavior is observed characterized by periodic "shedding" from a V-shaped solitary wave pattern. This work will be discussed in conjunction with the recent numerical calculations of T. Akylas and his research group. (Received August 27, 2009)

1052-76-214 **Katie L. Oliveras*** (katieoliveras@gmail.com) and **Bernard Deconinck** (bernard@amath.washington.edu). *Stability of stationary periodic solutions of the Euler equations.*

Euler's equations describe the dynamics of gravity waves on the surface of an ideal fluid with arbitrary depth. In this talk, We discuss the stability of one-dimensional traveling wave solutions to the full set of Euler equations via a generalization of a nonlocal formulation of the water wave problem due to Ablowitz, Fokas and Musslimani. Transforming the non-local formulation into a traveling coordinate frame, we obtain a new equation for the stationary solutions in the traveling reference frame as a single equation for the surface in physical coordinates. Using this new equation, we develop a numerical scheme to determine traveling wave solutions by exploiting the bifurcation structure of the non-trivial periodic solutions. Finally, we determine numerically the spectral stability for the periodic traveling wave solution by extending Fourier-Floquet analysis to apply to the non-local problem. We generate the full spectra for various traveling wave solutions. In addition to recovering past well-known results such as the Benjamin-Feir instability for deep water, We confirm the presence of high-frequency instabilities for shallow water. (Received August 28, 2009)

1052-76-255 **Harry Yeh*** (harry@engr.orst.edu), School of Civil and Construction Engineering, Oregon State University, 220 Owen Hall, Corvallis, OR 97331-3212. *Mach Reflection of a Solitary Wave Revisited.*

Melville (1977) conducted laboratory experiments to validate Miles' model (1977) for the Mach reflection of a solitary wave. The Mach stem amplitude and growth angle plus the reflected wave amplitude were measured. The results disagreed with Miles' predictions, although the formation of Mach stems were observed. The maximum amplification at the wall that Melville measured was barely 2, whereas the theory predicts the amplification of 4. We revisited the problem using a precision wave tank specifically designed for long waves. To examine temporal and spatial variations of water-surface profiles, the LIF (Laser Induced Fluorescent) technique was implemented. Unlike experiments for capillary waves or breaking waves, measurements of long waves require much higher resolution in the vertical than in the horizontal. Thus, we obtained three LIF surface profiles of a 27 cm segment and made a time-synchronized montage of the three-segment profiles: the resulting montage covers the 80 cm span in the transect perpendicular to the wall. Our measurements yield accurate anatomy of the Mach reflection to identify its characteristics. We will discuss discrepancies between the laboratory observations and the theoretical predictions, as well as the numerical predictions (Tanaka, 1993). (Received August 29, 2009)

1052-76-264 **Robert L Pego*** (rpego@cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213, and **Shu-Ming Sun**. *On spectral stability for solitary water waves.* Preliminary report.

We will discuss a draft proof of spectral stability of small solitary waves for the 2D Euler equations for water of finite depth without surface tension. (Received August 30, 2009)

1052-76-275 **Volker W Elling*** (velling@umich.edu), 2200 Fuller Ct. Apt. 1209B, Ann Arbor, MI 48105. *Supersonic and transonic shock reflection.*

We give a survey of recent progress on shock reflection. We discuss several subtle problems: the transition from regular to Mach reflection, the question of weak versus strong reflected shocks, and the proper posing of boundary/far-field conditions for uniqueness and existence discussions. We present techniques for rigorous construction or non-existence proofs of particular flows. (Received August 30, 2009)

1052-76-284 **Jon Wilkening*** (wilken@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720, and **David Ambrose**. *Computation of time-periodic solutions of the vortex sheet with surface tension.*

I will describe a spectrally accurate numerical method for finding non-trivial time-periodic solutions of nonlinear PDE. We minimize a functional (of the initial condition and the period) that is positive unless the solution is periodic, in which case it is zero. We use adjoint methods (originally developed for shape optimization) to compute the gradient of this functional with respect to the initial condition. We then minimize the functional using a quasi-Newton gradient descent method, BFGS.

We use our method to compute families of time-periodic solutions of the vortex sheet with surface tension separating two immiscible, irrotational ideal fluids. As a starting guess, we use analytically determined time-periodic solutions of the linearized problem about a flat interface with constant vortex sheet strength. We then use our numerical method to continue these solutions beyond the realm of linear theory to explore the topology and bifurcation structure of a two-parameter manifold of symmetric breathing solutions. (Received August 31, 2009)

1052-76-317 **Peter Constantin** and **Gautam Iyer*** (gautam@math.cmu.edu), Dept. of Math. Sci, Room 6113, Wean Hall, Carnegie Mellon University, Pittsburgh, PA, 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. Time permitting I will discuss the analogue in the presence of spatial boundaries. (Received August 31, 2009)

1052-76-334 **Pam Cook*** (cook@math.udel.edu), Dept Math Sciences, University of Delaware, Newark, DE 19716, and **Michael Cromer**, **Careth McKinley** and **Lin Zhou**. *Steady and transient flows of entangled fluids.*

Highly entangled systems such as wormlike micellar (surfactant) fluids exhibit spatially inhomogeneous shear-banding structures under deformation. Rheological equations of state capable of describing these fluids include a new model, the VCM model. This model specifically incorporates the rate-dependent breakage and reforming of the wormy micelles. The resulting coupled system of nonlinear partial differential equations describes the number density and stresses of each of the micellar species in addition to other stress-relaxation mechanisms. In shear flow the model predicts the localized shear-bands where the macroscopic field varies rapidly and the fluid microstructure is highly aligned. In filament stretching experiments elongating filaments suddenly rupture at high strain rates, a failure mechanism not related to the visco-capillary thinning observed in Newtonian fluids but due to a micellar failure event. This behavior is also captured by the model. The use of numerics and asymptotics to interrogate these models in transient and oscillatory shear, elongation, and pressure-driven flow in microfuidic devices will be described. Discussion of the use of related models to investigate other soft (biological materials) will be presented. (Received September 01, 2009)

1052-76-352 **Allen M. Tesdall*** (atesdall@gauss.math.csi.cuny.edu), 324 Pearl St. #4-D, New York, NY 10038. *High-resolution solutions for shock formation in transonic flow.*

Shock waves that form as the result of an interaction of a rarefaction wave with a sonic line are a generic feature of solutions of transonic flow problems. Examples include (i) the sequence of shocks that occur in Guderley Mach reflection, (ii) the shock that forms at the rear of a supersonic bubble on an airfoil in a slightly subsonic free stream flow, and (iii) the shock wave that forms when a supersonic flow hits the corner of an expanding duct. Whether the shock forms on the sonic line or inside the supersonic region appears to be an open question. We present high resolution numerical solutions of problems for the steady and unsteady transonic small disturbance equations that describe examples (ii) and (iii) above. Our solutions show that the shock forms strictly inside the supersonic region. These results appear to be the first that clearly show the supersonic nature of the shock formation point. (Received September 01, 2009)

1052-76-365 **Daniel Spirn*** (spirn@math.umn.edu), 206 Church St. S.E., MINNEAPOLIS, MN 55455, and **J. Douglas Wright**. *Strichartz estimates for the gravity capillary equations.*

Using rigorous oscillatory integral estimates, we prove dispersive decay estimates on the linearized equations governing gravity capillary waves. For the 3+1 dimensional problem we show that the waves decay as $t^{-5/6}$, and from here we establish a set of Strichartz estimates in appropriate Besov spaces. Finally, we show there is a slowest moving wave associated to a balance between surface tension and gravity. (Received September 02, 2009)

81 ► Quantum theory

1052-81-82 **Robert Seiringer*** (rseiring@princeton.edu), Department of Physics, Princeton University, Princeton, NJ 08542. *Hardy-Lieb-Thirring inequalities and relativistic stability of matter.*

Lieb-Thirring inequalities are bounds on power sums of the modulus of negative eigenvalues of Schroedinger-type operators. We present some recent generalizations of such bounds, allowing for the subtraction of a Hardy-term;

i.e., we show that the Lieb-Thirring inequalities remain true when the critical Hardy weight is subtracted from the Laplace operator. This result has some interesting applications concerning the stability of relativistic matter interacting with electromagnetic fields, and allows for the extension of previous results to all nuclear charges less than the critical one. This is joint work with E. Lieb and R. Frank. (Received August 20, 2009)

1052-81-136 **Christian Hainzl*** (hainzl@math.uab.edu). *Dynamical collapse of massive stars in the Hartee-Fock-approximation.*

I will talk about the finite-time blow-up for relativistic Hartree-Fock equations with radial initial data and negative energy. The corresponding Hartree-Fock equations for gravitating particles serve as approximation for the dynamical evolution of massive stars such as white dwarfs. (Received August 25, 2009)

1052-81-147 **Roderich Tumulka*** (tumulka@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Rd, Piscataway, NJ 08854. *Relativistic Realistic Quantum Theory: On a Recent Model Reconciling Quantum Nonlocality and Relativity.*

Realistic quantum theories are theories that describe an objective, microscopic reality that exists independently of observers and entail the same predictions for observations as orthodox quantum theory, at least within the accuracy of presently doable experiments. Non-relativistic realistic quantum theories, such as the Ghirardi-Rimini-Weber (GRW) collapse theory and Bohmian mechanics, have long been known, but the extension to the relativistic case presents a difficulty because of the quantum nonlocality discovered in 1964 by John Bell. In my talk I will discuss a fully relativistic version of the GRW theory for n entangled particles that I have developed recently, and that resolves this difficulty. (Received August 25, 2009)

82 ► Statistical mechanics, structure of matter

1052-82-54 **Yves Elskens*** (yves.elskens@univ-provence.fr), UMR 6633, eq. turbulence plasma, case 321, campus Saint-Jerome, Marseille cedex 13, 13397, and **Michael K-H Kiessling** (miki@math.rutgers.edu) and **Valeria Ricci** (ricci@unipa.it). *Vlasov limit for particles coupled with a wave field.*

We report on progress towards deriving the relativistic Vlasov-Maxwell system from the dynamics of $N \to \infty$ charged particles coupled with the electromagnetic fields, accomplished for a toymodel. The electromagnetic vector potential A^μ is replaced with a scalar field ϕ, the interaction regularized with a smooth kernel with compact support, and the coupling switched from repulsive to attractive. This 'gravity-like' toy dynamics is generated by a Hamiltonian which is bounded below, and globally well-posed.

The empirical N-particle measures under this N-body+field dynamics are weak solutions to the Vlasov equation which conserve mass, energy, momentum and angular momentum. The Kantorovich-Rubinstein distance between solutions does not grow faster than exponentially in time from its initial value.

If the (limit) initial measure is absolutely continuous with density $f_0 \in L^p$, then for all time t the (limit) solution $f_t \in L^p$ and Casimir functionals are invariant. (Received August 26, 2009)

1052-82-61 **Pavel Bleher*** (bleher@math.iupui.edu), Department of Mathematical Sciences, IUPUI, 402 N. Blackford Street, Indianapolis, IN 46202. *Exact solution of the six-vertex model with domain wall boundary conditions. Antiferroelectric phase.*

This is a joint work of the author with Karl Liechty, and it is a continuation of the works of Bleher–Fokin and Bleher–Liechty, in which the large N asymptotics is obtained for the partition function Z_N of the six-vertex model with domain wall boundary conditions in the disordered phase region, the ferroelectric phase region, and on the critical line between these two regions. In the present paper we obtain the large N asymptotics of Z_N in the antiferroelectric phase region, with the weights $a = \sinh(\gamma - t)$, $b = \sinh(\gamma + t)$, $c = \sinh(2\gamma)$, $|t| < \gamma$. We prove that the partition function has the asymptotic behavior $Z_N = C\theta_4(N\omega)F^{N^2}[1 + O(N^{-1})]$ as $N \to \infty$, where $C > 0$ is a constant,

$$F = \frac{\pi \sinh(\gamma - t)\sinh(\gamma + t)\theta_1'(0)}{2\gamma\theta_1(\omega)}, \qquad \omega = \frac{\pi}{2}\left(1 + \frac{t}{\gamma}\right),$$

and $\theta_k(x)$ are the Jacobi theta-functions with the elliptic nome $q = e^{-\pi^2/(2\gamma)}$. The proof is based on the Riemann-Hilbert approach to the underlying discrete orthogonal polynomials. (Received August 17, 2009)

1052-82-123 **Wolfgang Bauer*** (bauer@pa.msu.edu), Michigan State University, Department of Physics and Astronomy, 4208 BPS, East Lansing, MI 48824, and **Kerstin Paech** and **Scott Pratt**. *Does Zipf's Law hold in Nuclear Fragmentation?*

If atomic nuclei are bombarded with projectiles at relativistic energies, they disintegrate into smaller fragments. The distribution of fragment masses and other observables lets us conclude that these fragmenting nuclei undergo a phase transition in the process. We will present results on the universality class of this phase transition, with particular emphasis on the finite size modifications. The question if the fragment multiplicity distributions confirm to Zipf's Law will be answered. (Received August 24, 2009)

83 ► Relativity and gravitational theory

1052-83-6 **Michael K.-H. Kiessling*** (miki@math.rutgers.edu), Rutgers University, Department of Mathematics, 110 Frelinghuysen Rd., Piscataway, NJ 08854. *N-body problems in relativity.*

This talk surveys the state of affairs in the study of N body problems in relativity for a mathematical audience of non-specialists. Special and general relativistic problems from the classical and quantum realms of physics are covered. (Received August 27, 2009)

1052-83-151 **Luis Lehner*** (llehner@perimeterinstitute.ca), 31 Caroline St, N., Waterloo, Ontario N2L 2Y5, Canada. *Binary black hole as engines of both gravitational and electromagnetic emissions.*

Black holes are among the most extreme gravitational objects known. Binary systems composed of black holes are not only copious emitters of gravitational radiation but also can affect nearby fields (describing matter or electromagnetic energy) and induce different emission mechanisms. The current talk discusses some of these possibilities and present results from simulations incorporating general relativity, magnetohydrodynamics and electrodynamics. (Received August 25, 2009)

1052-83-153 **Lydia R Bieri*** (lbieri@math.harvard.edu), Harvard University, Department of Mathematics, Science Center, 1 Oxford Street, Cambridge, MA 02138. *Null Asymptotics of Solutions of the Einstein-Maxwell Equations in General Relativity and Gravitational Radiation.*

A major goal of mathematical General Relativity (GR) and astrophysics is to precisely describe and finally observe gravitational radiation, one of the predictions of GR. In order to do so, one has to study the null asymptotical limits of the spacetimes for typical sources. Among the latter we find binary neutron stars and binary black hole mergers. In these processes typically mass and momenta are radiated away in form of gravitational waves. D. Christodoulou showed that every gravitational-wave burst has a nonlinear memory. The insights of this work are based on the precise description of null infinity obtained by D. Christodoulou and S. Klainerman. Among the many pioneering results they derived the Bondi mass loss formula. This is all in the regime of the Einstein vacuum equations. N. Zipser studied the Einstein-Maxwell (EM) equations and computed limits along the lines of Christodoulou and Klainerman for this case. She derived a Bondi mass formula in the EM case. In this talk, we discuss the null asymptotics for spacetimes solving the EM equations, compute the radiated energy and derive limits at null infinity and compare them with the Einstein vacuum (EV) case. Here, we rely on the methods introduced in the works of Christodoulou and Klainerman, Bieri, Zipser. (Received August 25, 2009)

1052-83-183 **Brent O Young*** (bojy@math.rutgers.edu), Department of Mathematics, Rutgers University, Hill Center for the Mathematical Sciences, 110 Frelinghuysen Rd., Piscataway, NJ 08854-8019. *Derivation of the relativistic Vlasov-Poisson model with attractive coupling from N-body models.* Preliminary report.

The relativistic Vlasov-Poisson (rVP) model with attractive coupling is derived from a toy model of N classical point particles moving at relativistic speeds and interacting with (regularized) Newtonian gravity. The proof is a straightforward adaptation of the work of Neunzert and of Braun-Hepp for non-relativistic Vlasov models. Rather unconventional is a recent surmise by Kiessling and Tahvildar-Zadeh that rVP can be derived from a neutral two-species plasma model. The strategy for this derivation is explained and the first rigorous estimates are presented. (Received August 27, 2009)

1052-83-192 **Luc Nguyen*** (Luc.Nguyen@maths.ox.ac.uk), Mathmatical Institute, University of Oxford, 24-29 St Giles', Oxford, OX1 5LB, England. *Regularity of harmonic maps with prescribed rate of singularity and axially symmetric stationary electro-vacuum spacetimes.*

According to the Ernst-Geroch reduction, to each axially symmetric stationary vacuum/electro-vacuum spacetime, one can associate an axially symmetric harmonic map with singular boundary behavior. This idea has been exploited in the literature to construct asymptotically flat, axially symmetric stationary spacetimes with disconnected horizons, i.e. having multiple black holes. This family of spacetimes is uniquely parameterized by the "masses", the "momenta", the "charges" of the black holes and the "distances" between them. I'll discuss the regularity of the corresponding reduced harmonic maps and its implication on the regularity of those spacetimes. (Received August 27, 2009)

1052-83-277 **Shabnam Beheshti*** (beheshti@math.rutgers.edu), Department of Mathematics - Hill Center, 110 Frelinghuysen Rd., Rutgers University, Piscataway, NJ 08854-8019, and **Floyd L Williams**. *On the Wave Equation of a Charged, Massive Kerr Black Hole.* Preliminary report.

We present the general solution of an ODE arising in the works of Goncharov and Firsova on topologically inequivalent configurations (TICs) of massive complex scalar fields on Kerr black holes; an orthogonality conjecture is also proved as a result of transforming the equation to Sturm-Liouville form. The solutions generalise, in some sense, the classical monopole spherical harmonics (Wu & Yang, '76) studied in the massless case. (Received August 30, 2009)

1052-83-289 **A. Shadi Tahvildar-Zadeh*** (shadi@math.rutgers.edu), Department of Mathematics, Rutgers University, Piscataway, NJ 08854. *General-relativistic Nonlinear Electrodynamics.* Preliminary report.

We review the existence of families of exact symmetric solutions of the Einstein-Maxwell system of gravito-electrodynamics with arbitrary constitutive laws, and present some results concerning the nature of singularities present in them, and the propagation of scalar waves on these backgrounds. (Received August 31, 2009)

1052-83-291 **Manuel Tiglio*** (tiglio@umd.edu), CSCAMM, 4129 CSIC Bldg #406, Paint Branch Drive, University of Maryland, College Park, MD 20742-2389. *Binary black hole collisions: techniques, status and prospects.*

The two body problem in General Relativity corresponds to the description of the collision of two black holes. The problem, consisting on a rather large set of elliptic and hyperbolic quasi-linear partial differential equations on non-trivial geometries, is challenging from a mathematical, numerical and scientific computing perspective. At the same time it is a problem of great physical interest since it is expected to be one of the main sources of gravitational waves to be measured by a network of earth-based interferometer detectors already collecting data. These detectors aim at verifying Einstein's theory in the strong field regime for the very first time, and open a new window to the universe. Advanced techniques in all these fronts had to been used/developed to be able to tackle the problem. I will give a summary of these challenges, as well as some of the techniques being used to produce high accuracy simulations of binary black holes problem through massively parallel supercomputers, and the remaining challenges. (Received August 31, 2009)

86 ► Geophysics

1052-86-94 **Tetsu Hara*** (thara@uri.edu), Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882, and **Tobias Kukulka**. *Wave spectrum and breaking wave statistics of growing and mature seas.*

Existing numerical wave models are capable of predicting the surface wave spectrum near the spectral peak, but cannot predict the spectrum at higher frequencies nor the statistics of breaking waves. The objective of this study is to develop a theoretical model framework to predict both the spectrum and the breaking statistics over a broad range of frequencies. Since ocean surface waves are forced by wind, and the wind field itself is modified by the presence of surface waves, a coupled model of surface waves and near surface wind is required. By balancing air-side momentum and energy and by conserving wave energy, coupled nonlinear advance delay differential equations are derived, which govern simultaneously the wave and wind field. Under strongly wind forced conditions (young seas) the breaking statistics is the largest at the spectral peak. As the wave field develops, the number of breaking waves at the peak rapidly decreases. However, the breaking wave effect remains important at higher frequencies (smaller waves). (Received August 21, 2009)

1052-86-358 **Ma Tian**, Department of Mathematics, Sichuan University, Chengdu, Peoples Rep of China, and **Shouhong Wang*** (showang@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405. *El Nino Southern Oscillation as Sporadic Oscillations between Metastable States.*

El Nino Southern Oscillation (ENSO) is a global coupled ocean-atmosphere phenomenon, associated with floods, droughts, and other disturbances in a range of locations around the world. In spite of its importance and a long history of studies, the understanding of its nature and mechanism is still lacking, and a careful fundamental level examination of the problem is crucial.

We present in this talk a new mechanism of the ENSO, as a self-organizing and self-excitation system, with two highly coupled processes. The first is the oscillation between the two metastable warm (El Nino phase) and cold events (La Nina phase), and the second is the spatiotemporal oscillation of the sea surface temperature (SST) field. The interplay between these two processes gives rises the climate variability associated with the ENSO, leads to both the random and deterministic features of the ENSO, and defines a new natural feedback mechanism, which drives the sporadic oscillation of the ENSO. The new mechanism is rigorously derived using a dynamic transition theory developed recently by the authors, which has also been successfully applied to a wide range of problems in nonlinear sciences. (Received September 01, 2009)

91 ► Game theory, economics, social and behavioral sciences

1052-91-50 **Harold M Hastings*** (Harold.Hastings@Hofstra.edu), Dept. of Physics and Astronomy, Berliner 102, 151 Hofstra University, Hempstead, NY 11549-1510, and **Michael Bantegui**, **Michael Palmer** and **Thomas Savino**. *Stability and complexity of model economic systems: a random matrix approach.*

We explore the stability of the world trade network using a data-driven random matrix model. Despite their complexity, world trade dynamics are dominated by a small core of countries and links. Thus large fluctuations, perhaps outside of the basin of attraction for a "stable" growth trajectory, are much more likely than extrapolation based upon "typical" fluctuations would predict. Partially supported by the Department of Energy Award DE-FG02-08ER64623. This report was prepared as an account of work sponsored by an agency of the US Government. Neither the US Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the US Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the US Government or any agency thereof. (Received August 11, 2009)

1052-91-260 **Ioanid Rosu*** (irosu@uchicago.edu), Chicago, IL 60637. *Liquidity and Information in Order Driven Markets.*

This paper analyzes an order-driven market where liquidity traders and informed traders freely choose between limit and market orders. In equilibrium, informed traders submit a market order only when their privately observed fundamental value of the asset is far away from the current public price; otherwise they submit a limit order. The model generates a rich set of relations among spreads, trading activity, volatility, and the price impact of a trade: (i) consistent with research in other types of markets, higher fundamental volatility and smaller trading activity generate larger spreads; (ii) a higher percentage of informed traders surprisingly generates smaller spreads; (iii) limit orders carry information: e.g., the price impact of a buy limit order is usually about four times smaller than that of a buy market order, although in rare cases it can have zero or even negative price impact; (iv) the price impact of a trade decreases in the size of the spread; and (v) the average size of price impact does not depend on the number of informed traders. The results suggest that the ratio of the intra-day price volatility to the average bid-ask spread can be used to estimate the probability of informed trading. (Received August 30, 2009)

1052-91-283 **Jim Gatheral*** (jim_gatheral@ml.com), New York, NY. *No Price Manipulation and the Decay of Market Impact.*

Starting from an expression for the price process that generalizes previous work, we formulate a no-price-manipulation principle analogous to that of Huberman and Stanzl. We show that this principle imposes a

relationship between the shape of the market impact function and the decay of temporary market impact. We review some conventional market impact models and explore some implications of no-price-manipulation. (Received August 31, 2009)

1052-91-288 **Kasper Larsen*** (kasperl@andrew.cmu.edu), Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. *Bond and Stock Market Equilibrium with Heterogeneous Agents Receiving Unspanned Income.*

We provide the first closed-form solution for the equilibrium risk-free rate and the equilibrium stock price in a continuous time economy where agents have heterogeneous preferences and unspanned labor income risk. We show that low correlations between the investors' income processes and the stock's dividend process produces a low correlation between the stock's dividends and the equilibrium aggregate consumption, i.e., a lower Sharpe ratio, whereas the risk-free rate is unaffected in economies with many individuals. If the aggregate consumption dynamics remain fixed, the Sharpe ratio also remains the same whereas the risk-free rate (and the expected stock return) is lower in our economy relative to the corresponding representative agent economy where all risks are spanned. The reduction in the risk-free rate depends on the magnitude of all individuals' unspanned income risk and their risk aversion: The reduction is highest when the most risk-averse individuals face the largest unspanned income uncertainty. In stylized numerical examples the reduction in the risk-free rate is several percentage points. (Received August 31, 2009)

1052-91-356 **Olesya V. Grishchenko*** (olesya@psu.edu), 303 Business Building, University park, PA 16802, **Joel M. Vanden** (jmv13@psu.edu), 341 Business building, University Park, PA 16802, and **Jianing Zhang** (juz134@psu.edu), 310A Business Building, University Park, PA 16802. *A two-factor dynamic term structure model and pricing of TIPS securities.* Preliminary report.

In this paper we present an affine two-factor dynamic term structure model for Treasury nominal and inflation-indexed bonds. The latter are formally referred to as TIPS. We present closed-form solutions for nominal bonds and inflation-indexed bonds. Two state variables that drive the dynamics of bond prices are nominal short rate and inflation. We estimate the model using 1997-2008 monthly prices of nominal Treasury bonds and TIPS. In particular, we compute the embedded option value in TIPS. This value arises from the fact that while nominal coupon payments vary with inflation rate during the TIPS life, the principal at maturity is protected against deflation. Our preliminary results show that this value has recently become positive. (Received September 01, 2009)

92 ► Biology and other natural sciences

1052-92-108 **Sanju Vaidya*** (svaidya@mercy,edu), 555 Broadway, Dobbs Ferry, NY 10522. *Analysis of Gene Expressions Using Young Tableaux.*

In the last ten years, DNA microarrays (DNA chips) have been used to analyze functions of various genes. They are used to study gene expression patterns in many diseases such as cancer and diabetes. The main goal in analyzing microarray data is to identify genes differentially expressed across groups of samples or experimental conditions. We will use properties of permutations and Young tableaux to identify the pattern in data series of genes generated by microarray measurements. Young tableaux are certain tabular arrangements of integers. In the third volume of his book on the Art of Computer Programming, Knuth has refined a sorting procedure originated by Robinson and Schenstead. Using the Robinson- Schenstead- Knuth procedure, we will associate Young tableaux to permutations corresponding to data series of genes. We will use the concepts of algorithmic compressibility of Ahnert et al, formula of Frame et al for computing the number of tableaux and theorems of C. Schenstead about the length of the longest increasing and decreasing subsequences of a permutation to identify genes that are significantly related to the target disease. The analysis of gene expressions can lead to improved diagnosis and individualized medical treatment as well as earlier detection of diseases. (Received August 23, 2009)

93 ► Systems theory; control

1052-93-109 **Dimplekumar N Chalishajar*** (dipu17370@yahoo..com), 439, Mallory Hall, Department of Mathematics and computer Sc., Virginia Military Institute (VMI), Lexington, VA 24450, and **Falguni S Acharya** (falguni_69@yahoo.co.in), Department of Mathematics, Parul Insti. of Tech and Engg., Waghodia, Vadodara, GU 390002, India. *Trajectory Controllability of Integro differential second order semilinear system in Banach space.*

In this paper we have introduced the new nothin of controllability called Trajectory (T)-controllability. This new nothin can provide safe guard to the systen and it minimize the cost also. Here we have studied first order system for one dimensional casr R and then it is extended for n-dimentional case R^n and subsequently for infinite dimensional case. Then the same are proved for second order system also. The useful tools for this investigation is monotone operator theory and semigroups/cosine operators. Examples are provided to illustrate the theory.
(Received August 23, 2009)

00 ► General

1053-00-4 **Spyridon Alexakis***, MIT, Department of Mathematics, Cambridge, MA. *Global Conformal Invariants: A conjecture of Deser and Schwimmer.*

Global Conformal Invariants are integrals of local geometric scalars, which remain invariant under conformal changes of the underlying metric. I will discuss my proof of a conjecture of Deser and Schwimmer, which asserts that any such global invariant admits a decomposition into standard "building blocks" of three types.

I will present some ideas from the proof, putting emphasis on an algebraic question which lies at the heart of the problem. Time permiting, some analogous questions in Kahler geometry will also be discussed. (Received June 11, 2008)

1053-00-266 **Junfang Li*** (jli@math.uab.edu), Birmingham, AL 35294. *The evolution of eigenvalues of closed Riemmanian manifold along Ricci flow.* Preliminary report.

We will present our recent work on the monotonicity formulas of eigenvalues of various operators on closed Riemannian manifolds under Ricci flow. (Received September 07, 2009)

01 ► History and biography

1053-01-275 **Ray Mines*** (ray@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003. *Constructive Mathematics at New Mexico State University.*

This talk discusses the development of Bishop-type constructive mathematics in New Mexico during the seventies and eighties. (Received September 07, 2009)

03 ► Mathematical logic and foundations

1053-03-37 **Valentin V Andreev**, **Dale Daniel** and **Timothy H McNicholl*** (timothy.h.mcnicholl@gmail.com), Department of Mathematics, Lamar University, Beaumont, TX 77710. *Computing conformal maps onto circular domains.*

A *domain* is an open connected subset of the extended complex plane $\hat{C}$. A domain is *n-connected* if its complement has exactly n components. If one of these components consists of a single point, the domain is *degenerate*. The Riemann Mapping Theorem states that every non-degenerate 1-connected domain is conformally equivalent to the disk thus making the disk the *canonical domain* for the class of 1-connected domains. Bishop and Bridges's book contains a constructive proof of the Riemann Mapping Theorem. For domains of connectivity greater than 1, there are several canonical domains. These can be partitioned into the circular domains, the slit domains, and the polygonal domains. We are not aware of any constructive existence proofs for these mappings. We have however demonstrated the uniform computability of the conformal maps onto the circular domains. A partial result on this problem was presented at CCA 2008. We will discuss the techniques and ideas in the full solution including recent results on the computation of capacity of planar regions by Ransford and Rostand. We have also demonstrated the uniform computability of the conformal maps onto the slit domains. (Received July 10, 2009)

1053-03-39 **Maria Emilia Maietti*** (maietti@math.unipd.it), via Trieste n. 63, Dipartimento di Matematica pura ed applicata, Universita' di Padova, 35100 Padova, Italy. *Benefits of the two level minimalist foundation for constructive mathematics.*

In joint work with Giovanni Sambin in '05, we advocated the need of a two level minimalist foundation for constructive mathematics. Then we gave an example of it where each level is represented by a type theory a' la Martin-Loef. Here we describe how such a foundation is consistent with combinations of the formal Church thesis, the axiom of choice and Bar Induction, as advocated in '05. (Received July 11, 2009)

1053-03-40 **Wim Ruitenburg*** (wimr@mscs.mu.edu), Department of Mathematics, Marquette University, P.O. Box 1881, Milwaukee, WI 53201. *Model theory for intuitionistic predicate calculus.*

Model theory for intuitionistic predicate logic dates back at least to the 1960s with work by Kripke, Mints, and others. We discuss a recent renaissance with work along the lines of Visser, Ellison, Fleischmann, McGinn, Ruitenburg, Morteza Moniri, and Zaare. We consider preservation theorems reminiscent of the Chang-Łos-Szusko theorem, as well as formula hierarchies generalizing the classical ones of the forms Π^0_n and Σ^0_n. (Received July 12, 2009)

1053-03-41 **Michael A Warren*** (mwarren@uottawa.ca), Department of Mathematics and Statistics, 585 King Edward Ave., Ottawa, Ontario K1N 6N5, Canada. *Martin-Löf Complexes.*

Recent research has revealed an interesting connection between the intensional form of Martin-Löf type theory and structures arising in homotopy theory and higher-dimensional category theory. In this talk we will describe one application of this connection to homotopy theory by using a class of combinatorial structures called *Martin-Löf complexes*, that are obtained by freely adjoining cells to (higher-dimensional) graphs in accordance with the rules of type theory, to model certain homotopy types.

This is joint work with S. Awodey and P. Hofstra. (Received July 12, 2009)

1053-03-49 **Erik Palmgren*** (palmgren@math.uu.se), Uppsala University, Department of Mathematics, P.O.Box 480, 75106 Uppsala, Sweden. *Constructive aspects of maps between open sublocales.*

It is of interest to characterize the maps between open sublocales of two localic completions of locally compact metric spaces X and Y

$$M(X)_{|U} \to M(Y)_{|V}. \tag{1}$$

The characterization is not trivial from a constructive point of view. As shown by author the maps $M(X) \to M(\mathbb{R})_{|(0,\infty)}$ correspond to continuous functions $X \to \mathbb{R}$ that on each open ball has a positive uniform lower bound, rather than positive functions. Constructively, there is a distinction: Julian and Richman (improving on a result by Specker) gives a recursive example of a uniformly continuous positive function $[0,1] \to \mathbb{R}$ that has no uniform positive lower bound. These considerations makes it clear that the set of continuous point maps $\mathrm{Pt}(U) \to \mathrm{Pt}(V)$ between open subspaces of locally compact metric spaces has to meet some extra conditions to be in 1-1 correspondence to maps in (1). We provide such conditions. For open subspaces that are given by metric complements these are particularly simple. (Received July 22, 2009)

1053-03-60 **Neil W Tennant*** (tennant.9@osu.edu), Department of Philosophy, 230 North Oval Mall, The Ohio State University, Columbus, OH 43210. *Cut for Core Logic.* Preliminary report.

Core logic is a very natural subsystem of classical logic. Its deductive rules are obtained by smooth generalization from the rules we use to evaluate sentences as true or as false. It is constructive and relevant. Its rules are formulated in such a way that its proofs are always in normal form. In this study we establish an appropriate form of 'cut-elimination' theorem for core logic. It ensures transitivity of core deducibility wherever it is called for. (Received August 02, 2009)

1053-03-76 **Robert S. Lubarsky*** (Robert.Lubarsky@comcast.net), 416 NE 28 St., Wilton Manors, FL 33334, and **Fred Richman** (richman@fau.edu), Dept. of Mathematical Sciences, 777 Glades Rd., Boca Raton, FL 33431. *The Weak Fundamental Theorem of Algebra.*

The Fundamental Theorem of Algebra is not provable in constructive mathematics without special hypotheses. In contrast, its double negation interpretation, that the set of roots of any given polynomial can't be empty, must hold, via the double negation interpretation. We provide such a proof, in which the uses of Excluded Middle are narrowed to the equality to or apartness from 0 of finitely many pre-identified real numbers. Along the way, we generalize certain standard classical notions, namely distance and finiteness, to the constructive setting, and review some classical results, such as those about division of polynomials and relative primality. (Received August 13, 2009)

1053-03-121 **Russell G. Miller*** (Russell.Miller@qc.cuny.edu), Mathematics Dept., 65-30 Kissena Blvd., Flushing, NY 11367. *Real computability and roots of polynomials.* Preliminary report.

In ordinary Turing computability on fields such as $\mathbb{Q}$, the question of finding a root of a given polynomial boils down to the question of whether the field contains such a root. If it does, then a simple search procedure through the field suffices to produce the root, yielding a constructive proof of its existence. If it does not, then of course

there is no proof, constructive or otherwise, that it has a root. So the problem of finding a constructive proof is Turing-equivalent to the problem of finding a classical proof.

Blum, Shub, and Smale generalized the notion of Turing computability to arbitrary rings. Using their definition, we point out that the situation in the real numbers $\mathbb{R}$ is different. There is a straightforward real-computable procedure for deciding whether a polynomial in $\mathbb{R}[X]$ has a root in $\mathbb{R}$, but no real-computable function can produce a root for every polynomial which has one. Indeed, this remains true even when the machines are given the ability to find n-th roots of arbitrary positive real numbers. This distinguish the real numbers from Turing-computable (countable) fields, and offers possibilities for connections to constructive mathematics. (Received August 27, 2009)

1053-03-150 **Fred Richman***, Department of Mathematics, Florida Atlantic University, Boca Raton, FL 33431. *Does the axiom of choice imply the law of excluded middle?* Preliminary report.

The Goodman-Myhill theorem states that the axiom of choice implies the law of excluded middle. Errett Bishop claimed that a choice function exists in constructive mathematics because a choice is implied by the very meaning of existence. I will argue that both of these apparently irreconcilable statements are bogus. (Received August 31, 2009)

1053-03-225 **Carl Mummert*** (mummertc@marshall.edu), One John Marshall Drive, Huntington, WV 25755, and **Jeffry L. Hirst** (jlh@math.appstate.edu). *Reverse mathematics and uniformity in proofs without excluded middle.* Preliminary report.

We establish two theorems relating provability in intuitionistic systems of higher order arithmetic with uniform provability in weak classical systems. These results show that, when certain $\forall\exists$ sentences are provable in the intuitionistic systems, their uniform variants are provable in classical systems with weak comprehension axioms. By combining these results with ordinary reverse mathematics techniques, we are able to demonstrate the nonexistence of proofs of several mathematical principles in intuitionistic systems. (Received September 05, 2009)

1053-03-261 **Denis R. Hirschfeldt*** (drh@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 S. University Ave., Chicago, IL 60637. *Homogeneous models, PA degrees, and Weak König's Lemma.*

As an example of recent work on the effective content of basic model theory, which may well have analogs in the constructive setting, I will discuss the computability theoretic and reverse mathematical strength of the principle HMT that every countable, complete, consistent theory T has a countable homogeneous model $\mathcal{M}$. If T is decidable, then there are several ways to show that such an $\mathcal{M}$ can be obtained effectively from a given PA degree (i.e., a Turing degree of a nonstandard model of Peano Arithmetic). In joint work with Csima, Harizanov, and Soare, we showed that the strength of PA degrees is in general necessary for building homogeneous models of decidable theories.

A degree $\mathbf{d}$ is PA iff every computable, infinite, binary branching tree has a $\mathbf{d}$-computable path. Thus PA degrees are closely linked to WKL_0, the subsystem of second order arithmetic consisting of the usual weak base system RCA_0 of reverse mathematics together with Weak König's Lemma, the principle that every infinite binary branching tree has an infinite path. Lange showed that HMT and WKL_0 are equivalent over RCA_0. (Received September 07, 2009)

1053-03-291 **Wojciech Moczydlowski*** (wojtekm@google.com). *Bridging the Gap Between Replacement and Collection by Inaccessible Sets.* Preliminary report.

The nature of the relation between Replacement and Collection in the constructive world has been an intriguing problem ever since intuitionistic Zermelo-Fraenkel set theory (IZF) was introduced by Myhill in 1973. While in the classical setting the axioms are equivalent, the situation is far from clear once the excluded middle is eliminated. Friedman and Scedrov showed in 1985 that IZF_R, the version with Replacement, is weaker than IZF_C, the version with Collection, which is equiconsistent with ZF. They also conjectured that IZF_C proves consistency of IZF_R. No more is known.

We utilize inaccessible sets to shed light on this problem. More specifically, we show that $\mathrm{IZF}_{R\omega}$ and $\mathrm{IZF}_{C\omega}$, resulting by extending IZF_R and IZF_C with omega-many inaccessibles, are equiconsistent. By earlier results, their strength is the same as ZF_ω, the classical counterpart.

Since $\mathrm{IZF}_{R\omega}$ has a normalizing proof system (Moczydlowski 2007) these results establish it as a remarkably powerful constructive setting. It possesses desirable properties such as Disjunction Property. Despite its inherent impredicativity, programs can be extracted from proofs. To the best of our knowledge, it is the strongest such theory in existence. (Received September 08, 2009)

1053-03-317 **Laura Crosilla*** (matmlc@leeds.ac.uk), School of Mathematics, University of Leeds, Leeds, LS2 9JT, England. *Operations and sets, constructively (Joint work with A. Cantini (Florence, Italy)).*

Constructive operational set theory is a blend of two distinct traditions within the foundations for constructive mathematics: Aczel's constructive Zermelo Fraenkel set theory and Feferman's explicit mathematics. It is a constructive version of Feferman's recent operational set theory and of Beeson's intuitionistic set theory with rules.

In constructive operational set theory a notion of operation or rule is found aside the notion of constructive set. While sets are fully extensional, operations are non-extensional and partial.

We shall here present the salient elements of constructive set theory with operations as well as some recent work on weak systems. (Received September 08, 2009)

1053-03-320 **Sergei N. Artemov*** (sartemov@gc.cuny.edu), CUNY Graduate Center, 365 Fifth Avenue, New York, NY 10016. *Formalizing Brouwer-Heyting-Kolmogorov semantics.*

The logic of proofs LP ([1]) achieves Gödel's objective ([2]) of defining intuitionistic propositional logic IPC via classical proofs and provides a *Brouwer-Heyting-Kolmogorov (BHK)*-style provability semantics for IPC.

The arithmetical provability semantics can be naturally generalized to first-order language and to language with quantifiers over proofs. In both cases, axiomatizability questions have been answered in the negative. However, there have been promising advances towards a system of first-order logic of proofs which can serve as the *BHK* semantics for first-order intuitionistic logic.

References

[1] Artemov, S. Explicit provability and constructive semantics. Bulletin of Symbolic Logic, 7(1), 1–36, 2001.

[2] Gödel, K. Eine Interpretation des intuitionistischen Aussagenkalkuls. Ergebnisse Math. Kolloq., 4, 39–40, 1933.

(Received September 08, 2009)

1053-03-337 **Bas Spitters*** (spitters@cs.ru.nl), Department of Computer Science, P.O. Box 9010, NL-6500 GL, Nijmegen, Netherlands, and **Chris Heunen** and **Nicolaas Landsman**. *A topos for algebraic quantum theory.*

We relate algebraic quantum mechanics to topos theory, so as to construct new foundations for quantum logic and quantum spaces. Motivated by Bohr's idea that the empirical content of quantum physics is accessible only through classical physics, we show how a C*-algebra of observables A induces a topos T(A) in which the amalgamation of all of its commutative subalgebras comprises a single commutative C*-algebra. According to constructive Gelfand duality, the latter has an internal spectrum S(A) in T(A), which in our approach plays the role of a quantum phase space. Thus we associate a "pointfree space" to a C*-algebra (a noncommutative space). In this setting, states on A become probability measures on S(A), and self-adjoint elements of A define continuous functions from S(A) to Scott's interval domain. Noting that open subsets of S(A) correspond to propositions about the system, the pairing map that assigns a truth value to a state and a proposition assumes an extremely simple categorical form. Formulated in this way, the quantum theory defined by A is essentially turned into a classical theory, internal to the topos T(A). http://arxiv.org/abs/0709.4364 (Received September 08, 2009)

1053-03-351 **Krystian Adam Jobczyk*** (krystian_jobczyk@op.pl), ul. Nowolipie 16/12, 01-005 Warsaw, Poland. *"Canonic System for ZF and why is the Skolem-Loewenheim's Paradox a real paradox?".*

I try to consider which properties are characteristic for a canonic systems in my presentation. This is a good way to better understand what exactly means that any language is accepted by PDA. Although I would like consider a classical example of canonic system-a canonic system for Zermelo-Fraenkel's set theory (ZF) in my project, its possible to understand what means that any fixed system is a canonic system. To see that I show that a canonic system of any fixed system T as a good instrument (and field) to solve some problems, which cannot be resolved in T(some problems are not in canonic system undecidable). The kind of these problems is a question: is Skolem-Loewenheim;s Paradox or not? This problem will be just analised in my work. So we need consider a specific kind of canonic system. More precisally, I show that it's proving in ZF** that the class of all nonempty sets of ordinal numbers and the class of all nonempty sets are uncountable. It shows moreover that this situation is normal for every extension of ZF and explains why a Skolem-Loewenheim's Paradox is not a real paradox. My proof will be based on a concept of Quine's and Post's (modified by R. Suszko) canonic system for ZF** and will be a modification and generalization of theirs results. (Received September 09, 2009)

05 ► Combinatorics

1053-05-20 **Vyacheslav Pavlovich Krivokolesko*** (antonk@ktk.ru), Krasnoyarsk, 660021, Russia. *An integral representation for linearly convex polyhedra and several combinatorial identities.* Preliminary report.

Using an integral representation from [1] for functions that are holomorphic in a linearly convex polyhedron with a piecewise smooth boundary

$$G = \{z = (z_1, z_2) \in \mathbb{C}^2 : g^1(|z|) = -|z_1| + a < 0, g^2(|z|) = -|z_2| + b < 0,$$
$$g^3(|z|) = |z_1|^2 + |z_2|^2 - r^2 < 0, r > a, r > b\}. \tag{1}$$

we obtain some combinatorial identities.

Theorem. *For $0 < \alpha < 1$, $0 < \beta < 1$ the following identities hold:*

$$\frac{(s_1+s_2+1)!}{s_1!s_2!}\sum_{m=0}^{s_1}\frac{(-1)^m}{s_2+m+1}\binom{s_1}{m}\left((1-\alpha)^{s_2+m+1}-\beta^{s_2+m+1}\right)$$
$$\equiv (1-\alpha)^{s_2+1}\sum_{m=0}^{s_1}\binom{s_2+m}{m}\alpha^m - \beta^{s_2+1}\sum_{m=0}^{s_1}\binom{s_2+m}{m}(1-\beta)^m, \tag{2}$$

$$1 \equiv \frac{(s_1+s_2+1)!}{s_1!s_2!}\sum_{m=0}^{s_1}\frac{(-1)^m}{s_2+m+1}\binom{s_1}{m}\left((1-\alpha)^{s_2+m+1}-\beta^{s_2+m+1}\right) +$$
$$\alpha^{s_1+1}\sum_{m=0}^{s_2}\binom{s_1+m}{m}(1-\alpha)^m + \beta^{s_2+1}\sum_{m=0}^{s_1}\binom{s_2+m}{m}(1-\beta)^m. \tag{3}$$

Corollary. *For $m = 0, \dots s_1$ the following identities are valied:*

$$\binom{s_2+m}{s_2} = (-1)^m\frac{(s_1+s_2+1)!}{s_1!s_2!}\sum_{k=m}^{s_1}\frac{(-1)^k}{s_2+k+1}\binom{s_1}{k}\binom{k}{m} \tag{4}$$

In the spesial case $m = 0$ we recover the formula No.45 on page 611 in [2].

Bibliography:

[1] Krivokolesko V.P. and Tsikh A.K., Integral Representations in Linearly Convex Polyhedra, Siberian Mathematical Journal, Vol. 46, No.3, 579-593 (2005). Sib. Mat. J, Vol. 46, No.3, 579-593 (2005).

[2] Prudnikov A.P., Brychkov Yu.A., Marithev O.I. Integrals and rows [in Russian], Moskov, Nauka (1981).

(Received June 01, 2009)

1053-05-28 **Wenfong Ke** (wfke@mail.ncku.edu.tw), Tainan, 701, Taiwan, **Po-Yi Huang** (pyhuang@mail.ncku.edu.tw), Tainan, 701, Taiwan, and **Günter F Pilz*** (Guenter.Pilz@jku.at), Altenbergerstr. 69, 4040 Linz, Austria. *The Cardinality of Some Symmetric Differences.*

In this note, we prove that for positive integers k and n, the cardinality of the symmetric differences of $\{1, 2, \dots, k\}$, $\{2, 4, \dots, 2k\}$, $\{3, 6, \dots, 3k\}$, $\dots$, $\{n, 2n, \dots, kn\}$ is at least k or n whichever is larger. This solved a problem raised in [Contributions to General Algebra **8**, Hölder-Pichler-Tempsky, Vienna (1992), 233–238] where binary composition codes were studied. (Received June 26, 2009)

1053-05-30 **David Galvin*** (dgalvin1@nd.edu), Department of Mathematics, 255 Hurley Hall, University of Notre Dame, South Bend, IN 46556, and **Yufei Zhao**, Department of Mathematics, Massachusetts Institute of Technology, Cambridge, MA 02139. *The number of independent sets in graphs with small maximum degree.*

At most how many independent sets can a graph have? In 2001 Kahn conjectured that for any graph G without isolated vertices, the number of independent sets satisfies

$$i(G) \le \prod_{uv \in E(G)} \left(2^{d(u)} + 2^{d(v)} - 1\right)^{1/d(u)d(v)},$$

where $d(\cdot)$ denotes degree. By reducing to a finite search, we prove this bound for all G with maximum degree at most 5.

Kahn's conjecture is a special case of a 1991 conjecture of Alon: for a d-regular graph G on n vertices, the number of independent sets satisfies

$$i(G) \le (2^{d+1} - 1)^{n/2d}.$$

In 2001 Kahn proved this conjecture for bipartite graphs, and the full conjecture was recently resolved by Zhao.

In this talk, we will describe both proofs. (Received August 10, 2009)

1053-05-36 **Eric S Egge*** (eegge@carleton.edu), Department of Mathematics, Carleton College, Northfield, MN 55057. *Legendre-Stirling Permutations.* Preliminary report.

Recently Andrews and Littlejohn have given a combinatorial interpretation of Everitt, Littlejohn, and Wellman's Legendre-Stirling number of the second kind, akin to the usual set partitions interpretation of Stirling numbers of the second kind. In this talk we give a combinatorial interpretation of the coefficients of the polynomial $(1-x)^{3k+1}\sum_{n=0}^{\infty} LS(n+k,n)x^n$, where $LS(n,k)$ is the Legendre-Stirling number of the second kind. Like the usual interpretation of the Eulerian numbers (which arise in a similar context), our interpretation involves descents in permutations from a certain family. If time permits, we will also present Legendre-Stirling analogues of some classical Stirling number identities. (Received July 10, 2009)

1053-05-88 **Arash Asadi** and **Luke Postle*** (ljpostle@math.gatech.edu), 2735 Defoors Ferry Rd, Atlanta, GA 30318, and **Robin Thomas**. *Sub-Exponentially Many 3-Colorings of Triangle-Free Planar Graphs.*

Thomassen conjectured that every triangle-free planar graph has exponentially many 3-colorings. He proved that it has at least $2^{n^{1/12}/20000}$ distinct 3-colorings where n is the number of vertices. We show that it has at least $2^{\sqrt{n/432}}$ distinct 3-colorings. (Received August 20, 2009)

1053-05-89 **Jan Hladky**, **Daniel Kral** and **Serguei Norine*** (snorin@math.princeton.edu), Department of Mathematics, Fine Hall, Washington Road, Princeton, NJ 08542. *Counting flags in triangle-free digraphs.*

Many results in asymptotic extremal combinatorics are obtained using just a handful of instruments, such as induction and Cauchy-Schwarz inequality. The ingenuity lies in combining these tools in just the right way. Recently, Razborov developed a flag calculus which captures many of the available techniques in pure form, and allows one, in particular, to computerize the search for the right combination.

In this talk we outline the general approach and describe its application to the conjecture that a digraph with minimum outdegree n/3 contains a directed triangle. This special case of the Caccetta-Haggkvist conjecture has been extensively investigated in the past. We show that a digraph with minimum outdegree a*n contains a directed triangle for a=0.3465. The proof builds on arguments used to establish previously known bounds, due to Shen from 1998 (a=0.3542) and Hamburger, Haxell and Kostochka from 2008 (a=0.3531). It consists of a combination of several computer generated inequalities. (Received August 21, 2009)

1053-05-99 **Ronald J. Gould*** (rg@mathcs.emory.edu), Department of Mathematics and Computer Scienc, Emory University, Atlanta, GA 30322. *On Saturation Numbers.*

A graph G on n vertices is said to be H-saturated if G does not contain H as a subgraph, but the addition of any new edge to G produces H as a subgraph.

One of the classic questions in graph theory is what is the maximum number of edges in a graph that fails to contain H as a subgraph, that is, what is the maximum size of an H-saturated graph? This number is denoted $ex(n,H)$. This question has seen considerable work and produced a deep and rich theory.

The other extreme has been far less studied. That is, what is the minimum number of edges in an H-saturated graph? This is called the saturation number of H and is denoted by $sat(n,H)$.

In this talk we survey some of the basic facts about saturated graphs and recent results on saturation numbers. (Received August 25, 2009)

1053-05-102 **Omer Egecioglu*** (omer@cs.ucsb.edu), Department of Computer Science, University of California, Santa Barbara, CA 93106. *Hankel determinants, partial sums of the exponential series and Bessel polynomials.*

We consider differential equations and the evaluation of certain Hankel determinants in almost product form. The γ-operator technique to find the explicit form of the almost product evaluation relies on differential-convolution equations and establishes a differential equation for the determinant. As an example of the method, we will consider the evaluation of the family of Hankel determinants whose entries are partial sums of the Maclaurin series for the exponential function. We illustrate the application of the γ-operator technique on this example and derive a closed form evaluation of the determinant in terms of the Bessel polynomials. (Received September 07, 2009)

1053-05-107 **Catherine Yan*** (cyan@math.tamu.edu), Department of Mathematics, Texas A&M University, MS 3368, College Station, TX 77843-3368, and **William Chen**, **Andrew Wang** and **Alina Zhao**. *Mixed Statistics on* 01*-Fillings of Moon Polyominoes.*

We establish a stronger symmetry between the numbers of northeast and southeast chains in the context of 01-fillings of moon polyominoes. We introduce four pairs of mixed statistics on 01-filings of moon polyominoes,

each of them being a combination of northeast and southeast chains with respect to a bipartition of rows or columns of the moon polyomino. We show that they share the same symmetric distribution as (ne, se), the numbers of northeast chains and southeast chains, respectively. (Received August 26, 2009)

1053-05-115 **Rong Luo*** (rluo@mtsu.edu), Department of Mathematical Sciences, Middle Tennessee State University, Murfreesboro, TN 37129, and **Yue Zhao** (yzhao@pegasus.cc.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Independence number and hamiltonicity of edge chromatic critical graphs.* Preliminary report.

A simple graph G with maximum degree Δ is class one if it is edge Δ-colorable. Otherwise it is class two. A graph G is edge chromatic critical (or simply critical) if it is class two and $G - e$ is class one for each edge e. In 1960s, Vizing proposed the following two conjectures on critical graphs:

(1) (Vizing's Indpendence Number Conjecture) The independence number of a critical graph is at most half of its number of vertices.

(2) (Vizing's 2-Factor Conjecture) Every critical graph has a 2-factor.

We prove the following two results:

(a) The independence number of a critical graph G with maximum degree Δ is less than $\frac{5\Delta-6}{8\Delta-6}|V(G)|$.

(b) Every critical graph with maximum degree $\Delta \geq \frac{6}{7}|V(G)|$ is hamiltonian and thus has a 2-factor.

This is joint work with Yue Zhao at the University of Central Florida. (Received August 27, 2009)

1053-05-122 **Shanzhen Gao*** (sgao2@fau.edu), Deptment of Mathematical Sciences, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431. *Some Remarks On Self-Avoiding Walks.*

A self-avoiding walk (SAW) is a sequence of moves on a lattice which does not visit the same point more than once. A SAW is interesting for simulations because its properties cannot be calculated analytically. Calculating the number of self-avoiding walks in any given lattice is a common computational problem. We will present some interesting problems involving prudent self-avoiding walks and show how to solve a few of them. (Received August 31, 2009)

1053-05-123 **Kenneth Matheis*** (kmatheis@fau.edu), Deptment of Mathematical Sciences, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431, and **Shanzhen Gao** (sgao2@fau.edu), Deptment of Mathematical Sciences, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431. *Enumeration of Integer Matrices with Constant Row and Column Sums.*

The enumeration of integer matrices with constant row and column sums has been the subject of considerable study, and it is unlikely that simple formulas exist except for some very trivial cases. We will present some new results and problems in this area. (Received August 27, 2009)

1053-05-125 **Sergi Elizalde*** (sergi.elizalde@dartmouth.edu), Department of Mathematics, Dartmouth College, 6188 Kemeny Hall, Hanover, NH 03784. *Descent sets of cyclic permutations.*

The descent set of a sequence $a_1 a_2 \ldots$ is the set of indices i such that $a_i > a_{i+1}$. Consider the $n!$ cyclic permutations of $\{1, 2, \ldots, n+1\}$ written in one-line notation, and for each one of them remove the last entry $\pi(n+1)$. We show that the descent sets of these objects have the same distribution as the descent sets of permutations of $\{1, 2, \ldots, n\}$. We give a bijective proof of this fact, as well as an alternate derivation using work of Gessel and Reutenauer. (Received August 27, 2009)

1053-05-128 **Timothy Y Chow*** (tchow@alum.mit.edu), 805 Bunn Drive, Princeton, NJ 08540, and **Robin J Chapman**, **Amit Khetan**, **David Petrie Moulton**, **Robert J Waters** and **Mihai Ciucu**. *Simple enumerative formulas for lattice paths avoiding periodic staircase boundaries.*

There is a classical determinant formula for the number of lattice paths in the plane that take only unit steps east and north and that avoid a given boundary. Since the 19th century it has been known that there is a much simpler formula in certain special cases, notably when the boundary is the line $x = ky$ where k is a positive integer. We show that the natural generalization of this simple formula continues to hold when the line $x = ky$ is replaced by certain periodic staircase boundaries—but only under special conditions. We have proved our results both combinatorially and algebraically, and later, Irving and Rattan found yet another way to prove some of our theorems. It remains an open question what other classes of lattice paths admit similar simple formulas. (Received August 28, 2009)

1053-05-131 **Drew Armstrong*** (armstrong@math.miami.edu), University of Miami, Department of Mathematics, 1365 Memorial Drive, Ungar 529, Coral Gables, FL 33146. *Hyperplane arrangements and q,t-Catalan numbers.* Preliminary report.

We introduce a new hyperplane arrangement — called the Ish arrangement — which has the same characteristic polynomial as the Shi arrangement. Given a chamber of the Shi arrangement we let shi and ish denote the number of Shi and Ish hyperplanes, respectively, separating the chamber from the origin. We prove that the generating function for shi and ish is Haiman's q,t-Catalan number. (Received August 29, 2009)

1053-05-134 **J. Haglund*** (jhaglund@math.upenn.edu), 209 S. 33rd. St., math. Dept., Univ. of Penn., Philadelphia, PA 19104-6395. *Zeros of Pernaments and Rook Polynomials.*

We introduce a multi-variate polynomial defined via a pernament, and conjecture this polynomial is nonzero if all variables have positive imaginary part. We show how this conjecture implies the "Monotone Column Pernament" conjecture of Haglund, Ono, and Wagner, and prove various special cases of the conjecture using stability criterion of P. Branden. We discuss connnections between the conjecture and results of Szego and others. This is joint work with Mirko Visontai. (Received August 30, 2009)

1053-05-177 **Gábor Hetyei*** (ghetyei@uncc.edu), Department of Mathematics and Statistics, UNC-Charlotte, Charlotte, NC 28223-0001, and **Christian Krattenthaler** (christian.krattenthaler@univie.ac.at), Fakultät für Mathematik, University of Vienna, Nordbergstraße 15, A-1090 Vienna, Austria. *The Möbius function of the poset of bipartitions.*

Bipartitional relations were introduced by Foata and Zeilberger, who showed these are precisely the relations which give rise to equidistribution of the associated inversion statistic and major index. In this talk we consider the natural partial order on bipartitional relations given by inclusion, and explain why the Möbius function of every interval is 0, 1, or -1. We achieve this goal by engaging in a deeper topological study of the order complex of this partially ordered set. We will see that bipartitional relations on a set of size n form a graded lattice of rank $3n-2$. The order complex of this lattice is homotopy equivalent to a sphere of dimension $n-2$. Each proper interval in this lattice has either a contractible order complex, or it is isomorphic to the direct product of Boolean lattices and smaller lattices of bipartitional relations. The main tool in the proofs of these results is discrete Morse theory as developed by Forman, and an application of this theory to order complexes of graded posets, designed by Babson and Hersh.

This is joint work with Christian Krattenthaler. (Received September 02, 2009)

1053-05-187 **John Maharry*** (maharry@math.ohio-state.edu), Dept. of Mathematics, The Ohio State University, Columbus, OH , and **Daniel Slilaty** (slilaty@math.wright.edu), Dept. of Mathematics, Wright State University, Dayton, OH. *Projective-Planar Graphs with no $K_{3,4}$-minor.*

There are known exact excluded-minor characterizations of several small graphs, including K_5, $K_{3,3}$, V_8, Q_3 and C_7^2. Such characterizations for K_6 or the Petersen Graph would help to settle many conjectures, but seem out of reach at present. In this talk, we will present a characterization of $K_{3,4}$-Free graphs on the Projective plane. The maximal such graphs are generated by four operations on designated 'patches' of the embedding. Further, we will discuss progress in the non-Projective planar case, based the list of 35 minor-minimal non-projective planar graphs. (Received September 03, 2009)

1053-05-194 **Mark Ellingham*** (mark.ellingham@vanderbilt.edu) and **Xiaoya Zha**. *Orienting pseudographs and orientable cycle double covers for projective-planar graphs.*

We discuss some recent ideas for turning nonorientable embeddings into orientable ones. Together with a structure theorem for cubic projective-planar graphs, these ideas allow us to show that every 2-connected projective-planar graph has an orientable cycle double cover. (Received September 03, 2009)

1053-05-203 **Hélène Barcelo** and **Christopher Severs*** (csevers@msri.org), The Mathematical Sciences Research Institute, 17 Gauss Way, Berkeley, CA 94720-5070, and **Jacob A. White**. *The discrete fundamental group of the Associahedron and its relation to the type-A cluster algebra.*

The associahedron is a polytope that has received much attention in recent years. It has appeared in the study of areas such as operads, lattice theory, mathematical physics, algebraic geometry and cluster algebras, to name a few. The associahedron is of special interest to combinatorists because the vertices are counted by the Catalan numbers, which leads to many descriptions via Catalan objects such as triangulations of a regular polygon and bracketing of words.

We use the tools of discrete homotopy theory, developed by Laubenbacher and Barcelo, et al. to study the associahedron. We give a combinatorial description for the equivalence classes of the discrete fundamental group in terms of 5-cycles in the 1-skeleton of the associahedron. We then use this description to give a presentation for the discrete fundamental group.

Furthermore, we describe the pentagonal relations in the type-A cluster algebra via the discrete homotopy classes. We show that the homotopy classes correspond exactly to the pentagonal relations and that the classes which generate the abelianization of the discrete fundamental group also generate all pentagonal relations in the cluster algebra. (Received September 03, 2009)

1053-05-207 **Domenico Senato*** (domenico.senato@unibas.it), Viale dell'Ateneo Lucano 10, 85100 Potenza, Italy, and **Elvira Di Nardo**, Viale dell'Ateneo Lucano 10, 85100 Potenza, Italy.
Computations of classical, boolean and free cumulants via Abel polynomials.

We provide an unifying polynomial expression giving moments in terms of cumulants, and viceversa, holding in the classical, boolean and free setting. This is realized by using a suitable representation of Abel polynomials, relied on the classical umbral calculus, a symbolic language introduced by Rota and Taylor in "The classical umbral calculus", SIAM J. Math. Anal. 25 (1994), 694-711. Moreover via these generalized Abel polynomials, we construct a new class of cumulants, including the classical, boolean and free ones, and the convolutions linearized by them. We give a simple and computationally efficient algorithm for conversion formulae between moments and cumulants. The algorithm provides just one formula for all kind of cumulants and it is particularly suited to be implemented by using software for symbolic computations, as for example MAPLE. Comparisons with existing procedures, especially for conversions between moments and free cumulants, show the efficiency of the proposed approach. (Received September 04, 2009)

1053-05-209 **Alexandra Ovetsky Fradkin*** (aovetsky@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08540, and **Paul Seymour**. *A polynomial algorithm for the edge-disjoint paths problem for tournaments.* Preliminary report.

We present a polynomially bounded algorithm to solve the following problem: for fixed $k \geq 0$, given a tournament T and k pairs of vertices of T, decide if there are k mutually edge-disjoint paths of T joining the pairs. This problem is known to be NP-complete for digraphs in general for $k \geq 2$. (Received September 04, 2009)

1053-05-218 **Miklos Bona***, University of Florida, Gainesville, FL 32611-8105, and **Philippe Flajolet**.
Isomorphism and Symmetries in Random Phylogenetic Trees.

The probability that two randomly selected phylogenetic trees are isomorphic is found to be asymptotic to a decreasing exponential modulated by a polynomial factor. The number of symmetrical nodes in a random phylogenetic tree of large size obeys a limiting Gaussian distributions. Precise estimates for these two problems are obtained by means of bivariate generating functions, singularity analysis, and quasi-powers approximations. (Received September 04, 2009)

1053-05-237 **Michael Reid*** (reid@math.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Tiling with L polyominoes.*

Let L_n denote the polyomino of size n formed by placing a single square atop the leftmost square of a row of $n-1$ squares. A necessary condition for a rectangle to be tileable by L_n is that its area is a multiple of n. We previously conjectured that, for odd n, this condition is also sufficient, if both sides are large enough. We also made the stronger conjecture that the same is true, even if the tile L_n may only be rotated, but not reflected.

We discuss the motivation for and significance of these conjectures, and show how they recently became theorems. (Received September 06, 2009)

1053-05-248 **Oguz Kurt*** (oguz@math.ohio-state.edu), 231 W 18th Ave, Columbus, OH 43210.
Finding New Elementary Sets from Old Ones.

In 1967, Gupta conjectured that $\chi'(G) - \chi^*(G) < 1$ provided that $\chi'(G) > \Delta(G) + 1$ where Δ, χ' and χ^* are the maximum degree, the chromatic index and the fractional chromatic index of G, respectively. This conjecture was later named as Goldberg Conjecture since Goldberg conjectured the same problem in 1974. We introduce some new methods and terminology that are useful toward the proof of this conjecture. We also prove that $\chi' - \chi^* < 1$ provided that $\chi' > \frac{21}{20}\Delta + \frac{18}{20}$. This result is an improvement to the previously best known linear result toward the proof of Goldberg Conjecture. (Received September 07, 2009)

1053-05-249 **Alexander Burstein*** (aburstein@howard.edu), Department of Mathematics, Howard University, Washington, DC 20059. *On joint distribution of adjacencies and some Eulerian and Mahonian statistics.* Preliminary report.

We prove several results on the joint distribution on permutations of the number of adjacencies (descents by 1) and some Eulerian and Mahonian statistics. We also show that a certain bistatistic on Viennot's alternative tableaux is Euler-Mahonian. (Received September 07, 2009)

1053-05-253 **Dan Cranston** and **Gexin Yu*** (gyu@wm.edu). *A New Lower Bound on the Density of Vertex Identifying Codes for the Infinite Hexagonal Grid.* Preliminary report.

Given a graph G, an identifying code $C \subseteq V(G)$ is a vertex set such that for any two distinct vertices $v_1, v_2 \in V(G)$, the sets $N[v_1] \cap C$ and $N[v_2] \cap C$ are distinct and nonempty (here $N[v]$ denotes a vertex v and its neighbors). We study the case when G is the infinite hexagonal grid H. Cohen et.al. constructed two identifying codes for H with density $3/7$ and proved that any identifying code for H must have density at least $16/39 \approx 0.410256$. Both their upper and lower bounds were best known until now. Here we prove a lower bound of $12/29 \approx 0.413793$. (Received September 07, 2009)

1053-05-259 **Guoli Ding***, Mathematics Department, Louisiana State University, Baton Rouge, LA 70803, and **Carolyn Chun**, Mathematics Department, Louisiana State University, Baton Rouge, LA 70803. *Unavoidable Topological Minors of Infinite Graphs.*

A graph G is *loosely-c-connected*, or *ℓ-c-connected*, if there exists a number d depending on G such that the deletion of fewer than c vertices from G leaves precisely one infinite component and a graph containing at most d vertices. In this paper, we determine topological-minor-minimal ℓ-c-connected graphs. Corresponding results for minors and parallel minors are also obtained. (Received September 07, 2009)

1053-05-263 **Itaru Terada*** (terada@ms.u-tokyo.ac.jp), Graduate School of Mathematical Sciences, University of Tokyo, Komaba 3-8-1, Meguro-ku, TOKYO 170-0011, Japan. *Jordan types of certain nilpotent matrices.*

Let $G = (V = \{1, 2, \dots, n\}, E)$ be a simple acyclic oriented graph, σ a fixed-point-free arrow-reversing involution defined on a subset $Z \subset V$, and $Z = Z^+ \amalg Z^-$ a partition of Z such that $\sigma(Z^\pm) = Z^\mp$. If $a \in Z$, write $\varepsilon(a) = \pm 1$ according to $a \in Z^\pm$. Define two linear spaces $\mathcal{N}_*(G, \sigma)$, $* = \mathfrak{p}$ and $\mathfrak{k}$, consisting of nilpotent matrices, by

$$\mathcal{N}_*(G,\sigma) = \{\, X = (x_{ab}) \in M(n, \mathbb{C}) \mid x_{ab} = 0 \text{ unless } (a,b) \in E,\ x_{\sigma(b)\sigma(a)} = \varepsilon_* \varepsilon(a)\varepsilon(b) x_{ab} \text{ if } a, b \in Z \,\}$$
$$(\varepsilon_* = 1 \text{ if } * = \mathfrak{p},\ \varepsilon_* = -1 \text{ if } * = \mathfrak{k}).$$

We describe the "generic Jordan type" for (= the Jordan type common to most elements of) each of these two subspaces, extending Gansner and Saks' results for the case $Z = \varnothing$. The problem was motivated by certain special cases related to the (complexified) symmetric space GL_{2n}/Sp_{2n}. (Received September 07, 2009)

1053-05-269 **Hua Wang*** (hwang@georgiasouthern.edu). *'Semi-Regular Trees' and Their Applications.*

For trees, we present an interesting 'semi-regular' property, which emerged from the study of the extremal questions regarding trees and several topological indices from different backgrounds. We shall see that this 'semi-regular' property plays an important role in characterizing the extremal structures and potentially leads to a unified solution for various extremal problems. (Received September 07, 2009)

1053-05-271 **William Chen**, **Svetlana Poznanović*** (spoznan@math.tamu.edu), **Catherine Yan** and **Arthur Yang**. *Major Index for 01-Fillings of Moon Polyominoes.*

We propose a major index statistic on 01-fillings of moon polyominoes which, when specialized to certain shapes, reduces to the classical major index for permutations and set partitions. We consider the set $\mathbf{F}(\mathcal{M}, \mathbf{s}; A)$ of all 01-fillings of a moon polyomino $\mathcal{M}$ with given column sum $\mathbf{s}$ whose empty rows are A, and prove that this major index has the same distribution as the number of north-east chains, which are the natural extension of inversions (resp. crossings) for permutations (resp. set partitions). Hence our result generalizes the classical equidistribution results for the permutation statistics inv and maj. Two proofs will be presented. The first is an algebraic one using generating functions, and the second is a bijection on 01-fillings of moon polyominoes in the spirit of Foata's second fundamental transformation on words and permutations. (Received September 07, 2009)

1053-05-280 **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, **Xingxing Yu** (yu@math.gatech.edu), School of Mathematics, Atlanta, GA 30332, and **Wenan Zang** (wzang@maths.hku.hk), Department of Mathematics, the University of Hong Kong, Hong Kong, GA. *Chromatic index involving edge density.*

Let G be a multigraph with finite number of vertices and without loops. Let Δ denote *maximum degree* of G, χ' the chromatic index of G, and let

$$\Gamma = \max\{\frac{2|E(G[U])|}{|U|-1} : \ U \subseteq V, \ |U| \geq 3 \ \text{ and } \ \text{odd}\}.$$

Clearly, $\chi' \geq \Delta$. Conversely, Vizing showed that $\chi' \leq \Delta + 1$ if G is a simple graph. Furthermore, Vizing proved that $\chi' \leq \Delta + \mu$, where μ is the maximum number of multiple edges sharing two endvertices. For each $U \subseteq V(G)$, since each matching in the subgraph induced by U contains at most $\lfloor |U|/2 \rfloor$ edges, the inequality $\chi' \geq \Gamma$ holds. Goldberg (1973), Anderson (1977), and Seymour (1979) conjectured that if $\chi' \geq \Delta + 2$ then $\chi' = \Gamma$. Previously, Scheide and, independently, Chen, Yu, and Zang proved that if $\chi' \geq \Delta + \sqrt{\Delta/2}$ then $\chi' = \Gamma$. In this paper, we proved that if $\chi' \geq \Delta + \sqrt[3]{\Delta/2}$ then $\chi' = \Gamma$. (Received September 07, 2009)

1053-05-303 **John Freeman**, **Tomas Schonbek** and **Wandi Wei*** (wei@math.fau.edu), 777 Glades Road, Boca Raton, FL 33431. *On a Tennis Ball Problem.*

Let $s_i > t_i$ $(1 \leq i \leq n)$ be positive integers, and let $s = s_1 + \ldots + s_n$. The tennis ball problem we are considering here goes as follows. There are s tennis balls, labeled $1, 2, \ldots, s$, to be handled in n turns. At the first turn, t_1 balls are taken out from the ones labeled $1, \ldots, s_1$. At the ith turn $(2 \leq i \leq n)$, t_i balls are taken out from the ones that are left in the previous turn and the ones labeled with $s_1 + \ldots + s_{i-1} + 1, s_1 + \ldots + s_{i-1} + 2, \ldots, s_1 + \ldots + s_{i-1} + s_i$. We call the set of the balls taken-out an $(s_1, \ldots, s_n; t_1, \ldots, t_n)$-set. Our tennis ball problem asks for the number, denoted by $N(s_1, \ldots, s_n;\ t_1, \ldots, t_n)$, of possible $(s_1, \ldots, s_n;\ t_1, \ldots, t_n)$-sets.

We first characterize $(s_1, \ldots, s_n;\ t_1, \ldots, t_n)$-sets in two different ways, and then employ these characterizations to give two formulas for $N(s_1, \ldots, s_n;\ t_1, \ldots, t_n)$. For the case $s_i = 2$ and $t_i = 1$ $(1 \leq i \leq n)$, our formulas are reduced to the known result: the number of such sets is the $(n+1)$st Catalan number. (Received September 07, 2009)

1053-05-309 **John Irving*** (johncirving@gmail.com), 6047 Williams Street, Halifax, N.S. B3K1G1, Canada. *Factoring Permutations up to Commutation.* Preliminary report.

There has been much interest over the past 15 years in various enumerative aspects of permutation factorization, with a great deal of this study spawned by the intimate relationship between such combinatorial problems and algebraic geometry (more precisely, the geometry and topology of the moduli space of curves).

We shall consider an interesting combinatorial variant of the usual problem: We count decompositions of a permutation into transpositions, but do so up to an equivalence relation that allows for the commutation of adjacent disjoint factors. Our results demonstrate a surprising (and not fully understood) parallel with the rich structure of "ordinary" factorizations that may well have connections to geometry. (Received September 08, 2009)

1053-05-313 **Hemanshu Kaul*** (kaul@iit.edu), Engineering 1 Building #208, 10 West 32nd Street, Chicago, IL 60616, and **YoungJu Jo**. *Guarding Orthogonal Art Galleries with Holes.* Preliminary report.

The original art gallery problem (V.Klee, 1973) asked for the minimum number of guards sufficient to see every point of the interior of an n-vertex simple polygon. Chvatal (1975) proved that $n/3$ guards are always sufficient. If all the edges of the given simple polygon are either horizontal or vertical, then such a polygon is called an orthogonal polygon. Kahn, Klawe and Kleitman (1983) proved that $n/4$ guards are sufficient for such a n-vertex gallery.

We are interested in orthogonal gallery with holes, i.e, an orthogonal polygon enclosing some other orthogonal polygons called holes such that interior of each hole is empty (these are obstructions to visibility). In 1982, Shermer conjectured that any orthogonal polygon with n vertices and h holes can be guarded by $(n + h)/4$ guards. This conjecture remains open. The best known result shows that $(n + 2h)/4$ guards suffice (O'Rourke, 1987). In this talk we will discuss the history of these problems and some of the proofs involving graph coloring. We will outline our approach using graph coloring to prove that $(n + (5/3)h)/4$ guards suffice for an orthogonal gallery with n vertices with h holes. (Received September 08, 2009)

1053-05-329 **Cun-Quan Zhang*** (cqzhang@math.wvu.edu), Math. Dept, POBox 6310, Morgantown, WV 26506-6310. *The second circuit conjecture and cycle double cover conjecture.* Preliminary report.

It was asked by Seymour that, for every cubic, bridgeless graph G and every circuit C of G, whether or not G contains a circuit C' distinct from C with $V(C) \subseteq V(C')$ (The Second Circuit Problem).

This problem, if true, implies the famous cycle double cover conjecture. Although a counterexample was discovered by Fleischner (1994), the Second Circuit Problem remains as a valid approach to a CDC conjecture.

In this talk, we will survey some old and recent results, and propose some modifications of this problem and possible approaches to CDC conjecture (Received September 08, 2009)

1053-05-333 **John Shareshian** and **Michelle L Wachs*** (wachs@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33124. *Eulerian quasisymmetric functions.*

In this paper we consider an interesting class of symmetric functions that we call Eulerian quasisymmetric functions because they are defined as sums of fundamental quasisymmetric functions associated with permutations having a given number of excedences. These symmetric functions play an essential role in our study of the joint distribution of the permutation statistics major index and excedence number. In this talk I will discuss various properties of the Eulerian quasisymmetric functions, such as Schur positivity and Schur unimodality. Consequences for the (maj,exc) q-Eulerian polynomials and their cycle-type refinements will also be discussed. (Received September 08, 2009)

1053-05-336 **John Maharry** and **Neil Robertson*** (robertso@math.ohio-state.edu), Department of Mathematics, Ohio State University, Columbus, OH 43210, and **Vaidy Sivaraman** and **Daniel Slilaty**. *Projective plane embeddings of a graph and signed graph representations of a matroid.*

In the study of all signed graph representations of a given signed graph matroid one case involves finding all embeddings of any given graph on the projective plane. In the literature cases typified by the line-graph of the Petersen graph appear to have been overlooked. This flexibility issue will be covered and related to the corresponding signed graph representation problem. This is joint work with John Maharry, Vaidy Sivaraman, and Daniel Slilaty. (Received September 08, 2009)

1053-05-353 **Hasan Coskun*** (hasan_coskun@tamu-commerce.edu), Department of Mathematics, 2600 S. Neal St., Commerce, TX 75429. *A Multilateral Bailey Lemma and Multiple Andrews-Gordon Identities.*

We present a multilateral version of a BCn Bailey Lemma using the hyperoctahedral symmetries of Macdonald functions and Jackson coefficients. We then use the lemma to generate multiple analogues of Andrews-Gordon identities. (Received September 09, 2009)

1053-05-356 **Evan Morgan** and **Bogdan Oporowski*** (bogdan@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Decomposing and transforming cubic graphs.*

James Oxley asked whether every graph may have its edges partitioned into two sets such that the contraction of the elements of either set produces a series-parallel graph. While our attempts to fully answer his question have been unsuccessful, they lead us to interesting results, some of which provided partial answers, while some others gave us new insights into cubic graphs. One such new results states that any connected cubic graph can be transformed into any other connected cubic graph on the same vertex set by a sequences of operations that are generalizations of an edge slide. In the talk, I will discuss our successes, our failures, and, most importantly, the new questions raised by our research. (Received September 10, 2009)

1053-05-358 **Joseph P. Brennan*** (jpbrenna@mail.ucf.edu), Department of Mathematics, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816-1364. *Advances in algebraic methods in graph theory.* Preliminary report.

This talk will give a survey of the recent use of algebraic methods in addressing combinatorial questions in graph theory. (Received September 10, 2009)

1053-05-359 **Chris Stephens** (cstephen@mtsu.ed), Murfreesboro, TN 37132, and **Xiaoya Zha*** (xzha@mtsu.edu), Murfreesboro, TN 37132. *Spanning disks of toroidal embeddings.*

A spanning subset of an embedded graph (containing all vertices but missing some edges) may provide a simpler structure, yet still enough information, to approach certain problems about that graph. In this paper we

prove that any 3-representative embedding of a 4-connected graph in the torus has a spanning disk. Both representativity condition and connectivity condition are best possible. (Received September 10, 2009)

1053-05-366 **Shaun P Sullivan*** (ssulli21@fau.edu), 2900 Olivewood Ter, O102, Boca Raton, FL 33431, and **Heinrich Niederhausen**. *Counting Strings in Ballot Paths.*

A ballot path stays weakly above the diagonal $y = x$, starts at the origin, and takes steps from the set $\{\uparrow, \rightarrow\} = \{u, r\}$. A pattern is a finite string made from the same step set; it is also a path. We consider $b_{n,k}(m)$, the number of ballot paths containing a given pattern k times reaching (n, m). Certain types of patterns give sequences of polynomials that can be solved using multivariate Finite Operator Calculus. We only consider patterns p such that its reverse pattern $\tilde{p}$ is a ballot path. We require this restriction so that the recurrence relation contains only values of the polynomial sequence that correspond to ballot paths and not the extensions of the polynomial sequence. For example, the pattern $p = uuurr$ would give the recurrence $b_{n,k}(m) = b_{n-1,k}(m) + b_{n,k}(m-1) - b_{n-2,k}(m-3) + b_{n-2,k-1}(m-3)$ when $m > n$ and $b_{n,k}(n) = b_{n-1,k}(n)$, so if we used the first recurrence to define the polynomials, we would be using values below the diagonal that do not correspond to ballot paths. Notice that $\tilde{p} = uurrr$ is not a ballot path. To develop the recursions, we need to investigate the properties of the pattern we wish to avoid. Ballot paths reaching the diagonal can be viewed as Dyck paths. (Received September 11, 2009)

06 ► Order, lattices, ordered algebraic structures

1053-06-44 **Paola Toto*** (paola.toto@unile.it), Via Cappelli, 33, 35123 Padova, Padova, Italy, and **Maria Emilia Maietti** and **Giovanni Sambin**. *Many-valued structures for constructive topology.*

Sambin in his forthcoming book, *The Basic Picture a structural basis for constructive topology* (Oxford University Press, to appear), introduces a new topological theory, called "The Basic Picture". In this theory both the notion of topological space and its point-free version are generalized. The concept of overlap algebra is also introduced in order to put in algebraic form the properties needed to define the new topological structures. The ultimate goal of our work is to generalize such topological notions in the context of many-valued sets. In many-valued set theory sets are built by using propositions evaluated in an algebraic structure. To reach our goal a key point is to check whether the original algebrization of Sambin's topological notions can be considered also as the algebrization of their many-valued version. We prove that this is the case if and only if we take an overlap algebra as the underlying structure of truth values. (Received July 14, 2009)

1053-06-304 **Teena Carroll*** (teena.carroll@snc.edu), 100 Grant St., De Pere, WI 54115, and **Josh Cooper** and **Prasad Tetali**. *An Enumerative Perspective on the Chain Poset.*

The chain product poset $[t]^n$, is a generalization of the Boolean Lattice formed by looking at ordered n-tuples with the alphabet $\{0, \ldots, t\}$. We form a partially order using the standard direct product of n chains of length t. The resulting poset has some desirable properties: it is a ranked sperner poset with unique minimal and maximal elements. However it also lacks some nice properties, in particular, elements of the same rank may have vastly different degrees. We give estimates for the Whitney numbers, the number of linear extensions, and number of antichains for this poset. (Received September 07, 2009)

11 ► Number theory

1053-11-3 **Dino J Lorenzini*** (lorenzini@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602. *The index of an algebraic variety.*

Let K be a field and let X/K be an algebraic variety. The index of X/K is the greatest common divisor of the degrees over K of the points of X. In a simple example such as when X is a plane curve given by an equation f(x,y)=0 with f(x,y) in K[x,y], the index is the greatest common divisor of the integers [K(a,b):K], where f(a,b)=0, and a,b are in the algebraic closure of K.

After surveying basic facts on the index, we will explain how the index of X/K can be computed in a completely different way, using multiplicities of primary ideals in a singular local ring associated with the variety X. This is joint work with O. Gabber and Q. Liu. (Received September 08, 2009)

1053-11-42 **Li Zhou*** (Lzhou@polk.edu), Department of Mathematics, 999 Avenue H NE, Winter Haven, FL 33881, and **Lubomir Markov** (lmarkov@mail.barry.edu), Department of Mathematics and CS, 11300 NE Second Avenue, Miami Shores, FL 33161. *Recurrent proofs of the irrationality of certain values of elementary transcendental functions.*

We present short new proofs of the irrationality of $\tan r$ for $r \in \mathbb{Q} \setminus \{0\}$ and $\cos r$ for $r^2 \in \mathbb{Q} \setminus \{0\}$. We also discuss applications of our technique to simpler irrationality proofs such as those for π, π^2, and certain values of exponential and hyperbolic functions. (Received July 12, 2009)

1053-11-81 **Dimitar P Jetchev*** (jetchev@gmail.com), 444 W 58th st, apt. 4E, New York, NY 10019. *Global Divisbility of Heegner Points and Tamagawa Numbers.*

We improve Kolyvagin's upper bound on the order of the p-primary part of the Shafarevich-Tate group of an elliptic curve of rank one over a quadratic imaginary field. In many cases, our bound is precisely the one predicted by the Birch and Swinnerton-Dyer conjectural formula. (Received August 17, 2009)

1053-11-103 **Asher Auel*** (asher.auel@gmail.com), Department of Mathematics and CS, Emory University, 400 Dowman Drive W401, Atlanta, GA 30322. *Clifford sequences in the theory of line bundle-valued quadratic forms over arithmetic schemes.*

The theory of Witt groups of line bundle-valued quadratic forms over arithmetic schemes has undergone recent rapid development. In this talk, we will introduce an étale cohomological invariant of line bundle-valued quadratic forms that generalizes the classical Hasse-Witt invariant. This invariant arises from a newly constructed Clifford sequence for orthogonal similitide groups. In low ranks, we show how this Clifford sequence reflects accidental isomorphisms of Dynkin diagrams and is useful for classifying line bundle-valued quadratic forms in terms of 2-torsion elements of the Brauer group. We will also mention applications to the Milnor conjectures over arithmetic schemes. (Received August 25, 2009)

1053-11-111 **Chris Hall*** (christopher.hall@uwyo.edu), Ross Hall 305, Dept 3036, 1000 E. University Ave, Laramie, WY 82071. *Gonality and Hilbert Irreducibility.*

Given a Galois extension of the function field $\mathbb{Q}(t)$ one can specialize t to an element of a number field K in order to obtain a Galois extension of K. While the specialized Galois group is allowed to be smaller in general, a typical argument using Hilbert Irreducibility allows one to conclude that 'most' specializations have the same Galois group. The main goal of our talk will be to review a modern approach to drawing this conclusion. The key ingredient will be Faltings' celebrated (big) theorem which implies that a curve over a number field F with large gonality has only finitely many rational points defined over some small extension K/F. If time permits, we will describe an application to the endomorphism rings of the members of a (sufficiently general) one-parameter family of abelian varieties over $\mathbb{Q}$. (Received August 26, 2009)

1053-11-116 **A. Raghuram*** (araghur@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Eisenstein cohomology and special values of Rankin-Selberg L-functions.* Preliminary report.

I will begin this talk by introducing Eisenstein cohomology. Then, I will show how one can use an analysis of rank one Eisenstein cohomology for the group GL(N), where N is an odd positive integer that is at least 3, to prove algebraicity theorems for ratios of critical values of Rankin-Selberg L-functions for GL(a) x GL(b), with a + b = N. This is joint work with Guenter Harder, which generalizes previous work of Harder in the case of GL(2) x GL(1), and complements my own recent work on the central critical value of L-functions for GL(n) x GL(n-1). (Received August 27, 2009)

1053-11-136 **Eliot P Brenner*** (brenn240@math.umn.edu), Vincent Hall, 206 Church Street SE, Minneapolis, MN 55455. *Analytic Properties of Residual Eisenstein Series.*

We partially generalize the results of Kudla and Rallis on the poles of degenerate, Siegel-parabolic Eisenstein series to residual-data Eisenstein series. In particular, for a, b integers greater than 1, we show that poles of the Eisenstein series induced from the Speh representation $\Delta(\tau, b)$ on the Levi GL_{ab} of Sp_{2ab} are located in the "segment" of half integers X_b between a "right endpoint" and its negative, inclusive of endpoints. The right endpoint is $\pm b/2$, or $(b-1)/2$, depending on the analytic properties of the automorphic L-functions attached to τ. We study the automorphic forms $\Phi_i^{(b)}$ obtained as residues at the points $s_i^{(b)}$ (defined precisely in the paper) by calculating their cuspidal exponents in certain cases. In the case of the "endpoint" $s_0^{(b)}$ and "first interior point" $s_1^{(b)}$ in the segment of singularity points, we are able to determine a set containing *all possible* cuspidal exponents of $\Phi_0^{(b)}$ and $\Phi_1^{(b)}$ precisely for all a and b. In these cases, we use the result of the calculation to deduce that the residual automorphic forms lie in $L^2(G(k)\backslash G(\mathbf{A}))$. (Received August 30, 2009)

1053-11-146 **Ameya Pitale*** (pitale@aimath.org), 360, Portage Ave, Palo Alto, CA 94306. *L-functions for* $\mathrm{GSp}(4) \times \mathrm{GL}(2)$ *and special values.*

Special values of L-functions has a long and rich history. For example, the value of the Riemann zeta function at even positive integers is rational up to a suitable power of π. Due to the work of Shimura, Garrett and many others, special value results for L-functions associated to one or more modular forms are known. These fit into the general framework of a conjecture of Deligne on special values of L-functions. I will give a brief glimpse of some of these results. Recently, in a joint work with Ralf Schmidt, I have been working on the L-function of a Siegel modular form twisted by any cuspidal automorphic GL(2) representation. We obtain an integral representation for the L-functions and obtain special value results as an application. (Received August 31, 2009)

1053-11-153 **Mihran Papikian*** (papikian@math.psu.edu), Department of Mathematics, Pennsylvania State University, University Park, PA 16802. *On the arithmetic of modular curves of* $\mathcal{D}$*-elliptic sheaves.*

Modular curves of $\mathcal{D}$-elliptic sheaves are the function field analogues of Shimura curves. We study the existence of rational points on modular curves of $\mathcal{D}$-elliptic sheaves over local fields and the structure of fundamental domains of these curves in the Bruhat-Tits tree. We discuss some applications which include finding presentations for arithmetic groups arising from quaternion algebras over function fields and finding the equations of modular curves of $\mathcal{D}$-elliptic sheaves. (Received August 31, 2009)

1053-11-156 **John Voight*** (jvoight@gmail.com), Department of Mathematics and Statistics, University of Vermont, 16 Colchester Ave, Burlington, VT 05401. *Tables of modular elliptic curves over totally real fields.*

Employing algorithms to explicitly compute spaces of Hilbert modular forms, we provide a Cremona-like database of modular elliptic curves over totally real fields of small discriminant. We report on some interesting features of the data collected. (Received September 01, 2009)

1053-11-181 **Xander Faber*** (xander@math.mcgill.ca), McGill University, Department of Mathematics and Statistics, 805 Sherbrooke St. West, Montreal, Quebec H3A 2K6, Canada. *Prime Factors of Dynamical Sequences.*

Let $\phi(t) \in \mathbb{Q}(t)$ be a rational function of degree at least 2. For a given rational number x_0, define $x_{n+1} = \phi(x_n)$ for each $n \geq 0$. If this sequence is not eventually periodic, then $x_{n+1} - x_n$ has a primitive prime factor for all sufficiently large n. This result provides a new proof of the infinitude of primes for each rational function ϕ of degree at least 2.

I will present the above result, along with some interesting refinements. I will also give a geometric description that suggests a question about dynamics in higher dimensions. This is joint work with Andrew Granville. (Received September 02, 2009)

1053-11-196 **Amod Agashe*** (agashe@math.fsu.edu), Department of Mathematics, Florida State Univ, 208 Love Building, Tallahassee, FL 32312. *Rational torsion in elliptic curves and the cuspidal subgroup.*

Let E be an optimal elliptic curve over the rationals of conductor N, which we may view as an abelian subvariety of the modular Jacobian variety $J_0(N)$. The cuspidal subgroup of $J_0(N)$ is the group of degree zero divisors supported on the cusps of the modular curve $X_0(N)$. It follows from work of Mazur that if N is prime, then the rational torsion points of E are contained in the cuspidal subgroup, and thus the cuspidal subgroup "explains" the rational torsion in E. Based on some numerical data, we suspect that this may happen more generally even if N is not prime. In this talk, we will show that if N is square free and E has a rational torsion point of prime order r such that r does not divide 6N, then r divides the order of the cuspidal subgroup. (Received September 03, 2009)

1053-11-200 **Álvaro Lozano-Robledo*** (alozano@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 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 September 03, 2009)

1053-11-204 **Abhinav Kumar*** (abhinav@math.mit.edu), Department of Mathematics, Rm 2-169, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139. *K3 surfaces and Hilbert modular surfaces.* Preliminary report.

We will describe an explicit birational map between the moduli space of principally polarized abelian surfaces, and a certain 3-dimensional family of elliptic K3 surfaces. As an application, we will describe how to write equations for Hilbert modular surfaces (following Elkies), and give examples of genus 2 curves over $\mathbb{Q}$ whose Jacobians have real multiplication by the ring of integers of a real quadratic field, such as $\mathbb{Q}(\sqrt{77})$. (Received September 03, 2009)

1053-11-245 **Bianca L Viray*** (bviray@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, Berkeley, CA 94609. *Failure of the Hasse principle for Enriques surfaces.* Preliminary report.

Most counterexamples to the Hasse principle can be explained by an algebraic Brauer–Manin obstruction. We define some of the other possible obstructions and exhibit an Enriques surface where the failure of the Hasse principle is not explained by an algebraic Brauer–Manin obstruction. (Received September 06, 2009)

1053-11-246 **Martin H. Weissman*** (weissman.marty@gmail.com), Dept. of Mathematics, UCSC, 1156 High Street, Santa Cruz, CA 95064. *Dichotomy and the local Langlands conjecture for G_2.*

The local Langlands conjecture predicts that to every generic cuspidal irreducible representation of G_2 over a p-adic field, one may associate either a cuspidal irreducible representation of PGL_3, or else a generic cuspidal irreducible representation of $PGSp_6$. Conversely, this dichotomy for representations reduces the local Langlands conjecture for G_2 (for generic irreducible representations) to the local Langlands conjecture for the classical groups PGL_3 (where it is known) and $PGSp_6$ (where it is "almost" known).

In this talk I will describe recent work, joint with Gordan Savin, which proves this predicted dichotomy for generic cuspidal irreducible representations of G_2, over p-adic fields with $p \neq 2$ (when $p = 2$, a slightly weaker result is proven). I will also describe the corresponding dichotomy for Galois representations. The methods include theta correspondences in the exceptional groups E_6 and E_7, a study of Shalika periods, and spin L-functions for $PGSp_6$. (Received September 06, 2009)

1053-11-267 **Shahed Sharif*** (sharif@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27708-0320. *The period-index problem for genus 1 curves over number fields.*

The period of a curve is the smallest positive degree of Galois-invariant divisor classes. The index is the smallest positive degree of rational divisors. We construct examples of genus one curves with prescribed period and index over a given number field. (Received September 07, 2009)

1053-11-278 **Alexander Berkovich*** (alexb@ufl.edu), Dept. of Mathematics, 496 Little Hall, Gainesville, FL 32611. *On representation of an integer by $X^2 + Y^2 + Z^2$ and the modular equations of degree 3 and 5.*

I discuss a variety of results involving $s(n)$, the number of representations of n as a sum of three squares. One of my objectives is to reveal numerous interesting connections between the properties of this function and certain modular equations of degree 3 and 5. I propose an interesting identity for $s(p^2n) - ps(n)$ with p being an odd prime. (Received September 07, 2009)

1053-11-302 **Amanda M Beeson*** (Amanda.Beeson@williams.edu), Williams College, 288 Bronfman Science Center, Williamstown, MA 01267. *On the explicit construction of the maximal almost abelian extension of an imaginary quadratic base field.*

An *almost abelian group* is one in which every commutator is central and squares to the identity. In his paper entitled *Kronecker and Weber plus epsilon* Anderson constructs explicitly the maximal almost abelian extension of the rational numbers. I will discuss progress made on the analogous construction for an imaginary quadratic base field. I will also comment on some related problems that arise in the theory of modular functions. (Received September 07, 2009)

1053-11-306 **Aaron Levin***, 307 Olden Ln, Princeton, NJ 08540, and **Julie Tzu-Yueh Wang** and **Ta Thi Hoai An**. *A p-adic Nevanlinna-Diophantine Correspondence.* Preliminary report.

In analogy with the now well-known correspondence between Nevanlinna theory and Diophantine approximation (Vojta's dictionary), we discuss a correspondence between, on the one hand, p-adic Nevanlinna theory and p-adic

analytic maps, and on the other hand, certain Diophantine statements over the rational numbers and integers. (Received September 07, 2009)

1053-11-310 **Patrick K Corn*** (pcorn@mathcs.emory.edu), Department of Math and Computer Science, Emory University, 400 Dowman Dr., W402, Atlanta, GA 30322. *Brauer-Manin obstructions on K3 surfaces.*

We give examples of Brauer-Manin obstructions to the Hasse principle on K3 surfaces, with applications to the study of the Tate-Shafarevich group of the Jacobian of a genus-2 curve. (Received September 08, 2009)

1053-11-332 **Seyfi Turkelli*** (turkelli@math.uga.edu), 290 Appleby Dr, #266, Athens, GA 30605. *Counting Algebraic Numbers of Fixed Degree and Fixed Height over Global Fields.*

Masser-Vaaler and Thunder counts the algebraic numbers of fixed degree (over a fixed global field) and fixed height. In this talk, generalizing the work of Thunder, we will count the branch covers Y–> C (of a smooth projective curve C/F_q) in a conic bundle X–> C with fixed height and fixed degree. We will discuss open problems and possible generalizations. (Received September 08, 2009)

1053-11-341 **Matthew Boylan*** (boylan@math.sc.edu), University of South Carolina, Columbia, SC 29201, and **Sharon Garthwaite** (sag028@bucknell.edu), Bucknell University, Lewisburg, PA 17837. *The arithmetic-geometric mean and p-adic limits of modular forms.*

The arithmetic-geometric mean of Gauss is the coincident limit of two sequences which arise naturally from systematically taking arithmetic and geometric means. Gauss proved that these sequences and their limit, the AGM, are parametrizable by values of modular forms. In this talk, we will exhibit a sequence of weakly holomorphic modular forms whose p-adic limit parametrizes values of the AGM. The p-adic limit arises via the interplay between classical modular forms and harmonic weak Maass forms. The recent successes connecting harmonic Maass forms to partitions, Ramanujan's mock theta functions, Lie algebras, probability, mathematical physics, and topological invariants motivates independent interest in their study. (Received September 08, 2009)

1053-11-368 **Ramin Takloo-Bighash*** (rtakloo@math.uic.edu), Dept of Math, Stat, and Comp Sci., University of Illinois at Chicago, 851 S Morgan St (M/C 249), Chicago, IL 60607. *Bessel models and period integrals for* GSp(4).

In this talk I will discuss some recent results and conjectures on Bessel models and related period integrals for Siegel modular forms and their automorphic cousins. This is joint work with Dipendra Prasad and Atsushi Ichino. (Received September 11, 2009)

13 ► Commutative rings and algebras

1053-13-46 **David E. Dobbs*** (dobbs@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996-0612. *When does a ring extension of a going-down domain satisfy going-down?* Preliminary report.

If R is a going-down domain and T is a commutative unital ring extension of R, then $R \subseteq T$ satisfies going-down if and only if the associated reduced ring of T is a torsion-free R-module. (Received July 18, 2009)

1053-13-47 **Adam Van Tuyl*** (avantuyl@lakeheadu.ca), Department of Mathematical Sciences, Lakehead University, Thunder Bay, Ontario P7B5E1, Canada. *Sequentially Cohen-Macaulay Bipartite Graphs.*

Let G be a finite simple graph with vertex set $V_G = \{x_1, \ldots, x_n\}$ and edge set E_G. Associate to G its edge ideal in the ring $R = k[x_1, \ldots, x_n]$, that is, the ideal $I(G) = (x_i x_j \mid \{x_i, x_j\} \in E_G)$. We say that G is (sequentially) Cohen-Macaulay graph if the corresponding coordinate ring $R/I(G)$ is also (sequentially) Cohen-Macaulay. In this talk we consider the case of sequentially Cohen-Macaulay graphs under the extra hypothesis that G is bipartite. We show that the set of sequentially Cohen-Macaulay bipartite graphs is precisely the set of bipartite graphs whose independence complexes are vertex decomposable. We also give a formula for the Castelnuovo-Mumford regularity of $R/I(G)$ in terms of the invariants of G. (Received July 20, 2009)

1053-13-48 **Olivier A. Heubo-Kwegna*** (heubo@yahoo.fr), Department of Mathematical Sciences, Saginaw Valley State University, 7400 Bay Road, University Center, MI 48710, and **Alice Fabbri** (afabbri@mat.uniroma3.it), Dipartimento di Matematica, Università degli Studi Roma Tre, Largo San Leonardo Murialdo, 1, 00146 Roma, Italy. *Projective star operations and graded rings.*

We consider the polynomial ring $S := K[X_0, \ldots, X_n]$ over a field K and the rings $R_i := K[\frac{X_0}{X_i}, \ldots, \frac{X_n}{X_i}]$ for $0 \leq i \leq n$. We introduce the notion of a projective star operation on S and relate it to the classical star operations on the R_i's. We show that the projective Kronecker function ring $\mathbf{PKr}(S, \star)$ of S is the intersection of the Kronecker function rings $\mathbf{Kr}(R_i, \star_i)$, $0 \leq i \leq n$, where the $\star_i$'s are pairwise compatible e.a.b. star operations on the R_i's and $\star$ is a projective star operation on S built from the $\star_i$'s. (Received July 22, 2009)

1053-13-56 **W. Frank Moore**, **Greg Piepmeyer**, **Mark E. Walker** and **Sandra Spiroff*** (spiroff@olemiss.edu), Department of Mathematics, University of Mississippi, Hume Hall 305, University, MS 38677-1848. *Hochster's Theta Function and the Hodge-Riemann Bilinear Relations.* Preliminary report.

In 1981, M. Hochster introduced the *theta* function on a pair of finitely generated modules M and N, over a local hypersurface R, such that the lengths $\ell(\mathrm{Tor}_i^R(M,N))$ are finite for large enough i. By definition,

$$\theta^R(M,N) = \ell(\mathrm{Tor}_{2i+2}^R(M,N)) - \ell(\mathrm{Tor}_{2i+1}^R(M,N)),$$

for i sufficiently large. In 2006, H. Dao conjectured that *theta* vanishes for all finitely generated R-modules M and N when R is an isolated hypersurface singularity of even dimension and contains a field. We prove this conjecture under the additional assumption that R is graded with its irrelevant maximal ideal giving the isolated singularity. Furthermore, we describe the obstruction to vanishing in odd dimensions. This is joint work with Mark E. Walker, Greg Piepmeyer, and Frank Moore. (Received July 29, 2009)

1053-13-59 **Evan Houston*** (eghousto@uncc.edu), Department of Mathematics and Statistics, UNC Charlotte, Charlotte, NC 28223, **Abdeslam Mimouni** (amimouni@kfupm.edu.sa), Department of Mathematics and Statistics, King Faud University, Dhahran, 31261, Saudi Arabia, and **Mi Hee Park** (mhpark@cau.ac.kr), Department of Mathematics, Chung-Ang University, Seoul, SC 156-756, South Korea. *Integral domains which admit exactly two star operations.*

Let R be an integral domain. If R admits only two star operations, then they must be the trivial star operation and the v-operation (divisorial closure). We characterize such R when (a) R is integrally closed and (b) R is Noetherian. We also say a good bit about domains which admit only finitely many star operations. (Received July 31, 2009)

1053-13-69 **Marcela Chiorescu*** (marcela.chiorescu@gcsu.edu), Georgia College and State University, GA , and **Fred Richman** (richman@fau.edu), Florida Atlantic University, FL. *Minimal Zero-Dimensional Extensions.* Preliminary report.

The structure of minimal zero-dimensional extensions of rings with Noetherian spectrum in which zero is a primary ideal and with only finitely many prime ideals of height greater than one will be presented. These rings include Dedekind domains and $K[[X;Y]]$ where K is a field, but need not be Noetherian nor integrally closed. We show that for such a ring R there is a one-to-one correspondence between isomorphism classes of minimal zero-dimensional extensions of R and sets $\mathcal{M}$, where the elements of $\mathcal{M}$ are ideals of R primary for distinct prime ideals of height greater than zero. (Received August 11, 2009)

1053-13-71 **Basak Ay*** (bay@math.fau.edu) and **Lee Klingler** (klingler@fau.edu). *Unique Decomposition into Ideals for Reduced Commutative Noetherian Rings.*

We say that a commutative ring R has the unique decomposition into ideals (UDI) property if, for any R-module which decomposes into a finite direct sum of indecomposable ideals, this decomposition is unique up to the order and isomorphism class of the ideals. In a 2001 paper, Goeters and Olberding characterize the UDI property for Noetherian integral domains. In this paper, we characterize the UDI property for reduced Noetherian rings. (Received August 11, 2009)

1053-13-78 **John J. Watkins*** (jwatkins@coloradocollege.edu), Department of Mathematics, 14 East Cache La Poudre Street, Colorado Springs, CO 80903. *Krull Dimension of Polynomial Rings.*

We present a fundamental theorem due to J.W. Brewer, W.J. Heinzer, et al, on the height (or codimension) of prime ideals in polynomial rings, and use this theorem to give elementary proofs of several well known results concerning Krull dimension for polynomial rings. (Received August 16, 2009)

1053-13-80 **Nicholas Werner*** (werner@math.osu.edu), Department of Mathematics, The Ohio State University, 231 West 18th Ave, Columbus, OH 43210. *Integer-valued Polynomials over Quaternion Rings.*

When D is an integral domain with quotient field K, the ring $\mathrm{Int}(D) = \{f(x) \in K[x] \mid f(D) \subseteq D\}$ of integer-valued polynomials over D has been extensively studied. We will discuss integer-valued polynomials over certain non-commutative rings. Specifically, let i, j, and k be the standard quaternion units satisfying the relations $i^2 = j^2 = -1$ and $ij = k = -ji$, and define $\mathbb{Z}Q := \{a + bi + cj + dk \mid a, b, c, d \in \mathbb{Z}\}$. Then, $\mathbb{Z}Q$ is a non-commutative ring that lives inside the division ring $\mathbb{Q}Q := \{a + bi + cj + dk \mid a, b, c, d \in \mathbb{Q}\}$. For any ring R such that $\mathbb{Z}Q \subseteq R \subseteq \mathbb{Q}Q$, we define $\mathrm{Int}(R) := \{f(x) \in \mathbb{Q}Q[x] \mid f(R) \subseteq R\}$. In this talk, we will demonstrate that $\mathrm{Int}(R)$ is a ring (it is non-trivial to verify that $\mathrm{Int}(R)$ is closed under multiplication) and discuss some specific results concerning the ring $\mathrm{Int}(\mathbb{Z}Q)$ and its prime ideals. (Received August 21, 2009)

1053-13-82 **Sarah Glaz*** (glaz@math.uconn.edu), Department of Mathematics, The University of Connecticut, Storrs, CT 06269. *Gaussian Properties in Commutative Group Rings.* Preliminary report.

Let R be a commutative ring, and let f be a polynomial with coefficients in R. Denote by $c(f)$, the content of f, the ideal of R generated by the coefficients of f. A ring R is called a Gaussian ring if $c(f)c(g) = c(fg)$ for any two polynomials f and g with coefficients in R. Gaussian rings were defined by Tsang in 1965, and became an active topic of investigation due to their connection to Kaplansky's conjecture, which was solved between 1997 and 2005. The focus of these investigations lied in the comparison between the Gaussian property and several related ring theoretic and homological properties. Specifically the properties under consideration are: 1. R is a semihereditary ring. 2. w.dim$R$ is less or equal to 1. 3. R is an arithmetical ring. 4. R is a Gaussian ring. 5. R is locally a Prufer ring. 6. R is a Prufer ring. This talk will discuss the behavior of these six Gaussian properties in commutative group rings. In particular, we will consider several results and counterexamples, obtained by the speaker, to questions of ascent and descent of these properties between the ring R and the group ring RG, for an abelian group G. (Received August 18, 2009)

1053-13-87 **Trung Dinh*** (dinh@math.utah.edu), Department of Mathematics, University of Utah, Salt Lake City, UT 84112. *Associated primes of the example of Brenner and Monsky.* Preliminary report.

By work of several authors, many conditions, known to be sufficient and, in some cases, necessary for tight closure to commute with localization, are stated in terms of finiteness of certain set of associated primes, and behavior of exponents needed to annihilate local cohomology. In this talk I will discuss the finiteness of the set of associated primes of Frobenius powers of the ideal in the counterexample of Brenner and Monsky to the localization problem. (Received August 20, 2009)

1053-13-90 **Angela L Kohlhaas*** (akohlhaa@nd.edu), University of Notre Dame, 255 Hurley Hall, Notre Dame, IN 46556. *The core versus the adjoint of a monomial ideal.* Preliminary report.

Given an ideal I in a Noetherian ring R, the core of I is the intersection of all ideals contained in I with the same integral closure as I. The core naturally arises in the context of the Briançon-Skoda theorem as an ideal which contains the adjoint of a certain power of I. As the arbitrary-characteristic analog of the multiplier ideal, the adjoint is an important tool in the study of resolutions of singularities, and the question of when the core and the adjoint of a power of I are equal has been tied to a celebrated conjecture of Kawamata about the non-vanishing of sections of line bundles. By illustrating symmetry properties of the core of a monomial ideal in a polynomial ring, I will show that for certain classes of monomial ideals, this equality holds if and only if the core is integrally closed. (Received August 21, 2009)

1053-13-94 **Louiza Fouli**, **Janet Vassilev** and **Adela Vraciu***, vraciu@math.sc.edu. *A formula for tight closure core.*

The tight closure core of an ideal I is the intersection of all ideals $J \subseteq I$ that have the same tight closure as I. We prove a formula for the tight closure core for certain classes of ideals, which include ideals generated by part of a system of parameters, and sufficiently large Frobenius powers of arbitrary ideals (under additional assumptions for the ring). (Received August 24, 2009)

1053-13-96 **Luchezar L. Avramov*** (avramov@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588, **Srikanth B. Iyengar** (iyengar@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588, and **Joseph Lipman** (lipman@purdue.edu), Department of Mathematics, Purdue University, W. Lafayette, IN 47907. *Reflexivity and rigidity for complexes.*

A notion of rigidity with respect to an arbitrary semidualizing complex C over a commutative noetherian ring R is introduced and studied. One of the main results characterizes C-rigid complexes. Specialized to the case when C is the relative dualizing complex of a homomorphism of rings of finite Gorenstein dimension, it leads to broad generalizations of theorems of Yekutieli and Zhang concerning rigid dualizing complexes, in the sense of Van den Bergh. Along the way, new results about derived reflexivity with respect to C are established. Noteworthy is the statement that derived C-reflexivity is a local property; it implies that a finite R-module M has finite G-dimension over R if $M_{\mathfrak{m}}$ has finite G-dimension over $R_{\mathfrak{m}}$ for each maximal ideal $\mathfrak{m}$ of R. (Received August 24, 2009)

1053-13-100 **David E. Dobbs** and **Jay Shapiro*** (jshapiro@gmu.edu), Department of Mathematics, George Mason University, Fairfax, VA 22030-4444. *Normal pairs with zero-divisors.*

Results of Davis on normal pairs (R, T) of domains are generalized to(commutative) rings with nontrivial zero-divisors, particularly complemented rings. For instance, if T is a ring extension of an almost quasilocal complemented ring R, then (R, T) is a normal pair if and only if there is a prime ideal P of R such that $T = R_{[P]}$, R/P is a valuation domain and $PT = P$. Examples include sufficient conditions for the "normal pair" property to be stable under formation of infinite products and $\bowtie$ constructions. (Received August 25, 2009)

1053-13-109 **Mats Boij** and **Juan C. Migliore*** (migliore.1@nd.edu), Dept. of Math, University of Notre Dame, Notre Dame, IN 46556, and **Rosa M. Miro-Roig**, **Uwe Nagel** and **Fabrizio Zanello**. *Enumerating Pure O-sequences.*

A graded algebra A is *level of (socle) type* t if A is Cohen-Macaulay, the last free module in its minimal free resolution has rank t, and all summands of this last free module have the same twist. When A is Artinian and this twist is three more than the number of variables, we say that A has *socle degree* 3. We will fix the type but not the number of variables, and consider level Artinian *monomial* algebras of socle degree 3. The Hilbert function of such an algebra is called a *pure O-sequence* of socle degree 3 and socle type t. For fixed t, the number of pure O-sequences of socle degree 3 is finite. Let $P(t)$ denote this number. Then we show that

$$\lim_{t\to\infty} \frac{P(t)}{t^2} = \frac{9}{2}.$$

This result is contained in a longer joint paper with Mats Boij, Rosa Miro-Roig, Uwe Nagel and Fabrizio Zanello. The proof of this result requires several other results from the same paper, of independent interest, which we will mention. An important tool is that of Macaulay inverse systems. (Received August 26, 2009)

1053-13-110 **Daniel Erman*** (derman@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720-3840. *The Size of Free Resolutions.*

The Buchsbaum-Eisenbud-Horrocks rank conjecture roughly says that the Koszul complex is the "smallest possible" free resolution of a graded module. Although Boij-Soederberg theory is based on the principle of only considering Betti diagrams up to scalar multiple, we will explain how the structure of Boij-Soederberg theory is sufficiently strong to prove new cases of the Buchsbaum-Eisenbud-Horrocks rank conjecture. (Received August 26, 2009)

1053-13-112 **Sonja Mapes*** (smapes@math.duke.edu), Mathematics Department, 117 Physics Bldg, Box 90320, Durham, NC 27708. *Finite atomic lattices and their relationship to cellular resolutions.*

The minimal free resolution of a monomial ideal can be expressed entirely in terms of the LCM lattice of the ideal. It has also been shown that given a finite atomic lattice L with n atoms one can construct monomial ideals M with n generators whose LCM lattice is L. This talk explores the relationship between these lattices and the cellular resolutions of the associated monomial ideals by examining the parameter space of all such lattices. (Received August 26, 2009)

1053-13-132 **Claudia Polini*** (cpolini@nd.edu), University of Notre Dame, Notre Dame, IN, and **David Cox**, **Andrew Kustin** and **Bernd Ulrich**. *Curves of degree six.* Preliminary report.

We study plane curves of degree six that are given parametrically. We relate their singularities to the syzygies of the forms parametrizing the curves. (Received August 29, 2009)

1053-13-133 **Andrew Kustin**, **Claudia Polini** and **Bernd Ulrich*** (ulrich@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *Blowup algebras and elimination theory.* Preliminary report.

We report on recent advances in the elimination theory of Rees algebras and special fiber rings. Finding the defining equations of the latter corresponds to the implicitization of projective varieties that are given parametrically. (Received August 29, 2009)

1053-13-138 **Sang Bum Lee*** (sblee@smu.ac.kr), 7 Hongji-Dong, Chongro-Gu, Seoul, MD 110-743, South Korea. *Weak-injective modules over domains.* Preliminary report.

We continue to investigate the properties of weak-injective modules over domains defined by the author. They are basically divided in two parts. First, we look into the possibility of whether modules can be restricted to those of weak dimension at most 1 in the characterizations of several domains. Secondly, we try to see whether some properties of weak-injective modules, in particular, weak-injective envelopes of modules over domains can be generalized to those over commutative rings. (Received August 30, 2009)

1053-13-143 **Scott T. Chapman*** (scott.chapman@shsu.edu), Sam Houston State University, Department of Mathematics and Statistics, Box 2206, Huntsville, TX 77341, **Stephen McAdam**, The University of Texas at Austin, Department of Mathematics, and **George Schaeffer**, The University of California at Berkeley, Department of Mathematics. *Elastic properties of some semirings defined by positive systems.*

We consider two semirings motivated by the study of positive systems in control theory and consider their basic factorization properties. The first is the semiring $\mathbb{R}^+[X]$ of polynomials with nonnegative real coefficients. The second is a semiring of algebraic integers having the form $\mathbb{N}_0[\tau] = \{x + y\tau \mid \text{ where } x, y \text{ are nonnegative integers}\}$ for an appropriately chosen real quadratic integer τ. In each case, we show that the semiring has full infinite elasticity and that the Δ-set is $\{1, 2, 3, \ldots\}$. The proof in the latter case uses results of Hans Rademacher on the distribution of primes in quadratic extensions which may be of independent interest. (Received August 31, 2009)

1053-13-147 **Jesse Elliott*** (jesse.elliott@csuci.edu), 305 Channel Islands Drive, Camarillo, CA 93012. *Functorial properties of star operations.*

We define a *universal star operation* to be an assignment $* : A \longmapsto *_A$ of a star operation $*_A$ on A to every integral domain A. Prime examples of universal star operations include the divisorial closure star operation v, the t-closure star operation t, and the star operation $w = F_\infty$ of Hedstrom and Houston. For any universal star operation $*$, we say that an extension $B \supset A$ of integral domains is *$*$-ideal class linked* if there is a group homomorphism $\mathrm{Cl}_{*_A}(A) \longrightarrow \mathrm{Cl}_{*_B}(B)$ of star class groups induced by the map $I \longmapsto (IB)^{*_B}$ on the set of $*_A$-ideals I of A. We study several natural subclasses of the class of $*$-ideal class linked extensions. (Received August 31, 2009)

1053-13-148 **Uwe Nagel*** (uwenagel@ms.uky.edu), Department of Mathematics, University of Kentucky, 715 Patterson Office Tower, Lexington, KY 40506, and **Victor Reiner**. *Betti numbers of edge ideals and shifted skew shapes.*

Shifted skew shapes are well-known combinatorial objects. Each such shape gives rise to a bipartite and a non-bipartite graph. These graphs generalize Ferrers graphs and threshold graphs. In the talk we discuss the multigraded Betti numbers of the edge ideals of the graphs associated to skew shapes. They have a combinatorial interpretation and are independent of the characteristic of the base field. (Received August 31, 2009)

1053-13-160 **Bruce Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, Las Cruces, NM 88003-8001. *Stable rings and generic formal fibers of local Noetherian domains.* Preliminary report.

Bass proved in 1963 that if every ideal of a ring can be generated by 2 elements, then each ideal is projective over its ring of endomorphisms. Calling rings with the latter propery *stable*, Sally and Vasconcelos gave an example of a local Noetherian domain that is stable but which has an ideal that cannot be generated by 2 elements. They showed that such an example could only occur if R is analytically ramified; i.e., R is a "bad" stable domain. Their ring was an underring of a ring of convergent power series over a certain field of characteristic 2. In 1992, Heinzer, Lantz and Shah showed that this same construction could produce examples of multiplicity n for any choice of $n > 0$. These examples, as well as structural properties, suggest that the class of such rings should be rather small. However, we show that these rings are not as rare as they might first seem. We characterize these rings and discuss how to find examples in any characteristic and multiplicity as overrings of affine domains. We discuss also how the existence of bad stable domains as overrings of a local Noetherian domain A of dimension

$d > 0$ is equivalent to whether the dimension of the generic formal fiber of A is $d-1$. (Received September 01, 2009)

1053-13-167 **Timothy B.P. Clark*** (tbpclark@math.northwestern.edu), 2033 Sheridan Road, Mathematics Department, Evanston, IL 60208, and **Alexandre Tchernev** (tchernev@math.albany.edu), 1400 Washington Avenue, Department of Mathematics & Statistics, Albany, NY 12222. *CW complexes and poset resolutions.* Preliminary report.

Suppose that X is a regular CW complex. We utilize Björner's homotopy equivalence between X and its poset of cells $P(X)$ to establish a canonical isomorphism between the cellular chain complex of X and a complex of vector spaces associated to the poset $P(X)$ which is the output of a construction of Tchernev. When N is a monomial ideal whose (cellular) free resolution is supported by X, this isomorphism allows N to be resolved using a poset resolution. (Received September 01, 2009)

1053-13-178 **Bart E. Snapp*** (snapp@math.ohio-state.edu), Department of Mathematics, 100 Math Tower, 231 West 18th Avenue, Columbus, OH 43210. *A criterion for a ring to be Cohen-Macaulay and the canonical element conjecture.*

In the 1980's, Dutta gave a criterion for a local ring to be regular based on whether a syzygy of the residue field had a free summand. Recently, we gave a similar criterion for a ring to be Cohen-Macaulay; however, the proof was quite different. In this talk we will present a unified approach to both criteria. Additionally, we will discuss the connection of such criteria to the canonical element conjecture. (Received September 02, 2009)

1053-13-180 **Bethany A Kubik*** (bethany.kubik@ndsu.edu), Department of Mathematics, NDSU Dept # 2750, PO BOX 6050, Fargo, ND 58108. *Quasidualizing Modules.* Preliminary report.

Let R be a local complete noetherian ring. A noetherian R-module C is *semidualizing* if $\mathrm{Hom}_R(C,C) \cong R$ and $\mathrm{Ext}^i_R(C,C) = 0$ for all $i \geq 1$. We introduce and study the artinian counterpart which we call a *quasidualizing* module. We explore the relationship between these two concepts through Matlis Duality. (Received September 02, 2009)

1053-13-185 **Yongwei Yao*** (yyao@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *The linear growth property of* Tor *modules.* Preliminary report.

Let R be a Noetherian ring, I and J be ideals of R, and M and N be finitely generated R-modules. The *linear growth property* (for the primary decomposition) has been proved for $\{M/I^nM\}_{n=1}^{\infty}$, and later for $\{\mathrm{Tor}_c^R(N, M/I^nM)\}_{n=1}^{\infty}$ and $\{\mathrm{Ext}_R^c(N, M/I^nM)\}_{n=1}^{\infty}$, in which c is any fixed integer. In this talk, I will talk about the linear growth property of $\{\mathrm{Tor}_c^R(M/I^mM, N/J^nN)\}_{m,\,n=1}^{\infty}$ with c fixed. (Received September 02, 2009)

1053-13-190 **Marco Fontana*** (fontana@mat.uniroma3.it), Dipartimento di Matematica, Università degli Studi "Roma Tre", Largo San Leonardo Murialdo, 1, 00146 Roma, Italy. *Some remarks on b-Noetherian domains and other classes of domains defined by e.a.b. semistar operations.* Preliminary report.

Given an integral domain D with quotient field K and a semistar operation $\star$ on D, we say that a valuation overring V of D is *a $\star$-valuation overring of D* provided $F^\star \subseteq FV$, for each nonzero finitely generated fractional ideal F of D. Let $b(\star)$ be the `a.b.` semistar operation on D defined by $E^{b(\star)} := \bigcap\{EV \mid V \text{ is a } \star\text{-valuation overring of } D\}$, for each nonzero D-submodule E of K. Clearly, if d is the identity operation, $b(d)$ coincides with the classical b-operation.

In this talk, I will present some results on integral domains that can be characterized by using the b-operation or, more generally, the $b(\star)$-operation in connection with other distinguished (semi)star operations like the v–, the t– or the w–operation.

Some of these results are obtained in joint works with A. Loper and G. Picozza:

[1] M. Fontana - K.A. Loper, *Cancellation properties in ideal systems: a classification of e.a.b. semistar operations*, J. Pure Appl. Algebra **213** (2009), 2095-2103.

[2] M. Fontana - G. Picozza, *b-Noetherian domains and other classes of domains defined by e.a.b. semistar operations* (tentitive title), work in progress. (Received September 03, 2009)

1053-13-192 **Amanda I Beecher*** (amanda.beecher@usma.edu), D/Math, USMA, West Point, NY 10996, and **Timothy B.P Clark** and **Alexandre Tchernev**. *Describing a multigraded resolution from a lattice.* Preliminary report.

This talk will discuss a construction of a free resolution of a multigraded module from the so-called lattice of T-flats. We will focus on the differentials, since the free modules have previously been shown to be canonically isomorphic to those of the T-resolution constructed by Tchernev. We utilize a homotopy equivalence of Ziegler which relates the free modules to the order complex of part of the lattice of T-flats. This enables us to use a construction first introduced in a paper by Clark to map these complexes along a certain Mayer-Vietoris sequence. We use the basis found by Beecher in the description of the free modules to map the elements directly. The strategy has been an attempt to describe the differentials of the T-resolution combinatorially. (Received September 03, 2009)

1053-13-195 **Hema Srinivasan** (srinivasanh@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211, and **Sumi Seo*** (sumi@math.missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Multiplicity of Codimension three Almost Complete Intersections.*

One of main conjectures in commutative algebra in the last 20 years are the Multiplicity Conjectures by Herzong, Huneke and Srinivasan. We investigate the almost complete intersections in codimension three and construct general results about the structures of the graded resolutions of almost complete intersections. We use these structure theorems to compute the multiplicity and establish the conjectured bounds on the multiplicity of almost complete intersections in codimension three. These conjectures were proved recently by Eisenbud, Schreyer, Weyman, Boij and Söderberg. (Received September 03, 2009)

1053-13-201 **Thomas G Lucas*** (tglucas@uncc.edu), Department of Mathematics & Statistics, University of North Carolina Charlotte, Charlotte, NC 28223. *Minimal integral ring extensions.*

For a pair of commutative rings $R \subsetneq S$ with the same identity, S is said to be a minimal integral extension of R if S is integral over R and there are no rings properly between R and S. For a given minimal integral extension $R \subsetneq S$, the conductor $M = (R : S)$ is a maximal ideal of R. Three cases occur: (i) M is a maximal ideal of S, (ii) M is contained in exactly two maximal ideals of S, (iii) M is properly contained in a unique maximal ideal of S. With regard to case (ii), if M is contained in two maximal ideals of S and $Ann_R(M) \subseteq M$ with $Ann_R(M) \neq Ann_S(M)$, then S is isomorphic to $R \times R/M$. For case (iii), if M is properly contained in a unique maximal ideal of S and $Ann_R(M) \subseteq M$ with $Ann_R(M) \neq Ann_S(M)$, then S is isomorphic to the ring $R(+)R/M$ (the idealization of R/M over R) if and only if $Ann_S(M)^2 = (0)$. (Received September 03, 2009)

1053-13-212 **Long Hai Dao*** (hdao@math.ku.edu), University of Kansas, Department of Mathematics, 405 Snow Hall, 1460 Jayhawk Blvd, Lawrence, KS 66044. *Complexities of (co)homology of pair of modules.* Preliminary report.

For a pair of finite modules over a local or graded ring we aim to investigate the asymptotic behavior of Hilbert polynomials of the Ext and Tor modules. This is the generalization of the Betti or Bass numbers, when one of the module is the residue field. We will discuss some partial results and open questions (partly joint with Oana Veliche and Branden Stone) (Received September 04, 2009)

1053-13-213 **Hal Schenck** (schenck@illinois.edu) and **Alexandra Seceleanu*** (asecele2@illinois.edu). *Weak Lefschetz Property and Powers of Linear Forms.*

Classically, the weak Lefschetz theorems compare the topology of complex projective varieties and of their hyperplane sections. In an algebraic setting, an Artinian graded algebra has the Weak Lefschetz Property (WLP) if multiplication by a general linear form, from any graded component to the next, has maximal rank.

Let K be a field of characteristic zero. We show that an Artinian quotient of an ideal $I \subset K[x, y, z]$ generated by powers of linear forms has the Weak Lefschetz Property. Our approach is based on work of Brenner and Kaid who interpret the WLP in terms of the cohomology of the syzygy bundle associated to I. Our proof works without the semistability hypothesis of Brenner and Kaid, which typically does not hold.

Our result is significant as one of the few results on the WLP outside the class of monomial ideals or (almost)complete intersections. (Received September 04, 2009)

1053-13-220 **Hannah Robbins*** (robbinshr@gmail.com), P.O. Box 7388, 127 Manchester Hall, Wake Forest University, Winston Salem, NC 27109. *Associated Primes of Local Cohomology After Adjoining Indeterminates to the Ring.* Preliminary report.

If a ring R has small dimension, it is known that the local cohomology modules, $H^i_I(R)$, have only finitely many associated primes for any i and ideal $I \subseteq R$. In this talk we will show that if our ring has an easily controlled resolution of singularities, we can adjoin a finite set of indeterminates, either as polynomials or power series, while preserving the finiteness of $\mathrm{Ass}_R H^i_I(R)$. As a corollary we get that $\mathrm{Ass}_R H^i_I(R)$ is finite for polynomial and power series rings over a normal domain of dimension two or three with an isolated singularity. (Received September 04, 2009)

1053-13-223 **Janet Striuli*** (jstriuli@fairfield.edu), University of Fairfield, Fairfield, CT 06605, and **Adela Vraciu**. *Homological properties of Almost Gorenstein Rings.*

In this talk we will present recent results about homological properties for a class of almost Gorenstein rings. These results imply that over a Teter ring the only totally reflexive modules are the free ones. We provide an example of an almost Gorenstein ring which has infinitely many non-isomorphic totally reflexive modules. This is joint work with Adela Vraciu. (Received September 04, 2009)

1053-13-227 **Florian Enescu*** (fenescu@gsu.edu), Georgia State University, Department of Mathematics and Statistics, Atlanta, GA 30303. *Local cohomology, F-purity and antinilpotency.* Preliminary report.

I will discuss the notion of an antinilpotent module and present applications to the local cohomology module of local ring of positive characteristic with support in its maximal ideal. The case of a Cohen-Macaulay F-pure ring will be particularly studied. (Received September 05, 2009)

1053-13-235 **Kuei-Nuan Lin*** (link@math.purdue.edu). *Rees Algebras of diagonal ideals.*

Let X be an m by n matrix of variables over a field k. R and S are rings defined by the minors of X. We consider the diagonal ideal $\mathbb{D}$, the kernel of the diagonal map. By the work of Simis-Ulrich, we know the defining equations of special fiber ring of $\mathbb{D}$. When $R = S$, the special fiber ring is known as a homogeneous coordinate ring of secant variety. Some of the cases show that the special fiber ring is $k[X]$. It is nature to ask whether $\mathbb{D}$ is an ideal of linear type, which means that the natural map from the symmetric algebra of $\mathbb{D}$ onto the Rees algebra of $\mathbb{D}$ is an isomorphism. We aim at a more refined study of the ideal defining Rees algebra of $\mathbb{D}$. By knowing the defining equations, we can show that Rees algebra is Cohen-Macaulay and $\mathbb{D}$ is an ideal of linear type. (Received September 06, 2009)

1053-13-247 **Jeff Mermin*** (mermin@math.okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078, and **Satoshi Murai**. *Colored complexes and lex ideals without maximal Betti numbers.*

We exhibit a class of ideals in which lex objects attain every Hilbert function, but do not have maximal Betti numbers. (Received September 07, 2009)

1053-13-251 **Alexandre B. Tchernev*** (tchernev@math.albany.edu). *Homological properties of multigraded modules and β-invariants of matroids.* Preliminary report.

We discuss the role that the β-invariant of a matroid plays in describing the homological structure of multigraded modules. (Received September 07, 2009)

1053-13-256 **Oana Veliche*** (oana@sainthermanschool.org), 62 Harvard Avenue, Allston, MA 02134, and **Hailong Dao** (hdao@math.ku.edu). *Comparing complexities of pairs of modules.*

Let R be a local ring and M, N be finitely generated R-modules. The complexity of (M, N), denoted by $\mathrm{cx}_R(M, N)$, measures the polynomial growth rate of the number of generators of the modules $\mathrm{Ext}^n_R(M, N)$, $n \geq 0$. The talk will focus on several basic equalities and inequalities involving complexities of various types of pairs of modules. (Received September 07, 2009)

1053-13-268 **David A. Jorgensen**, University of Texas at Arlington, **Graham J. Leuschke*** (gjleusch@math.syr.edu), 215 Carnegie Library, Syracuse University, Syracuse, NY 13244, and **Sean Sather-Wagstaff**, North Dakota State University. *Dualizing modules and Gorenstein presentations.* Preliminary report.

It is a classical piece of commutative algebra that a Cohen-Macaulay local ring admits a dualizing module if and only if it is a homomorphic image of a Gorenstein ring. We augment this result by showing that such a ring admits a nontrivial semidualizing module if and only if it admits a presentation Q/I with Q Gorenstein and

such that the ideal I has a nontrivial decomposition $I = I_1 + I_2$ with Tor-independent totally reflexive quotients Q/I_j. (Received September 07, 2009)

1053-13-272 **Javid Validashti*** (jvalidas@math.ku.edu), Department of Mathematics, 405 Snow Hall, 1460 Jayhawk Blvd, The University of Kansas, Lawrence, KS 66045-7523, and **Daniel Katz** (dlk@math.ku.edu), Department of Mathematics, 405 Snow Hall, 1460 Jayhawk Blvd, The University of Kansas, Lawrence, KS 66045-7523. *Multiplicities and Rees valuations.*

Let R be a Noetherian local ring with maximal ideal $\mathfrak{m}$ and $I \subset R$ be an ideal with maximal analytic spread. Our goal is to study the connection between the Rees valuations and various multiplicities that can be associated to I for non $\mathfrak{m}$-primary ideals. In particular, we show that the j-multiplicity of I is determined by the Rees valuations of I centered on $\mathfrak{m}$. (Received September 07, 2009)

1053-13-273 **Louiza Fouli*** (lfouli@math.nmsu.edu), New Mexico State University, Department of Mathematical Sciences, Dept 3MB, P. O. Box 30001, Las Cruces, NM 88003, and **Craig Huneke** (huneke@math.ku.edu), Department of Mathematics, University of Kansas, Lawrence, KS 66045. *Characterizations of Systems of Parameters in non Cohen-Macaulay rings.* Preliminary report.

Let R be a Noetherian local ring of dimension d. Let $\underline{x} = x_1, \dots, x_d$ be a system of parameters, that is $\mathrm{ht}(\underline{x}) = d$. Let $\underline{y} = y_1, \dots, y_d$ be a sequence such that $(\underline{y}) \subset (\underline{x})$ and let A be a matrix such that $\underline{y} = A\underline{x}$. Dutta and Roberts give a criterion for when $(\underline{y})$ is also a system of parameters in a Cohen–Macaulay local ring. More specifically they show that the sequence $\underline{y}$ is a system of parameters if and only if the map $R/(\underline{x}) \xrightarrow{\cdot \det A} R/(\underline{y})$ induced by multiplication by $\det A$ is injective. We will discuss necessary and sufficient conditions for when the sequence $\underline{y}$ is a system of parameters without the assumption that the ring is Cohen-Macaulay. This is joint work with Craig Huneke. (Received September 07, 2009)

1053-13-274 **Ben Richert*** (brichert@calpoly.edu), Mathematics Department, Cal Poly, San Luis Obispo, San Luis Obispo, CA 93407, and **Michael Mogull**, **Sam Saiki** and **David jansson**. *The poset tree of graded Betti numbers for a fixed Hilbert function and the degree to height function.* Preliminary report.

Given a homogeneous ideal I in a polynomial ring $R = k[x_1, .., x_n]$, the degree to height function of I in degree d is defined to be the height of $I_{\leq d}$. This invariant is conjectured to identify unique maximal elements in subtrees of the poset tree of ideals in R whose quotients have a fixed Hilbert function. It has been asked whether the degree to height function can guarantee the existence of unique minimal elements in these same subtrees. By restricting to squarefree monomial ideals we discovered that this need not be the case. We also identified instances for which unique maximal elements need not exist among the resolutions of squarefree monomial ideals with given degree to height and Hilbert functions (showing that one possible extension of the lex-plus-powers conjecture to the squarefree monomial case does not hold), and instances in which the subtrees have holes. (Received September 07, 2009)

1053-13-277 **William Travis Trentham*** (william.trentham@ndsu.edu), Fargo, ND 58102. *On the Integral Closure on an Antimatter domain.*

In this talk we will be taking a look at the class of rings known as antimatter domains, i.e, domains which admit no irreducibles. More specifically, we would like to know if the integral closure of an antimatter domain (AMD) might admit atoms and, if so, to what extent. For example, can the integral closure of an AMD be atomic or even Noetherian? We will consider this question and point out where we ought NOT be looking for atoms in such integral closures. (Received September 07, 2009)

1053-13-279 **Jason Greene Boynton*** (jason.boynton@ndsu.edu), North Dakota State University, Department of Mathemtics, 300 Minard Hall, Fargo, ND 58105. *The $D + M$ construction and a generalization.*

In 1976 J.W. Brewer and E.A. Rutter investigated certain ring and ideal theoretic properties that behave nicely in the now well-studied $D + M$ construction. More recently, it has become fashionable to consider such pullback constructions in greater generality. In the spirit of Brewer and Rutter, we will survey some recent results concerning the transfer of ring and ideal theoretic properties in a special case of a pullback diagram called a conductor square. (Received September 07, 2009)

1053-13-299 **Dawn B McNair*** (dmcnair@jcsu.edu), 100 Beatties Ford Road, Charlotte, NC 28216. *Duals of Ideals in Rings with Zero Divisors.*

For a nonzero ideal I of R, we define $I^{-1} = (R : I) = \{x \in Q(R) | xI \subseteq R\}$ and call it the dual of I where $Q(R)$ is the complete ring of quotients of R. Much work has been with regard to determining when $(R : I)$ is a ring in the case R is a integral domain. This talk will extend those results to dense ideals in rings with zero divisors. We will prove several properties with duals of prime ideals including for a dense prime P of ring R, $(R : P) \neq (P : P)$ if and only if PR_P is invertible and P is of the form $P = (R : (1, x))$ for some $x \in Q(R)$. Attention will also be given to duals of ideals in Prüfer and Strong Prüfer rings. Such as if P is a semiregular prime ideal of Strong Prüfer ring R and P is noninvertible then $P^{-1} = (P : P)$ is a ring. (Received September 07, 2009)

1053-13-301 **Livia Hummel*** (hummell@uindy.edu), Department of Mathematics and Statistics, 215 Lilly Hall, 1400 East Hanna Avenue, Indianapolis, IN 46227. *Characterizations of Coherent Gorenstein Rings.*

Auslander and Bridger proved that local Noetherian Gorenstein rings are characterized by every ideal having finite Gorenstein dimension. The theory of coherent Gorenstein rings is based on this characterization, and requires a generalization of Gorenstein dimension and the Auslander-Bridger formula. In this talk I introduce this theory of coherent Gorenstein rings and explore its relation to other familiar characterizations of Gorenstein rings. (Received September 07, 2009)

1053-13-305 **Erin E Chamberlain*** (chamberlain@math.byu.edu), Brigham Young University, Department of Mathematics, 263 TMCB, Provo, UT 84602. *Infinite Cohen-Macaulay posets and non-Noetherian Stanley-Reisner rings.*

In the mid-seventies Hochster and Reisner related the algebraic and topological notions of Cohen-Macaulay rings and posets using the Stanley-Reisner ring. Reisner proved that for finite simplicial complexes, topologically Cohen-Macaulay is equivalent to the Stanley-Reisner ring being algebraically Cohen-Macaulay. Unfortunately, this idea only works for finite simplicial complexes because if the complex is infinite, the ring is no longer Noetherian, and the nice Cohen-Macaulay properties do not hold true in the non-Noetherian setting. Using local cohomology we will give a natural definition for Cohen-Macaulay modules over non-Noetherian rings and show that topologically Cohen-Macaulay is equivalent to algebraically Cohen-Macaulay for infinite yet finite dimensional simplicial complexes. (Received September 07, 2009)

1053-13-307 **Greg G Oman*** (ggoman@gmail.com), 4321 Pleasant Hill Rd., Athens, OH 45701. *Cardinalities of Residue Fields of Noetherian Integral Domains.*

We determine the relationship between the cardinality of a commutative Noetherian integral domain and the cardinality of a residue field. One consequence of the main result is that it is provable in ZFC that there is a Noetherian domain of cardinality $\aleph_1$ with a finite residue field, but the statement "There is a Noetherian domain of cardinality $\aleph_2$ with a finite residue field" is equivalent to the negation of the Continuum Hypothesis. If time permits, we will use these results to describe the ordered set $\mathrm{Spec}(R[x])$, where R is a one-dimensional Noetherian domain with finitely many maximal ideals. (Received September 07, 2009)

1053-13-308 **Andrew H Hoefel*** (andrew.hoefel@mathstat.dal.ca), Department of Mathematics and Statistics, Chase Building, Dalhousie University, Halifax, NS B3H 3J5, Canada. *Gotzmann Edge Ideals.*

Let P be the polynomial ring in n variables over a field. A homogeneous ideal $I \subset P$ generated in degree d is called Gotzmann if it has the smallest possible Hilbert function out of all homogeneous ideals with the same dimension in degree d. An edge ideal is a quadratic square-free monomial ideal and its minimal monomial generators correspond to the edges of a simple graph. From combinatorial bounds on Hilbert functions it can be shown that only star graphs have Gotzmann edge ideals. The analogous problem for all square-free monomial ideals leads to interesting inequalities. (Received September 07, 2009)

1053-13-312 **Jinjia Li*** (jinjiali@mtsu.edu), Departmenet of Mathematical Sciences, Middle Tennessee State Univeristy, Murfreesboro, TN 37132, and **Hailong Dao** and **Claudia Miller**. *On (non)rigidity of Frobenius endomorphism over Gorenstein rings.*

It is well-known that for a big class of local rings of positive characteristic, including complete intersection rings, the Frobenius endomorphism can be used as a test module for finite projective dimension. We exploit this property to study the structure of such rings and to investigate several situations where such a property fails. (Received September 08, 2009)

1053-13-318 **Jim Coykendall*** (jim.coykendall@ndsu.edu), Department of Mathematics, North Dakota State University, Fargo, ND 58108. *Factorization stability in polynomial and power series rings.* Preliminary report.

It is well known that if R is a UFD, then the corresponding polynomial ring over R (in any family of indeterminates) is also a UFD. There is a similar, but slightly weaker, result for power series rings that states that if R is a PID, then for all $n > 0$, $R[[x_1, x_2, \cdots, x_n]]$ is a UFD.

In this talk we will discuss a variety of questions of a stability flavor (e.g. if $R[x]$ is an HFD is $R[x, y]$ an HFD?), and some basic results and directions will be explored. (Received September 08, 2009)

1053-13-325 **Sean Sather-Wagstaff** (sean.sather-wagstaff@ndsu.edu), North Dakota State University, **Tirdad Sharif** (sharif@ipm.ir), Institute for Research in Fundamental Science, and **Diana M White*** (Diana.White@ucdenver.edu), University of Colorado Denver. *Resolutions and cohomology with respect to semidualizing modules.*

We will discuss recent work on resolutions and cohomology with respect to semidualizing modules. (Received September 08, 2009)

1053-13-344 **Hamid Rahmati*** (hamid.rahmati@ttu.edu) and **Janet Striuli**. *Artinian Gorenstein Rings and Infinite Syzygies.* Preliminary report.

Let R be a commutative local ring and M be an R-module. We say that M is an infinite syzygy if there is an exact sequence

$$0 \to M \to F_1 \to F_2 \to \cdots \to F_{n-1} \to F_n \to \cdots$$

where F_i is free for all $i \geq 1$. The ring R is artinian Gorenstein if and only if every finitely generated module is an infinite syzygy. We show that if the embedding dimension of R is small, one only needs to verify that the residue field is an infinite syzygy. (Received September 08, 2009)

1053-13-345 **Mary Elizabeth Hopkins*** (mhopkins@newhaven.edu). *Weakly Integrally Closed Numerical Monoids and Forbidden Patterns.* Preliminary report.

An integral domain D is weakly integrally closed if whenever x is in the quotient field of D, and J is a nonzero finitely generated ideal of D such that xJ is contained in JJ, then x is in D. We define weakly integrally closed numerical monoids similarly. If a monoid algebra is weakly integrally closed, then so is the monoid. The characteristic function of a numerical monoid M can be thought of as an infinite binary string s(M). A pattern of finitely many 0s and 1s is called forbidden if whenever s(M) contains it, then M is not weakly integrally closed. The pattern 11011 is forbidden. We show that a numerical monoid M is weakly integrally closed if and only if s(M) contains no forbidden patterns. We also show that for every finite set S of forbidden patterns, there exists a numerical monoid M that is not weakly integrally closed and for which s(M) contains no stretch (in a natural sense) of a pattern in S. In doing so, we answer the question proposed by Brewer and Richman as to whether or not weakly integrally closed numerical monoid algebras are characterized by the property that the binary string of the monoid does not contain the pattern 11011. (Received September 08, 2009)

1053-13-348 **W. Frank Moore***, Department of Mathematics, Malott Hall, Ithaca, NY 14853-, **Gregory Peipmeyer** (piepmeyerg@missouri.edu), Department of Mathematics, Columbia, MO 65211, **Sandra Spiroff** (spiroff@olemiss.edu), Department of Mathematics, University, MS 38677, and **Mark E. Walker** (mwalker5@math.unl.edu), Department of Mathematics, Avery Hall, Lincoln, NE 68588. *On Hochster's Theta function.*

Let R be an isolated hypersurface singularity, and let M and N be finitely generated R-modules. As R is a hypersurface, the torsion modules of M against N are eventually periodic of period two (i.e., $\operatorname{Tor}_i^R(M, N) \cong \operatorname{Tor}_{i+2}^R(M, N)$ for $i \gg 0$). Since R is an isolated singularity, these torsion modules are of finite length for i large enough. The theta invariant of the pair (M, N) is defined by Hochster to be

$$\theta(M, N) = \ell(\operatorname{Tor}_{2i}^R(M, N)) - \ell(\operatorname{Tor}_{2i+1}^R(M, N)) \text{ for } i \gg 0.$$

H. Dao has conjectured that the theta invariant is zero for all pairs (M, N) when R has even dimension and contains a field. This paper proves this conjecture under the additional assumption that R is graded with its irrelevant maximal ideal giving the isolated singularity. We also give a careful analysis of the theta pairing when the dimension of R is even, and relate it to a classical pairing on the smooth variety $\operatorname{Proj}(R)$. (Received September 08, 2009)

1053-13-355 **Wolfgang Hassler** and **Roger Wiegand*** (rwiegand@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588-0130. *Extended modules relative to a flat local homomorphism.*

In studying direct-sum behavior of finitely generated modules over a local ring $(R, \mathfrak{m}, k)$, it is often useful to pass to a larger local ring via a flat local homomorphism $R \to S$. For example, S might be the completion or the Henselization of R; or S might be obtained by lifting the map $k \to \overline{k}$, where $\overline{k}$ is the algebraic closure of k. One then needs to understand how the category of R-modules sits inside the corresponding category of S-modules. In particular, one needs to know which S-modules actually come from R-modules (that is, are in the image of the functor $M \mapsto S \otimes_R M$). We will discuss this problem, with particular emphasis on the case of rings of dimension zero or one. (Received September 09, 2009)

1053-13-367 **Roger A Wiegand** (rwiegand@math.unl.edu), Dept. of Mathematics, University of Nebraska Lincoln, Lincoln, NE 68502, and **Sylvia M Wiegand*** (swiegand@math.unl.edu), Dept. of Math., University of Nebraska Lincoln, Lincoln, NE 68502. *Prime ideals in power series rings.*

We discuss the structure of the set of prime ideals in certain two-dimensional domains of power series. In particular we complete a characterization, partially given earlier by the second author with Heinzer and Rotthaus, of the partially ordered set of R[[y]], where R is a one-dimensional Noetherian domain and y is an indeterminate over R. We also describe some spectra that arise for birational extensions of such rings. The latter is work from the Ph.D. thesis of Eubanks-Turner with the second author, which was completed with the help of Luckas and Saydam. (Received September 11, 2009)

1053-13-375 **Giulio Caviglia*** (gcavigli@math.purdue.edu), 150 N. University st., West Lafayette, IN 47907. *A class of Gorenstein algebras that are Koszul.*

It is known, by a result of Vishik and Finkelberg, that the coordinate ring of a smooth curve in its canonical embedding is Koszul whenever it is defined by quadratic relations. Such rings are Gorestein with an h-vector of the form $1 + nz + nz^2 + z^3$. Conca, Rossi, and Valla proved that quadratic Gorenstein rings with the above h-vector are always Koszul whenever n=3, n=4 or when the ring is defined by a generic cubic in the sense of Macaulay's inverse system.

We present some sufficient conditions for the koszulness of these rings which extend the above result to the case n=5. Our methods are based on the construction of a Koszul filtration by analizing the rank of the multiplication of certain linear forms. (Received September 11, 2009)

14 ► Algebraic geometry

1053-14-191 **vehbi e paksoy*** (vp80@nova.edu), Farquhar College of Arts and Sciences, Division of Math, Science and Technology, 3301 College Avenue, Ft. Lauderdale-Davie, FL 33314. *A criterion to determine Fano polygon spaces in* $\mathbb{R}^3$.

A projective manifold is called Fano, if its anti-canonical bundle is ample. In this presentation, we give a combinatorial method to determine if a given moduli space of spatial polygons with given side lenghts is Fano. We will use the equivalence between the space of spatial polygons and the configuration space of weighted points on complex projective line $\mathbb{CP}^1$ (Received September 03, 2009)

1053-14-208 **Bryden R. Cais*** (bryden.cais@gmail.com), 805 Sherbrooke St. West, Montreal, Quebec H2K4A1, Canada. *Modular curves and modular representations of* SL_2.

Abstract: Fix a prime p and let $X(p)$ be the modular curve over the integers classifying elliptic curves with full-level p structure. The group $G := \mathrm{SL}_2(\mathbf{F}_p)$ acts on $X(p)$ and hence on its (sheaf) cohomology. In this talk, we we will investigate the structure of the $\mathbf{Z}[G]$-module M given by the global sections of the canonical sheaf. In particular, we will describe the reduction modulo p of M as a mod p (modular) representations of G. This description relies heavily on the geometry of $X(p)$ in characteristic p and uses Rosenlicht's description of the dualizing sheaf in terms of regular differential forms. (Received September 04, 2009)

1053-14-210 **Tai Ha*** (tai@math.tulane.edu), Department of Mathematics, 6823 St. Charles Avenue, New Orleans, LA 70118. *Regularity of powers of ideals: revisited.*

Let $X = \mathrm{Proj}R$ be a projective scheme with at worst rational singularity, and let I be a homogeneous ideal in R. It is known that $\mathrm{reg}(I^n) = an + b$, a linear function in n, for $n \gg 0$. While the linear constant a is well understood from reduction theory, not much is known about the free constant b. Recently, Eisenbud and Harris showed that when I is generated by generic linear forms, b can be related to a "local" invariant, namely, the

maximal value of the regularity of fibers of the projection map given by the generators of I. In this talk, we'll discuss a more general situation, when I is generated by forms of the same degree. We show that b can also be related to a local invariant, the "local" a*-invariant, that is closely related to regularity, of fibers of certain map. (Received September 04, 2009)

1053-14-219 **Susan M Cooper*** (scooper4@math.unl.edu), Department of Mathematics, University of Nebraska - Lincoln, Avery Hall, Room 338, Lincoln, NE 68588, **Brian Harbourne** (bharbour@math.unl.edu), Department of Mathematics, University of Nebraska - Lincoln, Avery Hall, Room 331, Lincoln, NE 68588, and **Zach Teitler** (zteitler@tamu.edu), Department of Mathematics, Mailstop 3368, Texas A & M University, College Station, TX 77843. *Tearing Down Fat Point Schemes.*

Certain data about a finite set $\mathbb{X}$ of distinct reduced points in projective space can be obtained from the Hilbert function of $\mathbb{X}$. A characterization of these Hilbert functions is well known, and it is natural to try to generalize this characterization to non-reduced schemes.

In this talk we consider fat point schemes. In general, Hilbert functions of these schemes have not been characterized. However, if the points are in projective 2-space then Geramita-Migliore-Sabourin give a criterion characterizing a subclass of functions, all of which occur as Hilbert functions of double point schemes. For each function h in that subclass, Geramita-Migliore-Sabourin use a sequence of basic double links to construct a specific double point scheme whose Hilbert function is h. We take the opposite approach: by tearing down the fat point scheme as a sequence of residuals with respect to lines, we obtain upper and lower bounds for the Hilbert function. Moreover, we give a simple criterion for when the bounds coincide, yielding a precise calculation of the Hilbert function. In this case, we also obtain upper and lower bounds on the graded Betti numbers for the ideal defining the fat point scheme. (Received September 04, 2009)

1053-14-234 **Andrew Obus*** (obus@math.columbia.edu), Columbia University Dept. of Mathematics, MC4403, 2990 Broadway, New York, NY 10027. *Vanishing Cycles and Wild Monodromy.*

Let K be a complete discrete valuation field of mixed characteristic $(0, p)$ with algebraically closed residue field, and let $f : Y \to \mathbb{P}^1$ be a three-point G-cover defined over K, where G has a cyclic p-Sylow subgroup P. We examine the stable model of f, in particular, the minimal extension K^{st}/K such that the stable model is defined over K^{st}. Our main result is that, if $g(Y) \geq 2$, the inertia groups of f are prime to p, and $|P| = p^n$, then the p-Sylow subgroup of $\mathrm{Gal}(K^{st}/K)$ has exponent dividing p^{n-1}. This extends work of Raynaud in the case that $|P| = p$. (Received September 06, 2009)

1053-14-296 **Michael Temkin*** (temkin@math.ias.edu). *Inseparable Local Uniformization.*

It is known since the works of Zariski in early 40ies that desingularization of varieties along valuations (also called local uniformization of valuations) can be considered as the local part of the desingularization problem. It is still an open problem if local uniformization exists in positive characteristic and dimension larger than three, but local uniformization is always possible after a purely inseparable alteration. In this lecture, I will explain some ideas about proving the latter result and establish a link to Berkovich analytic spaces and the theory of analytic valued fields. (Received September 07, 2009)

1053-14-349 **Anthony Varilly-Alvarado*** (varilly@rice.edu), Math Department – MS 136, Rice University, 6100 S. Main St., Houston, TX 77005. *Progress on the arithmetic of rational surfaces.*

I will report on some results concerning the arithmetic of del Pezzo surfaces of degree 1 over number fields. In particular, I will discuss Zariski density of rational points and the failure of weak approximation. I will also convey how my results help our overall understanding of basic qualitative arithmetic phenomena on rational surfaces. (Received September 08, 2009)

15 ► Linear and multilinear algebra; matrix theory

1053-15-226 **Fumiko Futamura*** (futamurf@southwestern.edu), 1001 E University Ave, Georgetown, TX 78626, and **Akram Aldroubi**, **Carlos Cabrelli** and **Ursula Molter**. *Approximate Joint Diagonalization of Matrices.* Preliminary report.

Given a finite collection of matrices, we consider their optimal approximate joint diagonalization with respect to one or more unitary matrices. The case of matrices assumed to have the same diagonalizer has been studied and used in algorithms for blind source separation of signals. We consider this problem in a more general sense. (Received September 05, 2009)

20 ► Group theory and generalizations

1053-20-1 **Kai-Uwe Bux***, Fakultät für Mathematik, Universität at Bielefeld, Germany. *Arithmetic groups in positive characteristic.*

The connection of topology and group theory is via the fundamental group: every group G arises as the fundamental group of some space Y. In fact, Y can be chosen to be a CW complex with contractible universal cover. In this case, we say that Y is an Eilenberg-MacLane complex for G. It turns out that G determines its Eilenberg-MacLane complex up to homotopy equivalence. Hence, homotopy-invariants (e.g., homology and cohomology) of Y are actually invariants of G. Another source of obtaining invariants for the group G is to employ the ambiguity inherent in the Eilenber- MacLane complexes for G. The geometric dimension of G is the minimum dimension of an Eilenberg-MacLane complex for G. The finiteness length of G is the maximum m for which there is an Eilenberg-MacLane complex for G with finite m-skeleton. The finiteness length of G is $>= 1$ if and only if G is finitely generated and the finiteness length is $>= 2$ if and only if G is finitely presented.

Arithmetic groups, such as $SL_n(Z)$, $SL_n(Z[1/3])$, $SL_n(F_q[t])$, or $SL_n(F_q[t, 1/t])$ where F_q is a finite field provide a good case study for finiteness properties since they depend on two parameters that can be varied independently: one has to choose the group scheme (in our case SL_2, SL_3, ...) and the coefficient ring Z, $Z[t]$, $F_q[t]$, ...; the interesting question is how the finiteness length depends on the choice of these parameters. I will describe what is known with respect to this problem and what is conjectured (recently there has been mounting evidence for a particular conjecture that would settle the question for semi-simple groups). I also intend to at least point toward yet uncharted territory where only scattered results are known.No text available. (Received June 11, 2008)

1053-20-72 **Michael W Davis*** (mdavis@math.ohio-state.edu), Ohio State University, Math Department, 231 W. 18th Ave, Columbus, OH 43210. *Examples of buildings constructed via covering spaces.*

Covering space theory is used to construct new examples of buildings. (Received August 11, 2009)

1053-20-84 **John G Ratcliffe*** (j.g.ratcliffe@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Vanderbilt University, Nashville, TN 37240, and **Steven T Tschantz**. *JSJ Decompositions of Coxeter Groups over FA Subgroups.*

A group G is said to have property FA if G fixes a point of every tree on which G acts without inversions. A Coxeter group W, with Coxeter generators S, has property FA if and only if the product of any two elements of S has finite order in W. A visual subgroup of a Coxeter system (W, S) is a subgroup of W generated by a subset of S. A graph of groups decomposition of a Coxeter system (W, S) is said to be visual if every vertex and edge group is visual. We prove that every Coxeter system of finite rank has a visual JSJ graph of groups decomposition with edge groups having property FA. As an application, we reduce the twist conjecture to Coxeter systems that are indecomposable with respect to amalgamated products over visual subgroups with property FA. (Received August 18, 2009)

1053-20-149 **Nathaniel Stambaugh*** (nstambau@brandeis.edu), Brandeis University, 415 South St, MS 050, Waltham, MA 02454, and **Ruth Charney**, **Kim Ruane** and **Anna Vijayan**. *The automorphism group of RACGs with no SILs.* Preliminary report.

We study Right Angled Coxeter Groups (RACGs), and find that the automorphism group generated by partial conjugations is once again a RACG if its defining graph does not contain any separating intersection of links (SILs). In this talk I will state the key lemma and sketch its proof, along with an illustrative example. This result is then extended to more general graph products of abelian groups. (Received August 31, 2009)

1053-20-151 **Lisa Carbone*** (carbonel@math.rutgers.edu). *The Haagerup property, property (T) and the Baum-Connes conjecture for lattices in locally compact Kac-Moody groups.*

We discuss the construction and properties of lattices in locally compact Kac-Moody groups. For example there is a dichotomy between nonuniform lattices in Kac-Moody groups of noncompact hyperbolic type, with certain ones satisfying the Haagerup property and hence the Baum-Connes conjecture with coefficients, and others satisfying Kazhdan's property (T) and the Baum-Connes conjecture without coefficients. Kac-Moody groups with the Haagerup property act properly on simplicial trees and certain examples also contain infinite descending chains of cocompact lattices. (Received August 31, 2009)

1053-20-164 **John Meier***, Department of Mathematics, Lafayette College, Easton, PA 18042.
Revisiting Chiswell's Formula for the Growth of Graph Products.

Starting with a graph Γ and groups G_v assigned to the vertices $v \in \mathrm{V}(\Gamma)$, one can form the graph product G_Γ. This is the quotient of the free product of the vertex groups, modulo relations implying that G_v and G_w commute when $\{v, w\} \in \mathrm{E}(\Gamma)$. Graph products of groups provide a simple means of constructing examples of right-angled buildings.

In the early 1990s Chiswell produced a delightful formula for the standard growth series of a graph product, in terms of the standard growth series of the vertex groups. We show that this work extends to the complete growth series, where instead of listing the number of elements of a given length, one essentially lists the elements themselves.

This is joint with Daniel Allen, Megan Cream, Kate Finlay, and Ranjan Rohatgi. (Received September 01, 2009)

1053-20-176 **Tullia Dymarz*** (tullia.dymarz@yale.edu). *Bilipschitz equivalence is not equivalent to quasi-isometric equivalence for finitely generated groups.*

We show that certain lamplighter groups that are quasi-isometric (even commensurable) are nevertheless not bilipschitz equivalent. The proof involves structure of quasi-isometries from rigidity theorems, analysis of bilipschitz maps of the n-adics and uniformly finite homology. (Received September 02, 2009)

1053-20-183 **Michael L Mihalik*** (michael.l.mihalik@vanderbilt.edu), Department of Mathematics, Stevenson Center for Mathematics, Vanderbilt University, Nashville, TN 37240, and **Steven Tschantz**. *JSJ and accessibility results for Coxeter groups.*

Sela introduced the idea of JSJ-decompositions for groups. The idea is to consider a class $\mathcal{C}$ of groups and splittings of groups in $\mathcal{C}$ by groups in a class $\mathcal{E}$. For $G \in \mathcal{C}$ the goal is to produce a unique graph of groups decomposition $\mathcal{T}$ of G with edge groups in $\mathcal{E}$ so $\mathcal{T}$ reveals all splittings of G by groups in $\mathcal{E}$. If V is a vertex group of $\mathcal{T}$ then there is no $\mathcal{E}$-group that splits both G and V, or V is an "orbifold group" with "surface group-like" structure.

For a Coxeter system (W, S) we produce a unique (reduced) JSJ-decomposition $\mathcal{T}$ for splittings of W over virtually abelian subgroups. We show $\mathcal{T}$ is "visual" and algorithmic. If $V \subset S$, generates an orbifold group of $\mathcal{T}$ then $V = K \cup M$, where $\langle M \rangle$ is virtually abelian, $\langle K \rangle$ is virtually a surface group and $\langle V \rangle = \langle M \rangle \times \langle K \rangle$. Our decomposition is a reduced Fujiwara-Papasoglu decomposition.

Accessibility results are analogous to JSJ results. We discuss an accessibility result for splittings of finitely generated Coxeter groups over "minimal' splittings. (Received September 02, 2009)

1053-20-222 **Matthew C Zaremsky*** (mcz5r@virginia.edu). *Chevalley groups and Weyl group representatives.*

Let K be a field, and $G(K)$ a Chevalley group over K. Let (B, N) be the standard BN-pair in $G(K)$, with $T = B \cap N$ and Weyl group $W = N/T$. In joint work with Peter Abramenko, we prove that there exist elements $w \in W$ such that all representatives of w in N have finite order; in fact this order is independent of the choice of representative. This will have a direct application to transitivity properties of groups acting on buildings. (Received September 04, 2009)

1053-20-236 **Markus Schmidmeier*** (markusschmidmeier@gmail.com). *The entries in the LR-tableau.*

Littlewood-Richardson tableaux of shape $\beta\backslash\gamma$ are semistandard Young tableaux with filling α' which satisfy the lattice permutation property. The number of tableaux of type (α, β, γ) is the LR-coefficient $c^{\beta}_{\alpha,\gamma}$, it plays an important role in many areas in algebra. In particular, $c^{\beta}_{\alpha,\gamma}$ is the leading coefficient of the polynomial which, for a given finite abelian p-group B of type β, counts the subgroups A in B such that A has type α and such that the factor B/A has type γ.

Suppose that a subgroup embedding $(A \subset B)$ corresponds to LR-tableau Γ. In my talk I will describe how the entries in Γ determine the structure of the embedding, and how they position the object $(A \subset B)$ within the category of subgroup embeddings. (Received September 06, 2009)

1053-20-281 **Peter Abramenko*** (pa8e@virginia.edu), University of Virginia, Department of Mathematics, P.O. Box 400137, Charlottesville, VA 22904. *Group actions on buildings associated to Chevalley groups.*

Let G be a Chevalley group and K a field. In joint work with Matthew Zaresmky we show that a torsionfree subgroup H of G(K) cannot act strongly transitively on the spherical building associated to G(K) or on the corresponding affine building if K is endowed with a discrete valuation. In fact, there does not exist an apartment

A such that the stabilizer of A in H acts chamber transitively on A. This leads to many examples of (torsionfree S-arithmetic) groups which act Weyl transitively but not strongly transitively on affine buildings. Previously those examples were only known in the tree case (joint work with Ken Brown). (Received September 07, 2009)

1053-20-322 **Christopher Connell** and **G. Christopher Hruska*** (chruska@uwm.edu), Department of Mathematical Sciences, University of Wisconsin–Milwaukee, PO Box 413, Milwaukee, WI 53201-0413. *Measure theoretic invariants of commensurability for nonuniform lattices.*

Let X be a locally finite CAT(-1) complex (for instance X could be a tree). We develop a variant of Patterson–Sullivan measure for nonuniform lattices in $\mathrm{Aut}(X)$. These measures are invariant under commensurability, thus they can be used to prove that lattices are not commensurable.

The traditional Patterson–Sullivan measure on the boundary at infinity of X encodes the density of an orbit $\Gamma \cdot x$ as viewed from an internal point $y \in X$. If Γ is a nonuniform lattice, then any orbit necessarily avoids large regions of X. In these regions, the vertices of X have arbitrarily large finite stabilizers. The generalized Patterson–Sullivan measures encode, not just the density of an orbit, but also the density of all vertex stabilizers. (Received September 08, 2009)

1053-20-327 **Christopher H. Cashen*** (cashen@math.utah.edu), University of Utah, Department of Mathematics, 155 S 1400 E Room 233, Salt Lake City, UT 84112-0090, and **Natasha Macura**. *Mapping Tori of Free Group Automorphisms and Line Patterns in Free Groups.* Preliminary report.

I will talk about line patterns in free groups and how they provide quasi-isometry invariants for mapping tori of linearly growing free group automorphisms. (Received September 08, 2009)

1053-20-342 **Khalid Bou-Rabee** and **David Ben McReynolds*** (dmcreyn@math.uchicago.edu), 5734 S. University, Chicago, IL 60637. *Bertrand's postulate and subgroup growth.*

I will discuss a pair of generalizations of Bertrand's postulate on primes for finitely generated linear groups. Time permitting, I will discuss some connections with subgroup growth and L^1-norms of divisibility functions. (Received September 08, 2009)

1053-20-346 **Angela Kubena Barnhill*** (akubena@umich.edu), Department of Mathematics, University of Michigan, Ann Arbor, MI 48109, and **Anne Thomas**. *Unfolding lattices in right-angled buildings.*

For G a group and Γ a subgroup of G, recall that the *commensurator* of Γ in G is the set of all elements $g \in G$ so that G and $g\Gamma g^{-1}$ have a common finite index subgroup. In the Lie group setting, Margulis proved that a lattice is arithmetic if and only if its commensurator is dense. If X is a tree, results of Liu, Bass–Kulkarni, and Leighton show that the commensurator of every uniform lattice in $G = \mathrm{Aut}(X)$ is dense in G. When X is a right-angled building, we develop and use a technique of "unfolding" to construct new lattices and then use these lattices together with coverings of and actions on complexes of groups to show that the commensurator of the "standard uniform lattice" is dense in G. (Received September 08, 2009)

22 ► Topological groups, Lie groups

1053-22-65 **Lisa Carbone** and **Ben Martin*** (B.Martin@math.canterbury.ac.nz), Maths Department, University of Canterbury, Private Bag 4800, Christchurch, 8140, New Zealand. *Deformations of lattices in $PSL_2(K)$, K a local field.* Preliminary report.

Let K be a local field. A *lattice* is a discrete subgroup Γ of $PSL_2(K)$ such that the quotient space $\Gamma\backslash PSL_2(K)$ has finite measure. We consider deformations of lattices: that is, spaces of conjugacy classes of lattices that are all isomorphic to the same abstract group. If Γ is isomorphic to a free group on N generators then Γ is a so-called Schottky lattice; spaces of Schottky lattices were studied by Lubotzky. I will discuss deformations of certain lattices with torsion. This draws on ideas from two sources:

1) the theory of groups acting on trees; and

2) the theory of character varieties of finitely generated groups.

This talk is based on joint work with Lisa Carbone. (Received August 06, 2009)

1053-22-130 **Lizhen Ji*** (lji@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Well-rounded deformation retracts of symmetric spaces and Teichmuller spaces.* Preliminary report.

In this talk, I will discuss some results on equivariant deformation retractions of symmetric spaces with respect to arithmetic groups and Teichmuller spaces with respect to mapping class groups. (Received August 28, 2009)

1053-22-350 **Raf Cluckers**, **Clifton Cunningham** and **Julia Gordon*** (gor@math.ubc.ca), Department of Mathematics, University of British Columbia, 121-1984 Mathematics Rd., Vancouver, BC V6T 1Z2, Canada, and **Loren Spice**. *Motivic integration and Harish-Chandra characters.* Preliminary report.

This talk is about the project of using motivic integration to study Harish-Chandra distribution characters of certain supercuspidal representations of classical p-adic groups near the identity element. We show that the character belongs to a certain class of functions, defined by means of a language of logic, called "constructible motivic exponential functions". These functions are closely related to geometry; they are algorithmically computable, and when the residue characteristic p is large, it is possible to transfer the results about such functions between local fields of characteristic zero, and local fields of finite characteristic. I will discuss the potential implications of such transfer results for the characters. (Received September 09, 2009)

26 ► Real functions

1053-26-288 **Almut Burchard*** (almut@math.utoronto.ca). *Stability of the rearrangement inequality for the Coulomb energy.*

It is well-known that the Coulomb energy of a (positive) charge distribution increases, if the distribution is rearranged to be symmetric decreasing. One may ask if a charge distribution whose Coulomb energy is close that of its rearrangement must already be close to symmetric about some point? I will present a simple stability result on the Coulomb energy and sketch its proof. (Joint work with Gregory Chambers, greg.chambers@utoronto.ca) (Received September 07, 2009)

30 ► Functions of a complex variable

1053-30-98 **Hendrik De Bie*** (Hendrik.DeBie@UGent.be), Department of Mathematical Analysis, Krijgslaan 281, 9000 Ghent, Belgium. *Dunkl operators and realizations of* $\mathfrak{osp}(1|2)$.

In recent work, Ben Said, Kobayashi and Orsted introduced an a-deformation of the $\mathfrak{sl}_2$-relations satisfied by the Dunkl Laplacian. In this talk, we discuss the extensions of their results to Dirac operators. Although we obtain for each value of a a copy of $\mathfrak{osp}(1|2)$, only in the case $a = \pm 2$ the associated Dirac operator factorizes the a-deformed Dunkl Laplacian. Furthermore, we show how these two cases are related via a generalized Kelvin transformation.

We also connect our work with operators studied by other authors in the field of Clifford analysis. (Received August 25, 2009)

1053-30-173 **Graziano Gentili** (gentili@math.unifi.it) and **Caterina Stoppato*** (stoppato@math.unifi.it), Università degli Studi di Firenze, Dipartimento di Matematica "Ulisse Dini", Viale Morgagni 67/A, I-50134 Firenze, Italy. *The zero sets of slice regular functions and the open mapping theorem.*

A new class of regular quaternionic functions, defined by power series in a natural fashion, has been introduced in 2006. Several results of the theory recall the classical complex analysis, whereas others reflect the peculiarity of the quaternionic structure. A recent paper identified a larger class of domains, on which the study of regular functions is most natural and not limited to the study of quaternionic power series. We presently extend some basic results, concerning the algebraic and topological properties of the zero set, to regular functions defined on these domains. These results are used to prove the Maximum and Minimum Modulus Principles and a version of the Open Mapping Theorem in this new setting. (Received September 02, 2009)

1053-30-174 **Fabrizio Colombo** (fabrizio.colombo@polimi.it), Politecnico di Milano, Italy, **Graziano Gentili*** (gentili@math.unifi.it), Università di Firenze, Dipartimento di Matematica "U. Dini", viale Morgagni, 67/a, 50134 Firenze, Italy, **Irene Sabadini** (irene.sabadini@polimi.it), Politecnico di Milano, Italy, and **Daniele C. Struppa** (struppa@chapman.edu), Chapman University, CA. *Extension results for slice regular functions of a quaternionic variable.*

The theory of slice regular functions of a quaternionic variable has been introduced in 2006. Since then, the theory has been extensively studied in a series of papers which show the richness of this class of functions. This theory has demonstrated its interest by allowing a new application to the theory of quaternionic linear operators. The theory of slice regular functions is quite different from the more classical theory of regular functions in the sense of Cauchy-Fueter and, when compared with such theory, it shows many new and interesting features, such as the fact that it includes both polynomials and power series in the variable q.

In this paper we prove a new representation formula for slice regular functions, which shows that the value of such a function f at a point $q = x + yI$ can be recovered by the values of f at the points $x + yJ$ and $x + yK$ for any choice of imaginary units I, J, K. This result allows us to extend the known properties of slice regular functions defined on balls centered on the real axis to a much larger class of domains, called axially symmetric domains. We show, in particular, that axially symmetric domains play, for slice regular functions, the role played by domains of holomorphy for holomorphic functions. (Received September 02, 2009)

1053-30-184 **Michael T. Lacey**, School of Mathematics, Georgia Institute of Technology, 686 Cherry Street, Atlanta, GA 30332-0160, **Eric T. Sawyer**, Dept. of Mathematics & Statistics, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4K1, Canada, **Xavier Tolsa**, Departament de Matemàtiques, Edifici C Facultat de Ciències, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain, and **Ignacio Uriarte-Tuero***, Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Astala's conjecture on Hausdorff measure distortion under planar quasiconformal mappings and related removability problems.*

In his celebrated paper on area distortion under planar quasiconformal mappings (Acta 1994), Astala proved that if E is a compact set of Hausdorff dimension d and f is K-quasiconformal, then fE has Hausdorff dimension at most $d' = \frac{2Kd}{2+(K-1)d}$, and that this result is sharp. He conjectured (Question 4.4) that if the Hausdorff measure $\mathcal{H}^d(E) = 0$, then $\mathcal{H}^{d'}(fE) = 0$. This conjecture was known to be true if $d' = 0$ (obvious), $d' = 2$ (Ahlfors), and $d' = 1$ (Astala, Clop, Mateu, Orobitg and UT, Duke 2008.) The approach in the last mentioned paper does not generalize to other dimensions.

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

Lacey, Sawyer and UT jointly proved completely Astala's conjecture in all dimensions (Acta, 2009?) The proof uses Astala's 1994 approach, geometric measure theory, and new weighted norm inequalities for Calderón-Zygmund singular integral operators which cannot be deduced from the classical Muckenhoupt A_p theory.

These results are intimately related to removability problems for various classes of quasiregular maps. I will particularly mention sharp removability results for bounded K-quasiregular maps obtained jointly by Tolsa and UT. (Received September 02, 2009)

1053-30-311 **Stephen D. Casey*** (profstephencasey@gmail.com), Math/Stat Department, American University, 4400 Massachusetts Avenue, N.W., Washington, DC 20016-8050. *Deconvolution and Sampling on Non-Commensurate Lattices via Complex Interpolation Theory.*

Solutions to the analytic Bezout equations associated with certain multichannel deconvolution problems rest upon the strongly coprime condition. We first describe this condition, and show that it is a natural setting in which to solve deconvolution problems. Our solutions are developed via interpolation on unions of non-commensurate lattices. They provide insight into how one can develop general sampling schemes on properly chosen non-commensurate lattices. We will give specific examples of these types of lattices, and use a generalization of B. Ya. Levin's sine-type functions to develop interpolating formulae. We close by exploring the stability of these formulae to sample jitter and additive signal noise. (Received September 08, 2009)

1053-30-365 **Erik Lundberg*** (elundberg@mail.usf.edu), 10014 N Pawnee Ave, Tampa, FL 33617. *Complex Lightning bolts: a barrier to analytic continuation of harmonic functions.*

We consider Dirichlet's problem in the plane with polynomial data on algebraic curves. How far outside the data curve can the solution be analytically continued? Making a complex change of variables, we see that if a special finite set called a "lightning bolt" can be located on the (complexified) data curve, then singularities have to occur. The lightning bolt is generated by following (complex) characteristics of Laplace's equation between

consecutive vertices. We end with the question: "Can quaternions be used to generalize this technique to 4 dimensions?" (Received September 11, 2009)

1053-30-369 **Matvei Libine*** (mlibine@indiana.edu) and **Igor Frenkel**. *Quaternionic Analysis, Representation Theory and Physics.*

This is a joint work with Igor Frenkel.

I will describe our new developments of quaternionic analysis using representation theory of various real forms of the conformal group as a guiding principle. These developments will lead to a solution of Gelfand-Gindikin problem. Along the way we discover striking new connections between quaternionic analysis and mathematical physics. In particular, the Maxwell equations are realized as the quaternionic counterpart of the Cauchy formula for the second order pole. We also find a representation-theoretic meaning of the polarization of vacuum and one-loop Feynman integrals.

This talk is partially based on the joint paper with Igor Frenkel, "Quaternionic analysis, representation theory and physics", Advances in Mathematics 218 (2008) pp 1806-1877; also available at arXiv:0711.2699 (Received September 11, 2009)

1053-30-370 **Soeren Krausshar*** (Soeren.Krausshar@wis.kuleuven.be), **Swanhild Bernstein** and **Svend Ebert**. *Construction of diffusion wavelets on conformally flat cylinders and tori (joint work with Swanhild Bernstein and Svend Ebert).*

Abstract:

In this talk we study the solutions to the diffusion equation on some conformally flat cylinders and on the n-torus. Using the Clifford algebra calculus with an appropriate Witt basis, the solutions can be expressed as multi-periodic eigensolutions to the parabolic Dirac operator. We study their fundamental properties, give representation formulas of all these solutions and develop some integral representation formulas. As main application, we construct well localized diffusion wavelets on this class of cylinders and tori by means of multiperiodic eigensolutions to the parabolic Dirac operator. We also present some concrete numerical simulations for the three dimensional case. (Received September 11, 2009)

1053-30-371 **Adrian Vajiac*** (avajiac@chapman.edu). *"Singularities of functions of one and several bicomplex variables".*

In this talk we study the singularities of holomorphic functions of bicomplex variables. In particular, we use computational algebra techniques to show that even in the case of one bicomplex variable, there cannot be compact singularities. The same techniques allow us to prove a duality theorem for such functions. (Received September 11, 2009)

1053-30-372 **Mihaela Vajiac*** (mvajiac@chapman.edu). *"Bicomplex Hyperfunctions".*

In this talk I will develop the foundations for a theory of hyperfunctions as cohomology classes of bicomplex hyperholomorphic functions. The sheaf $\mathcal{H}$ of bicomplex hyperholomorphic functions was defined and studied in an earlier paper. In this second paper we discuss some cohomological properties of $\mathcal{H}$; specifically we compute its flabby dimension and we use the knowledge of its resolution to define a sheaf of hyperfunctions. These hyperfunctions will be objects defined on a codimension three real analytic variety in the space $\mathbb{BC}$ of hypercomplex numbers. This is consistent with the fact that the flabby dimension of $\mathcal{H}$ is three. (Received September 11, 2009)

1053-30-374 **Frank Sommen*** (fs@cage.ugent.be). *Microlocalization using Clifford analysis.*

In earlier work we proved that every distribution or hyperfunction in R^m can be obtained as a boundary value $f(x+0)-f(x-0)$ of a function $f(x+xo)$ in $R^{m+1}\backslash R^m$ which satisfies the generalized Cauchy-Rieman equation $(\partial xo + \partial x)f(x+xo) = 0$ for monogenic functions.

In particular the delta distribution $d(x)$ is the boundary value of the Cauchy kernel $E(x+xo) = 1/Am + 1(xo-x)/|x+xo|^{m+1}$.

Microlocalisation involves a kind of non-linear Radon transform by which the delta distribution is decomposed further into distributions $D(x,w)$ which are singular in the origin and in the direction w (w belongs to the unit sphere); these functions are used to study wavefront sets and micro-supports. In our presentation we illustrate that this classical microlocal decomposition of the delta-distribution can be obtained by using boundary values of monogenic functions as opposed to functions of several complex variables. As a side result we obtain the formula $d(x) = 2/Am + 1[(1-ax)(xo-x)/|xo+x|^{m+1}]o$ whereby the notation [.]o refers to the scalar part and xo + x belongs to the parabola $xo = a|x|^2$. (Received September 11, 2009)

33 ► Special functions

1053-33-86 **Gilbert G. Walter*** (ggw@uwm.edu), Dept. of Mathematical Sciences, PO Box 413, UWM, Milwaukee, WI 53211, and **Tatiana Soleski**. *Chromatic Series for Functions of Slow Growth.*

The theory of chromatic derivatives leads to chromatic series which replace Taylor's series for bandlimited functions. For such functions, these series have a global convergence property not shared by Taylor's series. In this work the theory is extended to bandlimited functions of slow growth. This includes many signals of practical importance such as polynomials, periodic functions, and almost periodic functions. This extension also enable us to get improved local representation and convergence results for chromatic series. (Received August 19, 2009)

34 ► Ordinary differential equations

1053-34-211 **Robert Roussarie*** (roussari@u-bourgogne.fr), I.M.B., Université de Bourgogne, B.P. 47 870, 21 078 Dijon, France. *SOME NEW RESULTS ON SLOW-FAST SYSTEMS.*

I want to present some new results on 2-dimensional *slow-fast systems* obtained in collaboration with Freddy Dumortier. Principal questions on these systems are about bifurcations of theirs so-called *canard cycles* (which always appear in family). We have studied asymptotics of canard cycles by using a geometrical tool : *blowing up* the system at its turning points. This allows to study different mechanisms for creating canard cycles and to compute theirs asymptotics which depend principally on the number of *breaking parameters* or levels (which parametrized the family of canard cycles). In generic cases, these asymptotics are given in terms of *slow divergence integrals* which can be computed in an algebraic way (when the system is polynomial). From this computation we can deduce several explicit bifurcation results for slow-fast systems. As a by-product, we have constructed in collaboration with Daniel Panazzolo, *some classical Liénard equations of degree* 7 *which exhibit at least* 4 *limit cycles*. This result contradicts an old conjecture of A. Lins Neto, W. de Melo and C.C. Pugh. (Received September 04, 2009)

1053-34-217 **Greg Spradlin*** (spradlig@erau.edu), Math. Dept., ERAU, 600 S. Clyde Morris Bv., Daytona Beach, FL 32114. *Heteroclinic Solutions to an Asymptotically Autonomous Second Order Equation.*

A differential equation of the form $\ddot{x}(t) = a(t)V'(x(t))$ is studied, where V is a double-well potential with minima at $x = \pm 1$ and $a(t) \to l > 0$ as $|t| \to \infty$. It is proven that under certain additional assumptions on a, there exists a heteroclinic solution x to the differential equation with $x(t) \to -1$ as $t \to -\infty$ and $x(t) \to 1$ as $t \to \infty$. The assumptions allow $l - a(t)$ to change sign for arbitrarily large values of $|t|$, and do not restrict the decay rate of $|l - a(t)|$ as $|t| \to \infty$. (Received September 04, 2009)

35 ► Partial differential equations

1053-35-32 **Baoquan Yuan*** (bqyuan@hpu.edu.cn), No. 2001 Century Avenue, Jiaozuo City, Henan 454000, and **Fengping Li**, No. 2001 Century Avenue, Jiaozuo City, Henan 454000. *Regularity criteria of axisymmetric solutions to the 3D magnetohydrodynamic equations.*

In this paper, we study the regularity criteria for axisymmetric weak solutions to the MHD equations in $\mathbb{R}^3$. Let ω_θ, J_θ and u_θ be the azimuthal components of ω, J and u in the cylindrical coordinates, respectively, then the axisymmetric weak solution (u, b) is regular on $(0, T)$, if $(\omega_\theta, J_\theta) \in L^q(0, T; L^p)$ or $(\omega_\theta, \nabla(u_\theta e_\theta)) \in L^q(0, T; L^p)$ with $\frac{3}{p} + \frac{2}{q} \leq 2$, $\frac{3}{2} < p < \infty$. In the endpoint case, one need conditions $(\omega_\theta, J_\theta) \in L^1(0, T; \dot{B}^0_{\infty,\infty})$ or $(\omega_\theta, \nabla(u_\theta e_\theta)) \in L^1(0, T; \dot{B}^0_{\infty,\infty})$. (Received July 06, 2009)

1053-35-33 **Richard Mikula*** (rmikula@lhup.edu), 401 W. 4th Street, Lock Haven, PA 17745. *PRESCRIBING GAUSS-KRONECKER CURVATURE ON GROUP INVARIANT CONVEX HYPERSURFACES.*

We consider the problem of prescribing Gauss-Kronecker curvature in Euclidean space. In particular, by a degree theory argument, we prove the existence of a closed convex hypersurface in R3 which has its Gauss-Kronecker curvature equal to F, a prescribed positive function, which is invariant under a fixed-point free subgroup G of the orthogonal group O(3), requiring that F satisfy natural growth assumptions near the origin and at infinity. (Received July 07, 2009)

1053-35-35 **Stefan C Mancas*** (mancass@erau.edu), 600 S Clyde Morris Blvd, Department of Mathematics, LB124, Daytona Beach, FL 32114, and **Harihar Khanal** (khana66a@erau.edu), 600 S Clyde Morris Blvd, Department of Mathematics, LB 121, Daytona Beach, FL 32114. *Solitary waves, periodic and elliptic solutions to the Benjamin, Bona & Mahony (BBM) equation modified by viscosity.*

We use a traveling wave reduction or a so-called spatial approximation to comprehensively investigate periodic and solitary wave solutions of the modified Benjamin, Bona & Mahony equation (BBM) to include both dissipative and dispersive effects of viscous boundary layers. Under certain circumstances that depend on the traveling wave velocity, a class of solitary waves solutions will be obtained in terms of the Jacobi elliptic function. Then, we will solve the IBVP using Fourier spatial discretization and a semi-implicit scheme for time differencing and compare the results obtained numerically and analytically. (Received July 09, 2009)

1053-35-54 **Evelyn Sander** and **Thomas Wanner*** (twanner@gmu.edu), Dept of Mathematical Sciences, George Mason University, 4400 University Drive, MS 3F2, Fairfax, VA 22030. *The Dynamics of Nucleation in Stochastic Cahn-Morral Systems.*

Stochastic Cahn-Morral systems serve as basic models for several phase separation phenomena in multi-component metal alloys. In this talk, I will discuss dynamical aspects of a certain type of phase separation – known as homogeneous nucleation – in which the material separates into small droplets. Numerical studies will be presented in the context of alloys consisting of three metallic components which give a statistical classification for the distribution of droplet types as the component structure of the alloy is varied. We relate these statistics to the equilibrium structure of the deterministic Cahn-Morral system and show that even highly unstable equilibria can be observed during the nucleation process, and in fact serve as organizing centers for the dynamics. (Received July 29, 2009)

1053-35-83 **tim a smith***, 600 S. Clyde Morris Blvd, Daytona Beach, FL. *On BBM equations with higher order dissipation terms.*

In our recent work we have been studying the BBM equation with an additional term to represent dissipation by viscous effects. In the following we will discuss this same BBM equations with higher order dissipation terms. (Received August 18, 2009)

1053-35-106 **Scott W. Rodney*** (scott.rodney@gmail.com), Dept. of Mathematics, Physics and Geology, Cape Breton University, 1250 Grand Lake Road, Sydney, NS B1P6L2, Canada, **R. L. Wheeden** (wheeden@math.rutgers.edu), Dept. of Mathematics - Hill Center, Rutgers, The State University of New Jersey, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, and **S-K Chua** (matcsk@nus.edu.sg), Dept. of Mathematics, Faculty of Science, The National University of Singapore, 2, Science Drive 2, 117543, Singapore. *A Compactness Theorem for Generalized Sobolev Spaces.* Preliminary report.

I present a preliminary report on joint work with R.L. Wheeden of Rutgers University and Seng Kee Chua of the National University of Singapore. We give a Rellich-Kondratchov type compactness theorem for generalized Sobolev spaces defined as a cross product of a Lebesgue space and a normed linear space of measurable $\mathbb{R}^k$ valued functions. This theorem applies to the case of degenerate Sobolev spaces defined with respect to non-negative quadratic forms on $\mathbb{R}^n$ in the presence of a homogeneous space structure. (Received August 26, 2009)

1053-35-108 **Alexis F. Vasseur*** (vasseur@math.utexas.edu) and **Cristina Caputo**. *Global regularity for a class of systems of Reaction-Diffusion equations.*

In this talk, we present the study of the regularity of solutions to some systems of reaction-diffusion equations, with reaction terms having a subquadratic growth. We show the global boundedness and regularity of solutions, without smallness assumptions, in any dimension N. The proof is based on blow-up techniques. The natural entropy of the system plays a crucial role in the analysis. It allows us to use of De Giorgi type methods introduced for elliptic regularity with rough coefficients. Even if those systems are entropy supercritical, it is possible to control the hypothetical blow-ups, in the critical scaling, via a very weak norm. (Received August 26, 2009)

1053-35-139 **Dean R. Baskin*** (dbaskin@math.stanford.edu), Department of Mathematics, Building 380, Stanford University, Stanford, CA 94538. *The Klein-Gordon equation on asymptotically de Sitter spaces.*

Asymptotically de Sitter spaces are Lorentzian manifolds that resemble the de Sitter space near infinity. They are asymptotic solutions of the Einstein equations with positive cosmological constant. We construct the forward fundamental solution for the wave and Klein-Gordon equations on these manifolds and describe properties of solutions. (Received August 30, 2009)

1053-35-145 **John Meng-Kai Hong*** (jhong@math.ncu.edu.tw), Department of Mathematics, National Central University, Chung-Li, 32054, Taiwan. *Sub-to-super transonic steady states and their linear stabilities for gas flows.*

In this talk we consider the stability of sub-to-super transonic steady states of a one-dimensional model of isentropic compressible flows through a nozzle of varying area with or without viscosity. These sub-to-super transonic steady states are newly found by using the geometric singular perturbation theory. We show that the sub-to-super steady states are physically relevant in the sense that they are linear stable as long as their velocities are great than 1/ sqr(2) of the sound speed. (Received August 31, 2009)

1053-35-154 **Xiaojing Xu*** (xjxu@bnu.edu.cn), School of Mathematical Sciences, Beijing Normal University, Beijing, 100875, Peoples Rep of China. *Local Existence and Blow-up Criterion of the 2-D Compressible Boussinesq Equations without Dissipation Terms.*

In this paper, we consider the local existence and a blow-up criterion for smooth solutions to the 2-D isentropic compressible Boussinesq equations, and obtain some new commutator estimates. In particular, we show that the time integral of the spatial maximum of gradient of velocity controls the breakdown of smooth solutions. (Received September 01, 2009)

1053-35-159 **Jeremy Marzuola** and **Jason Metcalfe*** (metcalfe@email.unc.edu), Department of Mathematics, University of North Carolina, Chapel Hill, NC 27599-3250, and **Daniel Tataru** and **Mihai Tohaneanu**. *Dispersion for the wave equation on Schwarzschild backgrounds.*

In this talk, we discuss two of the more robust ways of measuring dispersion for the wave equation: localized energy estimates and Strichartz estimates. We shall look at such estimates for the wave equation on Schwarzschild space-times. There are three main estimates that we prove. First, we prove a localized energy estimate using a positive commutator argument. The novelty of this is that we do not require a different choice of multiplier on each harmonic and we are able to attain an estimate that is smooth across the event horizon. Secondly, we use a rough WKB analysis to improve this estimate near the photon sphere, and in particular prove that only logarithmic losses are necessitated. Finally, we combine this improved localized energy estimates with a global parametrix construction of the second and third authors for small perturbations of the d'Alembertian to prove lossless Strichartz estimates for all non-sharp exponents. (Received September 01, 2009)

1053-35-172 **Y. Charles Li*** (liyan@missouri.edu). *A Resolution of the Sommerfeld Paradox.*

I will report on a resolution of the Sommerfeld paradox (joint work with Zhiwu Lin, Georgia Tech.), certain numerical implementation (joint work with Yueheng Lan, Tsinghua Univ.), and analytical conditions satisfied by traveling wave (steady state) solutions of Couette, plane/pipe Poieuille flows (joint work with Divakar Viswanath, Univ. Michigan). (Received September 01, 2009)

1053-35-179 **Jiahong Wu*** (jiahong@math.okstate.edu), Department of Mathematics, 401 Mathematical Sciences, Stillwater, OK 74078. *Global regularity for a class of generalized MHD equations.*

It remains unknown whether or not smooth solutions of the 3D incompressible MHD equations can develop finite-time singularities. One major difficulty is due to the fact that the dissipation is insufficient to control the nonlinearity and the 3D MHD equations are sometimes regarded as "supercritical". This talk presents a recent global regularity result for the generalized MHD equations with a class of hyperdissipation. This result is inspired by a recent work of Terence Tao on a generalized Navier-Stokes equations, but the result for the MHD equations is not completely parallel to that for the Navier-Stokes equations. Besov space techniques are employed to establish the result for the MHD equations. (Received September 02, 2009)

1053-35-205 **Zhiwu Lin*** (zlin@math.gatech.edu), School of Mathematics, 686 Cherry Street, Atlanta, GA 30332. *Invariant Manifolds for Euler Equations.* Preliminary report.

Consider a linearly unstable steady state of 2D or 3D Euler equations of an inviscid fluid in a bounded domain. With Chongchun Zeng, recently we prove the existence of stable and unstable manifolds near such unstable flows under a spectral gap condition. In particular, the gap condition can be verified for any linearly unstable 2D and 3D shear. The existence of invariant manifolds reveals the local dynamical structures near an unstable flow. The main difficulties of proving existence of invariant manifolds for Euler equations are due to the loss of derivatives in the nonlinear terms and the non-smoothing property of the linearized Euler operator. We developed a mixed Eulerian and Lagrangian approach to handle these difficulties. This approach is being extended to prove invariant manifolds for several other problems in fluid and plasmas. (Received September 04, 2009)

1053-35-206 **Zhouping Xin*** (zpxin@ims.cuhk.edu.hk), Room 701, Academic Building No. 1, The Chines, University of Hong Kong, Sha Tin, New Territories, Hong Kong , Hong Kong. *Vanishing Viscosity Limit for Navier-Stokes Systems.* Preliminary report.

In this talk, I will discuss soem results on the vanishing viscosity limits for incompressible Navier-Stokes systems with varios boundary conditions. In particular, we discuss the boundary layer behavior for the Navier-slip boundary conditions with slip length depending on the viscosity coefficient and well-posedness theory for Prandtl's boundary layer systems. Some convergence results will be presented also. (Received September 04, 2009)

1053-35-214 **Hongjie Dong*** (Hongjie_Dong@brown.edu), 182 George Street, Providence, RI 02906, and **Natasa Pavlovic**. *Regularity criteria for fluid equations in critical spaces.*

I will present some recent results on regularity criteria for some fluid equations in critical spaces. (Received September 04, 2009)

1053-35-215 **Shar Sajjadi***, 600 S. Clyde Morris Blvd, Daytona Beach, FL 32114, and **Timothy Smith**. *BBM-Burger's equation.*

On some recent advances of the BBM-Burger's equation with applications to viscous fluids and higher order dissipation (Received September 04, 2009)

1053-35-221 **Chi Hin Chan*** (cchan@math.utexas.edu), 820 Washington Avenue S.E. Apt # 8, Minneapolis, MN 55414, and **Magdalena Czubak**. *On the regularity of solutions to fractal Burgers equation with critical exponent.*

In this talk, we present a piece of joint work of Chi Hin Chan and Magdalena Czubak, in which we establish the existence of smooth solutions to fractal Burgers equation with critical exponent by applying the parabolic De Giorgi's method as developed by Luis Caffarelli and Alexis Vasseur. In the talk, we will make a parallel comparison between our work on fractal Burgers' equation with critical exponent and the work by Caffarelli and Vasseur in their paper "Drift diffusion equations with fractional diffusion and the quasi-geostrophic equation." (Received September 04, 2009)

1053-35-228 **Dongho Chae*** (chae@skku.edu), Department of Mathematics, Sungkyunkwan University, Suwon, 440-746, South Korea. *Remarks on the blow-up of the axisymmetric Euler equations.*

We discuss the finite time blow-up problem for the axisymmetric 3D incompressible Euler equations with swirl. Under the assumption of local minima for the pressure on the axis of symmetry with respect to the radial variations we show that the solution blows-up in finite time. Off the axis of symmetry we show that the radial increment of pressure is not consistent with the global existence of classical solution. (Received September 05, 2009)

1053-35-229 **Stephen Cantrell*** (rsc@math.miami.edu), University of Miami, Department of Mathematics, Coral Gables, FL 33124. *The interplay of advection and diffusion in the evolution of dispersal.*

In this talk we examine a Lotka-Volterra reaction-diffusion-advection model for two competing species in a closed bounded heterogeneous habitat. The species are assumed to be identical except for their dispersal strategies: one disperses by random diffusion only, while the dispersal of the other combines random dispersal and advection along an environmental resource gradient. When there is no advective component to the second species' movement, it is now well known that in this modeling context that the species with the lower diffusion rate excludes the other. However, in convex habitats the introduction of weak advection may reverse the predictions of the model, so that a species whose dispersal includes weak advection and a certain level of random diffusion can exclude a species whose dispersal is purely diffusive but slightly slower. We show that this advantage is not consistently maintained as the advective tendency becomes stronger. Rather, when advection becomes sufficiently strong, both competitors are able to increase when rare, and consequently, the two competitors coexist. Effectively, the strong advective tendency causes the second species to concentrate on the most favorable portions of the habitat leaving enough resources available to sustain the first. (Received September 05, 2009)

1053-35-257 **Jerry L. Bona**, IL, **Chun-Hsiung Hsia*** (willhsia@math.ntu.edu.tw), Department of Mathematics, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei, 10617, Taiwan, and **Tian Ma** and **Shouhong Wang**. *Hopf bifurcation of the oceanic convection problems.*

A key problem in climate dynamics is to understand and predict the periodic, quasi-periodic, aperiodic and fully turbulent characteristics of large scale geophysical flows. Bifurcation theory enables us to determine how

qualitatively different flow regimes appear and disappear as a control parameter varies, and to explore the theoretical limits of predicting these flow regimes. In this talk, we focus on the onset of Hopf bifurcation due to the stratification of the oceanic fluid. (Received September 07, 2009)

1053-35-260 **Keraani Sahbi*** (keraani@math.univ-lille1.fr). *On the global existence for the Boussinesq system.*

In this talk we present some recent results about the problem of global existence for the Boussinesq system. (Received September 07, 2009)

1053-35-276 **Jonathan Luk***, Department of Mathematics, Fine Hall, Washington Road, Princeton, NJ 08544. *Decay Rate of the Linear Wave Equation on a Schwarzschild Black Hole.*

We prove that sufficiently regular solutions to the wave equation $\Box_g \phi = 0$ on the exterior of the Schwarzschild black hole obey the estimates $|\phi| \leq C_\delta v_+^{-\frac{3}{2}+\delta}$ and $|\partial_t \phi| \leq C_\delta v_+^{-2+\delta}$ on a compact region of r and along the event horizon. This is proved with the help of a new vector field commutator that is analogous to the scaling vector field on Minkowski spacetime. This result improves the known decay rates in the region of finite r and along the event horizon. (Received September 07, 2009)

1053-35-283 **William Beckner***, Department of Mathematics, University of Texas, Austin, Austin, TX. *Sobolev embedding on Lie groups.*

Geometric inequalities are discussed in terms of non-unimodular Lie groups corresponding to manifolds with non-positive curvature. (Received September 07, 2009)

1053-35-287 **Mihai H Tohaneanu*** (mtohanea@math.purdue.edu), 427 S River Rd, Apt # 21, West Lafayette, CA 47906. *Strichartz estimates for Kerr backgrounds.*

We prove Strichartz estimates for solutions to the equation $\Box_g u = f$, where $\Box_g$ stands for the d'Alembertian associated to the metric of the Kerr spacetime. The proof uses the machinery developed in joint work with Jeremy Marzuola, Jason Metcalfe and Daniel Tataru that allows us to obtain Strichartz estimates provided that a suitable local energy estimate already exists. (Received September 07, 2009)

1053-35-289 **Shigeki Aida*** (aida@sigmath.es.osaka-u.ac.jp). *Log-Sobolev inequalities and semi-classical limit of $P(\phi)_2$-Hamiltonians.*

We determine the semi-classical limit of the lowest eigenvalue of a $P(\phi)_2$-Hamiltonian on a finite volume interval using the estimates derived from log-Sobolev inequalities. (Received September 07, 2009)

1053-35-297 **Alessio Figalli*** (figalli@math.polytechnique.fr). *Quantitative isoperimetric inequalities and stability of crystals.*

The equilibrium shape of a crystal is determined by the minimization under a volume constraint of its free energy, consisting of an anisotropic interfacial surface energy plus a bulk potential energy. In the absence of the potential term, the equilibrium shape can be directly characterized in terms of the surface tension and turns out to be a convex set, the Wulff shape of the crystal. Our first result is a sharp quantitative inequality showing that any shape with almost-optimal surface energy is close in L^1 to the Wulff shape. This is a joint work with Francesco Maggi (Florence) and Aldo Pratelli (Pavia). Under the action of a weak potential, or equivalently if the total mass of the crystal is small enough, the surface energy of the equilibrium shape is actually close to that of the corresponding Wulff shape, and the previous result applies. However, stronger geometric properties are now expected (like convexity or closedness in some stronger norm), due to the fact that the considered shapes are minimizers. This is a joint work with Francesco Maggi (Florence). (Received September 07, 2009)

1053-35-326 **G. C. Verchota*** (gverchot@syr.edu), Dept. Mathematics, Syracuse University, Syracuse, NY 13244. *Linear elliptic operators requiring indefinite terms in the quadratic Dirichlet form in order for a full coercive estimate to hold.*

Certain 4th order linear real constant coefficient elliptic differential operators $L = \sum_{|\alpha|=|\beta|=2} a_{\alpha\beta}\partial^{\alpha+\beta}$ are shown to satisfy a coercive integro–differential estimate

$$c \sum_{|\alpha|\leq 2} \int_\Omega |\partial^\alpha u|^2 dX \leq \sum_{|\alpha|=|\beta|=2} \int_\Omega a_{\alpha\beta}\partial^\alpha u \, \overline{\partial^\beta u} dX + c_0 \int_\Omega |u|^2 dX, \quad (c > 0)$$

over the full Sobolev space $W^{2,2}(\Omega)$ only when the right side contains quadratic terms that are indefinite, in fact negative definite on an infinite dimensional subspace of $W^{2,2}(\Omega)$. These terms are shown to be necessary even when L, in addition, can be written as a sum of squares of homogeneous 2nd order operators $\sum p_j^2(\partial)$, so that L also has formally positive forms $\sum_j \int_\Omega |p_j(\partial)u|^2 dX$. In these cases all formally positive forms are shown to be noncoercive over $W^{2,2}(\Omega)$. (Received September 08, 2009)

1053-35-340 **Phillip D Whitman*** (pwhitman@math.princeton.edu), 11 Lawrence Dr #105, Princeton, NJ 08540. *Uniqueness of solutions to linear wave equations on the Schwarzschild spacetime.* Preliminary report.

Recent work on black hole uniqueness by Ionescu, Klainerman, Alexakis and others has led to increased interest in the problem of prescribing data on the event horizons of black holes for solutions to linear wave equations. Ionescu and Klainerman show that if we require that the solution be stationary on any Kerr spacetime, then we have uniqueness throughout the entire domain of outer communication. Additionally, if we require that the solutions be analytic, we will again have uniqueness throughout the domain of outer communication. However, we expect nonuniqueness of smooth, nonstationary (and not analytic) solutions. We will discuss recent work concerning constructing counterexamples to unique continuation in this framework on the Schwarzschild spacetime. (Received September 08, 2009)

1053-35-361 **vladimir soucek*** (soucek@karlin.mff.cuni.cz), Mathematical Institute, Charles University, 186 75 Prague, Czech Rep. *Clifford analysis in dimension 4.* Preliminary report.

Clifford analysis started as a study of properties of solutions of the Dirac equation. In the special case of dimension 4, it was studied by Feuter and his school already 70 years ago. Meanwhile, Clifford analysis developed enormously and it is now a broad field of study. But still, the case of dimension for is much better understood than the higher dimensional cases.

In the lecture, I will discuss various results from different branches and subfields developed in recent decades in the case of dimension 4. It will cover topics both from Clifford analysis in one and several variables. A distinguished feature of Clifford analysis is that symmetry groups of various systems of equations considered are quite big. The most typical case is conformal invariance of many equations studied but in more variables, groups of symmetries are different.

Due to a key role played by symmetry considerations, the role of tools coming from representation theory is enormous. So in the lecture, we shall have to use some basic notions and tools coming from (finite dimensional) representation theory. (Received September 11, 2009)

1053-35-362 **petr somberg*** (somberg@karlin.mff.cuni.cz), Mathematical Institute, Charles University, 186 75 Prague, Czech Rep. *Invariants of geodesics and conformal geometry.* Preliminary report.

Cauchy-Riemann equations for the existence of a derivative of quaternionic-valued function on R^4 form an overdetermined system of PDE's, usually called the twistor equation. Equations for Killing forms (or, more generally, for functions with values in more complicated representations of the orthogonal group) are overdetermined conformally invariant equations generalizing the twistor equation.

It is well-known that Killing forms on a Riemannian manifold yield tensor fields preserved (covariantly constant) along geodesics. We show that this is just an example of quite general phenomenon underlying the relationship between Riemannian and conformal geometry, i.e. we define generalized Killing tensor-spinors as suitable subspaces of conformal Killing tensor-spinors and prove that their contraction with geodesic vector field is covariantly constant along geodesics. (Received September 11, 2009)

1053-35-363 **Juhi Jang** and **Dong Li*** (mpdongli@gmail.com), Department of Mathematics, University of Iowa, 14 Maclean Hall, Iowa City, IA 52242, and **Xiaoyi Zhang**. *On semilinear nonlinear wave equations and Klein-Gordon equations with critical nonlinearities.*

We will explain some recent results on the construction of wave operators for a large class of semilinear nonlinear wave equations, Klein-Gordon equations with critical nonlinearities. (Received September 11, 2009)

1053-35-364 **Xiaoyi Zhang*** (zh.xiaoyi@gmail.com), 14 Maclean Hall, Iowa city, IA 52242, and **Dong Li**. *The regularity of almost periodic modulo solution and applications.*

We consider the L_x^2 solution u to mass critical NLS $iu_t + \Delta u = \pm|u|^{\frac{4}{d}}u$. We proved that in dimensions $d \geq 4$, if the solution is spherically symmetric and is *almost periodic modulo scaling*, then it must belong to $H_x^{1+\epsilon}$ for some $\epsilon > 0$. Moreover, the kinetic energy of the solution is localized uniformly in time. One important application of the theorem is a simplified proof of the scattering conjecture for mass critical NLS without reducing to three enemies. As another important application, we establish a Liouville type result for L_x^2 initial data with ground state mass. We prove that if a radial L_x^2 solution to focusing mass critical problem has the ground state mass and does not scatter in both time directions, then it must be global and coincide with the solitary wave up to symmetries. Here the ground state is the unique, positive, radial solution to elliptic equation $\Delta Q - Q + Q^{1+\frac{4}{d}} = 0$. This is the first rigidity type result in scale invariant space L_x^2. (Received September 11, 2009)

37 ► Dynamical systems and ergodic theory

1053-37-45 **Hendrik W Broer*** (h.w.broer@rug.nl), University of Groningen, Benoulliborg, builing 5161, Nijenborgh 9, 9747 AG Groningen, Groningen, Netherlands. *On Multi-Periodic Dynamics, overview and some recent results.*

An overview of the Kolmogorov-Arnold-Moser Theory of multi- or quasi-periodic dynamics is given, both in and outside the world of conservative dynamics. Certain occurrences of multi-periodicity are revisited in a coherent way. Also two new aspects will be addressed, the theory of quasi-periodic bifurcations and the global KAM Theory for bundles of tori. The latter enables the definition of monodromy for nearly integrable Hamiltonian systems. (Received July 17, 2009)

1053-37-57 **Evelyn Sander*** (esander@gmu.edu), Dept. of Math. Sci. MS-3F2, George Mason University, 4400 University Dr., Fairfax, VA 22030, and **James A. Yorke**. *Period-doubling cascades galore.*

Period-doubling cascades are a familiar topic, since they arise naturally in many unrelated experimental and numerical systems. Yet little is known about why they exist. In a bifurcation diagram with an initial cascade as a parameter varies, secondary cascades occur within every periodic window. Thus there are an infinite number of cascades whenever there is one. In work with Jim Yorke, we show that the amount of chaos in the system as the parameter grows determines which cascades exist. We can characterize the chaos as the parameter grows for certain N-dimensional systems, where N is arbitrary but finite, giving rise to an explanation of its pattern of cascades. Furthermore, we have proved that the pattern of cascades is robust; namely that large local perturbations cannot destroy any cascades. Rather, a perturbation simply shifts the position of each cascade. (Received July 29, 2009)

1053-37-75 **Jean-Pierre FRANCOISE*** (Jean-Pierre.Francoise@upmc.fr), 175 Rue de Chevaleret, 75252 Paris, France. *Successive derivatives of return maps and relative cohomology.* Preliminary report.

We consider several extensions of the algorithm of the successive derivatives of return maps to global situations. This algorithm is closely related to relative cohomology and to the complex version of Bautin theory . We also discuss new applications of relative cohomology techniques to global normal forms. This includes both limit cycles of plane vector fields and Hamiltonian systems. We consider for instance the number of limit cycles which can emerge from an elliptic sector. We also discuss the algorithm of successive derivatives of periods and its relation with Birkhoff normal forms.

References: JP Francoise Successive derivatives of a first return map, application to the study of quadratic vector fields. Ergodic Theory and Dynamical Systems. 16 (1996), 87-96.

JP Francoise The successive derivatives of the period function of a plane vector field. Journal of Differential Equations. 146 (1998), 320-335. (Received August 13, 2009)

1053-37-85 **Ale Jan Homburg** (a.j.homburg@uva.nl), Science Park 904, 1098 XH, Amsterdam, Netherlands, and **Todd Young*** (young@math.ohiou.edu), Department of Mathematics, 321 Morton, Athens, OH 54701. *Bifurcations of random differential equations with bounded noise on surfaces.*

In random differential equations, with bounded noise, minimal forward invariant (MFI) sets play a central role since they support stationary measures. We study the stability and possible bifurcations of MFI sets. In dimensions 1 and 2 we classify all minimal forward invariant sets and their codimension-one bifurcations in bounded noise random differential equations under generic conditions.

We find in 1 dimension that there is only 1 codimension-one bifurcation, which is an analog of the saddle-node bifurcation. In 2 dimensions we show that there are 3 distinct codimension-one bifurcations. (Received August 19, 2009)

1053-37-97 **Zin Arai** (arai@cris.hokudai.ac.jp), Japan Science and Technology Agency, Hokkaido University, Creative Research Initiative "Sousei", Sapporo, 001-0021, Japan, **William Kalies** (wkalies@fau.edu), Department of Mathematical Sciences, Florida Atlantic University, 777 Glades Rd, Boca Raton, FL 33431, **Hiroshi Kokubu** (kokubu@math.kyoto-u.ac.jp), Department of Mathematics, Kyoto University, Kyoto, 606-8502, Japan, **Konstantin Mischaikow*** (mischaik@math.rutgers.edu), Department of Mathematics and BioMaPS, Hill Center-Busch Campus, 110 Frelinghusen Rd, Piscataway, NJ 08854, **Hiroe Oka** (oka@rins.ryukoku.ac.jp), Department of Applied Mathematics and Informa, Faculty of Science and Technology, Ryukoku University, Seta, Otsu, 520-2194, Japan, and **Pawel Pilarczyk**, Centre of Mathematics, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal. *A Database Schema for the Analysis of Global Dynamics of Multiparameter Systems.*

A generally applicable, automatic method for the efficient computation of a database of global dynamics of a multiparameter dynamical system is introduced. An outer approximation of the dynamics for each subset of the parameter range is computed using rigorous numerical methods and is represented by means of a directed graph. The dynamics is then decomposed into the recurrent and gradient-like parts by fast combinatorial algorithms and is classified via Morse decompositions. These Morse decompositions are compared at adjacent parameter sets via continuation to detect possible changes in the dynamics. The Conley index is used to study the structure of isolated invariant sets associated with the computed Morse decompositions and to detect the existence of certain types of dynamics. The power of the developed method is illustrated with an application to the two-dimensional, density-dependent, Leslie population model. (Received August 24, 2009)

1053-37-168 **Robert Vandervorst***, de Boelelaan 1081, 1081 HV Amsterdam, Netherlands, **J.B. Van den Berg**, de Boelelaan 1081, 1081 HV Amsterdam, Netherlands, and **F. Pasquotto**, de Boelelaan 1081, 1081 HV Amsterdam, Netherlands. *Closed characteristics on non-compact hypersurfaces.*

Viterbo demonstrated that any (2n-1)-dimensional compact hypersurface M of contact type has at least one closed characteristic. This result proved the Weinstein conjecture for the standard symplectic space. Various extensions of this theorem have been obtained since, all for compact hypersurfaces. In this paper we consider non-compact hypersurfaces M coming from mechanical Hamiltonians, and prove an analogue of Viterbo's result. The main result provides a strong connection between the top half homology groups H*(M), * = n, . . . , 2n-1, and the existence of closed characteristics in the non-compact case (including the compact case). (Received September 01, 2009)

1053-37-331 **Sarah Day*** (sday@math.wm.edu), College of William and Mary, Department of Mathematics, P.O. Box 8795, Williamsburg, VA 23188, and **Benjamin Holman** and **Sebastian Schreiber**, Department of Evolution and Ecology, One Shields Ave, University of California, Davis, CA 95616. *Quantifying Patterns in a Coupled-Patch Population Model.*

The coupled patch model for population dynamics incorporates both local dynamics and dispersal. When an appropriate threshold is applied, population values give rise to patterns (in space) and may evolve in a complicated manner in time. I will discuss joint work with Benjamin Holman and Sebastian Schreiber in which we study coupled Ricker maps and the complicated patterns they produce. We use computational homology, and in particular the computation of Betti numbers, to measure the patterns and their evolution in time. (Received September 10, 2009)

1053-37-347 **M. Drew LaMar*** (mdlama@wm.edu), Department of Applied Science, The College of William and Mary, 311 McGlothlin-Street Hall, Williamsburg, VA 23187, and **Gregory D. Smith** (greg@wm.edu), Department of Applied Science, The College of William and Mary, 305 McGlothlin-Street Hall, Williamsburg, VA 23187. *Synchronization of pulse-coupled oscillators on random directed networks.*

A network of pulse-coupled oscillators is an effective model in the study of neural synchronization. In this talk, we explore the effect of correlations between the in- and out-degrees (i.e. node-degree correlations) of random directed networks on the synchronization of identical pulse-coupled oscillators. We demonstrate through numerical experiments that networks with negative node-degree correlation are less likely to achieve global synchrony and synchronize more slowly than networks with positive node-degree correlation. Pulse-coupled oscillator networks with negative node-degree correlation often exhibit multiple coherent attracting states, with trajectories performing fast transitions between them. These effects of node-degree correlation on dynamics of pulse-coupled oscillators are consistent with aspects of network topology (e.g., the effect of node-degree correlation

on the eigenvalues of the Laplacian matrix) that have been shown to affect synchronization in other contexts. (Received September 08, 2009)

39 ► Difference and functional equations

1053-39-165 **Mariette Maroun*** (maroun@ulm.edu), 700 University Ave, 349 Airway Sc. Bldg, Monroe, LA 71209, and **Youssef M Dib** (dib@ulm.edu), 700 University Ave, 33 Airway Sc. Bldg, Monroe, LA 71209. *Permanence of the Water Hyacinth in Northeast Louisiana.*

The invasive specie of Water Hyacinth was introduced into the United States of America in late 1800. This aquatic plant consist of three different stages. It take over upon introduction into fresh water bodies because of its sexual and as-sexual reproductive system. From early 1970's till now, scientists have been trying to control it in different manners from chemical to biological. A model will be provided to show that long term control of this plant depend only on its survival. (Received September 01, 2009)

1053-39-166 **Youssef M Dib*** (dib@ulm.edu), 700 University Ave, 333 Airway Sc. Bldg, Monroe, LA 71209, and **Mariette Maroun** (maroun@ulm.edu), 700 University Ave, 333 Airway Sc. Bldg, Monroe, LA 71209. *VIVO and VITRO HSV_1 infections, Latency-Reactivation by Systems Theory Approach.*

A nonlinear methematical model for HSV1 viral infections will be produced from its background. Differential cell are the host of this virus. Once infected, this differential cell would survive as long as it host this virus. It is assumed that both HSV1's DNA and Nuclear DNA in the differential cell depend on Thyroid Hormone liganded with its receptore. Numerical simulation proving the biological relevence will be shown. In addition, future research direction for this model will be discussed. (Received September 01, 2009)

41 ► Approximations and expansions

1053-41-120 **Ahmed I Zayed*** (azayed@math.depaul.edu), Department of Mathematical Sciences, DePaul University, Chicago, IL 60201. *Generalizations of Chromatic Derivatives and Series.*

Chromatic series expansions of bandlimited functions provide an alternative representation to the Whittaker-Shannon-Kotel'nikov sampling series. Chromatic series share similar properties with Taylor series insofar as the coefficients of the expansions, which are called chromatic derivatives, are based on the ordinary derivatives of the function. Chromatic derivatives are linear combinations of ordinary derivatives in which the coefficients of the combinations are related to a system of orthonormal polynomials.

In this talk we outline a number of generalizations of chromatic derivatives and series, including generalizations to generalized functions and higher dimensions. (Received August 27, 2009)

1053-41-197 **Ilya A Krishtal*** (ikrishtal@niu.edu), Northern Illinois University, Department Of Mathematical Sciences, Watson Hall 320, DeKalb, IL 60115. *Wiener's Lemma and frame memory localization.*

A version of Wiener's (Tauberian) lemma states that an invertible matrix with summable diagonals has an inverse in the same class. Summable diagonals is a type of memory localization for the operator defined by the matrix. In this talk we show that other types of memory localization yield similar results for inverse operators. In particular, we consider localization with respect to frames, fusion frames, and g-frames. In this way, we argue that Wiener's Lemma is primarily a statement about the preservation of memory localization by inverse operators. (Received September 03, 2009)

42 ► Fourier analysis

1053-42-52 **Alex Stokolos*** (astokolos@georgiasouthern.edu), Georgia Southern University, Department of Mathematical Sciences, 203 Georgia Ave, Statesboro, GA 30460. *On multidimensional extension of Dini test.*

An anisotropic multidimensional version of Dini test will be presented. (Received July 24, 2009)

1053-42-66 **Amin Boumenir*** (boumenir@westga.edu), University of West Georgia, Carrollton, GA 30118, and **Vu Kim Tuan**, University of West Georgia, Carrollton, GA 30118. *Sampling in Hardy Spaces.*

We prove a new sampling formula for functions in Hardy spaces and disprove the existence of a Shannon sampling type formula there. This extends the sampling method to compute eigenvalues of a singular Sturm-Liouville problem in the presence of a continuous spectrum. We also show a new series representation of the Riemann zeta function in the half plane. (Received August 10, 2009)

1053-42-127 **Akram Aldroubi*** (akram.aldroubi@vanderbilt.edu), Dept. of Mathematics, Vanderbilt University, Nashville, TN 37240, and **Carlos Cabrelli**, **Christopher Heil**, **Keri Kornelson** and **Ursula Molter**. *Characterization of invariance in shift-invariance spaces.*

A shift-invariant space is a space of functions that is invariant under integer translations. Such spaces are often used as models for spaces of signals and images in mathematical and engineering applications. In this work we characterize those shift-invariant subspaces that are also invariant under additional (non- integer) translations. For the case of finitely generated spaces, these spaces are characterized in terms of the generators of the space. As a consequence, it is shown that principal shift-invariant spaces with a compactly supported generator cannot be invariant under any non-integer translations. (Received August 28, 2009)

1053-42-135 **Akram Aldroubi** and **Haichao Wang*** (wanghaichao0501@gmail.com), 1229A SC, Dept of Mathematics, Vanderbilt Universiy, Nashville, TN 37240. *Uncertainty principle in Shift invariant spaces.*

In this talk, we consider the time-frequency localization of the orthonormal generator of a shift invariant space. We prove that if a principal shift invariant space is also $\frac{1}{n}\mathbf{Z}$-invariant for some $n > 1$, then the orthonormal generator and its Fourier transform can not both decay as fast as $\frac{c}{x^r}$ for positive constants $r > 1$ and c (Received August 30, 2009)

1053-42-158 **Caroline Sweezy*** (csweezy@math.nmsu.edu), Department of Mathematical Sciences, New Mexico State University, P. O. Box 30001, 3MB, Las Cruces, NM 88003-8001. *Two weight conditions for norm bounds on solutions to Poisson's equation in a bounded nonsmooth domain in Euclidean space.* Preliminary report.

One way to understand the rate of change of a temperature function on a bounded domain is to consider how the gradient of the temperature behaves with respect to different measures. Methods originally used by Wheeden and Wilson to investigate solutions to the Dirichlet problem can be adapted to for solutions to the nonhomogeneous equation, Lu=div(f) in D, u(x)=0 on boundary(D), to obtain sufficient conditions on Borel measures m and v so that the L^q norm of a local Hölder norm of u(x) with respect to the measure m on D is dominated by the L^p norm of div(f) and of f with respect to v on the same domain, for $3 \leq n < p \leq q < \infty$. A local Hölder norm of u is been used instead of the gradient of u. Results for both the steady state and the time dependent equations will be discussed. (Received September 01, 2009)

1053-42-162 **Der-Chen E. Chang*** (chang@georgetown.edu), Department of Mathematics, St.Mary's Hall, Washington, DC 20057. *Variations on the Theorem of Pompeiu.*

Let X be alocally compact topological space and let G be a topological group acting on X. Assume that μ is a non-negative invariant Radon measure on X and $\{\gamma_j\}_{j=1}^N$ is a finite collection of compact subsets in X. Consider the Pompeiu transform

$$P : C(X) \to (C(G))^N$$

defined by

$$(P_j f)(g) := \int_{g\gamma_j} f d\mu,$$

where P_j is the jth component of the transform P and $g\gamma_j = \{g \circ x : x \in \gamma_j\}$. We say the family $\{\gamma_j\}_{j=1}^N$ has the Pompeiu property if P is injective. The Pompeiu problem is to decide as explicitly as possible whether the family has the Pompeiu property.

In this talk, we present some recent results in Heisenberg group for Pompeiu problem both for cases of a ball and for a bidisk. We also consider some aspects of the Morera side of the problem. (Received September 01, 2009)

1053-42-170 **Izabella Laba** and **Malabika Pramanik*** (malabika@math.ubc.ca), 1984 Mathematics Road, Department of Mathematics, University of British Columbia, Vancouver, BC V5B 2E7, Canada. *Maximal operators and differentiation theorems on sparse sets.*

In this work joint with Izabella Laba, we study maximal averages associated with singular measures on $\mathbb{R}$. Our main result is a probabilistic construction of singular Cantor-type measures supported on sets of Hausdorff dimension $1-\epsilon$, $0 \le \epsilon < \frac{1}{3}$ for which the corresponding maximal operators are bounded on $L^p(\mathbb{R})$ for $p > (1+\epsilon)/(1-\epsilon)$. As a consequence, we are able to answer a question of Aversa and Preiss on density and differentiation theorems in one dimension. (Received September 01, 2009)

1053-42-193 **David V. Cruz-Uribe*** (david.cruzuribe@trincoll.edu), Department of Mathematics, Trinity College, 300 Summit St., Hartford, CT 06106-3100, and **Jose Maria Martell** and **Carlos Perez**. *Sharp weighted estimates for the Hilbert transform, Riesz transforms, and the Beurling-Ahlfors operator.*

We give a new proof of the sharp weighted L^p inequality

$$\|Tf\|_{L^p(w)} \le C(n,T)[w]_{A_p}^{\max\left(1,\frac{1}{p-1}\right)} \|f\|_{L^p(w)},$$

where T is the Hilbert transform, a Riesz transform, or the Beurling-Ahlfors operator. By the sharp form of the Rubio de Francia extrapolation theorem due to Dragičević *et al.*, it suffices to prove this inequality when $p = 2$. These inequalities were first proved by Petermichl and Volberg. Their proofs reduced the problem to proving the sharp L^2 estimates for certain dyadic Haar shift operators; these in turn were proved using Bellman function techniques. More recently, Lacey, Petermichl and Reguera-Rodriguez gave a unified proof that avoided Bellman functions and instead used a two-weight, $T1$ theorem for Haar shift operators due to Nazarov, Treil and Volberg. Our proof instead uses a remarkable new pointwise estimate due to Lerner that is based on the sharp local maximal function of Jawerth and Torchinsky. Our approach also yields sharp norm inequalities for dyadic paraproducts and other operators, and can also be used to get new two-weight inequalities with "A_p bump" conditions. (Received September 03, 2009)

1053-42-238 **Steven C. Hofmann*** (hofmanns@missouri.edu), Dept. of Mathematics, University of Missouri, Columbia, MO 65211, and **Svitlana Mayboroda** and **Alan McIntosh**. *Hardy spaces adapted to divergence form elliptic operators.*

The classical Stein-Weiss H^p spaces are closely linked to the Laplacian. For example, these spaces may be characterized in terms of the L^p behavior of appropriate non-tangential maximal functions or square functions associated either to the Poisson semigroup $e^{-t\sqrt{\Delta}}$ or to the heat semigroup $e^{-t\Delta}$. Moreover, at least for some range of p, they may be characterized in terms of the L^p behavior of the Riesz Transforms $\nabla(\Delta)^{-1/2}$.

Auscher, Duong, McIntosh and Yan have developed certain aspects of Hardy space theory, paralleling the classical results, in which the Laplacian is replaced by another operator L which enjoys a pointwise Gaussian heat kernel bound.

In this talk, we shall discuss joint work with S. Mayboroda and A. McIntosh, in which we develop Hardy space theory corresponding to a second order divergence form operator

$$L := -\mathrm{div} A\nabla$$

(where A is an $n \times n$ complex elliptic matrix of bounded measurable coefficients), for which pointwise heat kernel bounds may be lacking. Much of this theory still runs parallel to the classical theory, but there are now certain differences, and it is these differences that we shall emphasize. (Received September 06, 2009)

1053-42-239 **Laura De Carli*** (decarlil@fiu.edu), Department of Mathematics, University Park, Miami, FL 33199, and **Steve M Hudson**. *Generalizations of Bernoulli inequality.* Preliminary report.

We present generalizations of the classical Bernoulli inequality which are relevant in harmonic analysis and their applications to Weierstrass products. (Received September 06, 2009)

1053-42-244 **D. Aalto** (daniel.aalto@utu.fi), **L. Berkovits** (lberkovi@mail.student.oulu.fi), **O. E. Maasalo** (outi.elina.maasalo@tkk.fi) and **H. Yue*** (yueh@trine.edu). *John-Nirenberg lemma II for a doubling measure.*

In the paper that John and Nirenberg (1961) introduced the BMO space and characterized functions in the space in terms of a related distribution inequality, they also discussed the corresponding issues for functions f being integrable in a given cube Q_0 and satisfying

$$K_f := sup\left\{\sum_i |Q_i|^{1-p}\left[\int_{Q_i}|f-f_{Q_i}|d\mu\right]^p\right\}^{1/p} < \infty \qquad (1)$$

where the supremum is taken over all collections $\{Q_i\}_{i=0}^{\infty}$ with Q_i being subcubes of Q_0 such that $\bigcup Q_i = Q_0$ with disjoint interiors. We call the space with the norm defined by (1) the John-Nirenberg space with exponent p and denote it by $JN_p(Q_0)$.

The John-Nirenberg lemma II claims that if f is a function in $JN_p(Q_0)$, then $f - f_{Q_0}$ is in weak $L^p(Q_0)$.

We discuss the space JN_p and the lemma in the context of a doubling metric measure space.
(Received September 06, 2009)

1053-42-265 **Camil Muscalu*** (camil@math.cornell.edu), Department of Mathematics, Cornell University, Ithaca, NY 14853. *Pseudo-differential operators: a natural approach.* Preliminary report.

The goal of the talk is to describe a very natural and simple way of proving boundedness of pseudo-differential operators (linear or multi-linear) by "reducing" the problem to its corresponding multiplier variant. (Received September 07, 2009)

1053-42-286 **Elliott H. Lieb*** (lieb@princeton.edu). *Inversion positivity and the sharp Hardy-Littlewood-Sobolev inequality.*

We give a new proof of certain cases of the sharp HLS inequality. Instead of symmetric decreasing rearrangement it uses the reflection positivity of inversions in spheres. In doing this we extend a characterization of the minimizing functions due to Li and Zhu. (Received September 07, 2009)

1053-42-328 **Atanas G. Stefanov*** (stefanov@ku.edu), Department of Mathematics, 1460, Jayhawk Blvd, Lawrence, KS 66045. *On pseudo-differential operators with rough symbols.*

We consider pseudo-differential operators with rough (not even continuous in general) symbols in the x variable. The L^p operator norms are estimated explicitly in terms of scale invariant quantities involving the symbols. Some applications will be discussed as well. (Received September 08, 2009)

1053-42-330 **Robert Azencott** (razencot@math.uh.edu), Department of Mathematics, 651 Phillip G. Hoffman Hall, University of Houston, Houston, TX 77204-3008, **Saurabh Jain*** (sjain@math.uh.edu), Department of Mathematics, 651 Phillip G. Hoffman Hall, University of Houston, Houston, TX 77204-3008, and **Manos Papadakis** (mpapadak@math.uh.edu), Department of Mathematics, 651 Phillip G. Hoffman Hall, University of Houston, Houston, TX 77204-3008. *Rigid Motion Invariant Classification of 3D-Textures.* Preliminary report.

We develop a novel rotationally invariant three-dimensional texture classification scheme using Gaussian Markov Random Fields on $\mathbb{Z}^3$ to model textures sampled on a discrete lattice. To obtain these samples we restrict the domain of definition of a continuous texture considered as a realization of a stationary Gaussian Random Field on $\mathbb{R}^3$ to $\mathbb{Z}^3$. Using the mathematical framework of the Isotropic Multiresolution Analysis, we justify why it is correct to restrict the domain of definition of the continuous texture, formulate the concept of 3D-rigid motions of textures, and develop a method for computing 3D-rigid motion invariant texture signatures necessary for the texture classification. (Received September 08, 2009)

1053-42-376 **Nadine Badr*** (badr@math.univ-lyon1.fr), Institut Camille Jordan, Universite Claude Bernard Lyon 1, 43 boulevard du 11 novembre 1918, Villeurbanne, F-69622, and **Galia Dafni** (gdafni@mathstat.concordia.ca), Department of Mathematics and Statistics, Concordia University, 1455 de Maisonneuve Blvd. West, Montreal, Quebec H3G1M8. *An atomic decomposition of the Hajlasz Sobolev space M^1_1 on manifolds*

We compare several possible notions of Hardy-Sobolev spaces on a Riemannian manifold with a doubling measure. We consider characterizations of these spaces in terms of maximal functions, atomic decompositions, and gradients, and identify them with the L^1 Sobolev space M^1_1, defined by Hajlasz. We obtain atomic decompositions in both the homogeneous and non-homogeneous cases. (Received September 15, 2009)

43 ► Abstract harmonic analysis

1053-43-343 **Andrea J Fraser*** (afraser@mathstat.dal.ca), Department of Mathematics and Statistics, Dalhousie University, Halifax, NovaScotia B3H 3J5, Canada. *A class of singular integral operators on the Heisenberg group.*

This talk concerns a class of singular integral operators on the Heisenberg group H_n, characterized by certain regularity and cancellation conditions on their convolution kernels. These conditions are analogous to those describing the kernels of the product-type Calderon—Zygmund operators on R^n, such as the product Hilbert

transform. I show here that such operators are bounded on $L^p(H_n)$. The proof follows a 'reverse transference' method of Muller, Ricci and Stein. (Received September 08, 2009)

46 ► Functional analysis

1053-46-27 **Alexander A Katz*** (katza@stjohns.edu), St. John's University, Dep. of Math & CS, 300 Howard Ave., DaSilva 314, Staten Island, NY 10301. *On Enveloping C*-algebra of Rickart JB-algebra.*

In the paper we introduce and study Rickart JB-algebras which are JB-algebras in which an annihilator of each one-point set is a principle ideal generated by a projection. Examples of those algebras include JBW-algebras (JB-algebras with a pre-dual space) and Baer JB-algebras (often called AJW-algebras, or Jordan algebras of Kaplansky). The main result we prove states that an arbitrary invertible JB-algebra is an Rickart JB-algebra then and only then when its universal enveloping C*-algebra is an Rickart C*-algebra. (Received June 25, 2009)

1053-46-31 **Alexander A. Katz** (katza@stjohns.edu), St. John's University, Dep. of Math & CS, 300 Howard Ave., DaSilva 314, Staten Island, NY 10301, **Roman Kushnir*** (kushnir_roman@yahoo.com), University of South Africa, Department of Mathematical Sciences, P.O.Box 392, Pretoria, 0003, South Africa, and **Venera Sh. Mukhamedieva** (mukhamedieva@farpi.uz), Ferghana Polytechnic Institute, Department of Mathematics, 86 Ferghana City, Ferghana, 712000, Uzbekistan. *On decomposition of C*-algebras over semifields into continuous fields of C*-algebras over Stonean compacts.*

In a previous paper we introduced C*-algebras over semifields which are simultaneously Banach-Kantorovich spaces over complex regular universal semifields, and complex *-algebras with natural axioms similar to the axioms of C*-algebras, making those object to be a natural generalization of the category of C*-algebras within the category of Banach modules over semifields. It has been as well established there that a continuous field of C*-algebras over Stonean compact of the semifield canonically determines a C*-algebra over a semifield. In the present sequel we show that each C*-algebra over semifield can be naturally decomposed into a continuous field of C*-algebras over the Stonean compact of the semifield. (Received July 01, 2009)

1053-46-354 **Svitlana Mayboroda***, svitlana@math.purdue.edu, and **Alexander Volberg**. *Square function, Riesz transform and rectifiability.*

A celebrated 1991 theorem of David and Semmes ascertains that the L^2-boundedness of all Calderón-Zygmund operators with respect to a Hausdorff measure H^s on a set E implies that s is an integer and E is rectifiable ("contains big pieces of Lipschitz graphs"). In the present work we establish that it is, in fact, sufficient to assume pointwise boundedness of a single operator, namely, the square function associated to the Riesz transform, in order to arrive to the same conclusion. (Received September 09, 2009)

47 ► Operator theory

1053-47-171 **Maria Cristina Pereyra*** (crisp@math.unm.edu), Department of Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131, and **Daewon Chung** (midiking@math.unm.edu), Department of Mathematics and Statistics, MSC03 2150, 1 University of New Mexico, Albuquerque, NM 87131. *Towards sharp bound for the commutator on weighted Lebesgue spaces.*

In this talk we discuss boundedness properties of the commutator $[b, H]$ on weighted spaces $L^p(w)$, where b is a BMO function and H is the Hilbert transform. It is known that if the weight w is in the Muckenphout A_p-class, then the commutator is bounded in $L^p(w)$, what is not known yet is the optimal rate of dependence of the operator norm on the A_p-characteristic of the weight. (Received September 01, 2009)

49 ► Calculus of variations and optimal control; optimization

1053-49-188 **Zuhair M. Nashed**, 4000 Central Florida Blvd, Orlando, FL 32816, and **Alexandru C Tamasan***, 4000 Central Florida Blvd, Orlando, FL 32816. *Local stability in a minimization problem for conductivity imaging.*

We consider the problem of minimization of the functional $\int_\Omega a(x)|\nabla u(x)|dx$ over functions u of bounded variation with prescribed trace f at the boundary. The stability of the minimum value of the functional with respect to the coefficient $a \in L^2(\Omega)$ is established in the vicinity of a coefficient of the form $a = \sigma|\nabla u|$, where u solves $\nabla \cdot \sigma \nabla u = 0$ with $u|_{\partial\Omega} = f$. This problem occurs in conductivity imaging when knowledge of the magnitude of the current density field inside a body is available. The method of proof is constructive. (Received September 03, 2009)

1053-49-293 **Gary Lawlor*** (lawlor@mathed.byu.edu). *A new proof for the double bubble in 3-space.*

We give a calibration proof that the least-area way to separately enclose two volumes in $\mathbf{R}^3$ is the standard double bubble. (Received September 07, 2009)

51 ► Geometry

1053-51-104 **M. Davis**, **T. Januszkiewicz** and **J.-F. Lafont*** (jlafont@math.ohio-state.edu). *Obstruction to Riemannian smoothing of CAT(-1) manifolds.*

I will give some new examples of smooth manifolds supporting locally CAT(-1) metrics, but which do not support any Riemannian metric of non-positive curvature. The examples arise from Davis complexes associated to certain right-angled Coxeter groups G, where the groups G are obtained from suitable triangulations of the 3-sphere. This is joint work with M. Davis and T. Januszkiewicz. (Received August 25, 2009)

1053-51-224 **Viktor Schroeder*** (vschroed@math.uzh.ch), Insitute of Mathematics, University of Zurich, Winterthurerstr. 190, Zurich, Switzerland. *Ptolemy spaces with many circles.*

The boundary of a CAT(-1) space carries a natural class of metrics which satisfy the Ptolemy condition. In these spaces there is a natural concept of circles. In this talk we study Ptolemy spaces with many circles and give applications to CAT(-1) spaces. (Received September 05, 2009)

52 ► Convex and discrete geometry

1053-52-113 **Stefan Witzel*** (switzel@mathematik.tu-darmstadt.de), Schlossgartenstrasse 7, Darmstadt, 64293. *Finiteness properties of $\mathcal{G}(\mathbb{F}_q[t])$.*

We show that if $\mathcal{G}$ is an isotropic, absolutely almost simple group of rank n defined over $\mathbb{F}_q$, then the arithmetic lattice $\mathcal{G}(\mathbb{F}_q[t])$ in $\mathcal{G}(\mathbb{F}_q((t)))$ is of topological finiteness type F_{n-1}. The method is to use simplicial Morse theory on the Euclidean twin building associated to $\mathcal{G}(\mathbb{F}_q[t, t^{-1}])$.

In the case where $\mathcal{G}$ is a classical group and q is large compared to n, the result is due to P. Abramenko and (in the case A_n) H. Abels. (Received September 01, 2009)

1053-52-295 **Grigoris Paouris*** (grigoris@math.tamu.edu). *Small ball probability estimates, PSI_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 Psi-2-body has bounded isotropic constant, with a slightly better estimate. This is a joint work with Nikos Dafnis. (Received September 07, 2009)

53 ► Differential geometry

1053-53-19 **Vladimir Chernov*** (Vladimir.Chernov@dartmouth.edu), Mathematics Department, 6188 Kemeny Hall, Dartmouth College, Hanover, NH 03755, and **Stefan Nemirovski** (stefan@mi.ras.ru), Mathematisches Institut, Ruhr-Universität, Bochum, 44780 Bochum, Germany and, Steklov Mathematical Institute, 119991, Moscow, Russia. *"Legendrian links, causality, and the Low conjecture".*

Let (X^{m+1}, g) be a globally hyperbolic spacetime with Cauchy surface diffeomorphic to an open subset of $\mathbb{R}^m$. The Legendrian Low conjecture formulated by Natário and Tod says that two events $x, y \in X$ are causally related if and only if the Legendrian link of spheres $\mathfrak{S}_x, \mathfrak{S}_y$ whose points are light geodesics passing through x and y is non-trivial in the contact manifold of all light geodesics in X. The Low conjecture says that for $m = 2$ the events x, y are causally related if and only if $\mathfrak{S}_x, \mathfrak{S}_y$ is non-trivial as a topological link. We prove the Low and the Legendrian Low conjectures. We also show that similar statements hold for any globally hyperbolic (X, g) such that the universal cover of its Cauchy surface is diffeomorphic to an open domain of $\mathbb{R}^m$. An interesting fact, proved in the joint work with Yuli Rudyak, is that a certain weakened version of the Low conjecture is true for all nonrefocussing globally hyperbolic spacetimes. This includes all the cases where a Cauchy surface has infinite fundamental group or is not a closed manifold. (Received May 27, 2009)

1053-53-141 **Sergiy Koshkin*** (koshkins@uhd.edu), University of Houston-Downtown, CMS Department, 1 Main Street, #S705, Houston, TX 77002. *Gauge theory of Faddeev-Skyrme functionals.*

We study geometric variational problems for a class of nonlinear sigma-models in quantum field theory. Mathematically, one needs to minimize an energy functional on homotopy classes of maps from closed 3-manifolds into compact homogeneous spaces G/H. The minimizers are known as Hopfions and exhibit localized knot-like structure. Our main results include proving existence of Hopfions as finite energy Sobolev maps in each (generalized) homotopy class when the target space is a symmetric space. For more general spaces we obtain a weaker result on existence of minimizers in each 2-homotopy class. Our approach is based on representing maps into G/H by equivalence classes of flat connections. The equivalence is given by gauge symmetry on pullbacks of G–>G/H bundles. We work out a gauge calculus for connections under this symmetry, and use it to eliminate non-compactness from the minimization problem by fixing the gauge. (Received August 31, 2009)

1053-53-182 **John Ryan*** (jryan@uark.edu), Department of Mathematics, Fayetteville, AR 72701, and **Craig Nolder**. *Conformal symmetry in Clifford analysis and some nonlinear Dirac equations.* Preliminary report.

We shall study the conformal symmetry of operators of Dirac type, focusing on the p-Dirac equation and a dispersive Dirac equation. (Received September 02, 2009)

1053-53-186 **Jeffrey L. Jauregui*** (jeff@math.duke.edu), Mathematics Department, Duke University, Box 90320, Durham, NC 27707. *A Generalization of the Riemannian Penrose Inequality.*

The Riemannian Penrose Inequality estimates the ADM mass of an asymptotically flat manifold in terms of the area of its boundary, provided the boundary consists of outer-minimizing minimal surfaces. In this talk I will discuss current work to give a lower bound for the mass in the case that the boundary is not necessarily minimal. Connections will be made to the theory of "zero area singularities." (Received September 02, 2009)

1053-53-254 **Stéphane Sabourau*** (sabourau@lmpt.univ-tours.fr), LMPT, Université de Tours, Parc de Grandmont, 37200 Tours, France. *Curvature-free inequalities on surfaces and the minimax principle on the one-cycle space.*

The existence of a closed geodesic on every Riemannian two-sphere can be obtained using a minimax principle on the loop space. This principle extends to the one-cycle space of every surface and yields a closed geodesic in this case too. We will present various curvature-free relationships between the length of this closed geodesic and the area or the diameter of closed Riemannian surfaces. (Received September 07, 2009)

1053-53-262 **Fernando A Schwartz*** (fernando@math.utk.edu), Department of Mathematics, The University of Tennessee, 104 Aconda Court, 1534 Cumberland Avenue, Knoxville, TN 37996. *Inequalities for the ADM mass.* Preliminary report.

We will present some inequalities involving the ADM mass of an asymptotically flat Riemannian manifold with nonnegative scalar curvature. (Received September 07, 2009)

1053-53-294 **Frank Morgan*** (Frank.Morgan@williams.edu). *Manifolds with Density and Isoperimetric Problems.*

Putting a positive density on a Riemannian manifold has served probabilists, Perelman, and others well. We focus on the isoperimetric problem and some recent results. (Received September 07, 2009)

54 ► General topology

1053-54-198 **N. Brodskiy*** (brodskiy@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996, and **J. Higes**. *Asymptotic dimension of tree-graded spaces.*

Tree-graded spaces were introduced and studied by C. Drutu and M. Sapir. Given a metric space X of finite asymptotic dimension $\operatorname{asdim} X \leq n$, we consider a quasi-isometric invariant of the space called dimension function. The space X is said to have asymptotic Assouad-Nagata dimension $\operatorname{asdim}_{AN} X \leq n$ if there is a linear dimension function in dimension n. We estimate dimension function of a tree-graded space using dimension functions of its pieces. As a corollary we find the asymptotic Assouad-Nagata dimension of the free product of finitely generated infinite groups: $\operatorname{asdim}_{AN}(G * H) = \max\{\operatorname{asdim}_{AN}(G), \operatorname{asdim}_{AN}(H)\}$. (Received September 03, 2009)

55 ► Algebraic topology

1053-55-61 **Sam Nelson*** (Sam.Nelson@cmc.edu), Department of Mathematics, Claremont McKenna College, 850 Columbia Ave, Claremont, CA 91711. *Group enhancements of counting invariants.*

Counting invariants of knots and links count homomorphisms from a knot quandle (or biquandle, rack, group, etc.) into a finite target object of the same type. *Enhancements* associate a Reidemeister-invariant 'signature' of some type to each such homomorphism, refining and strengthening the counting invariant. In this talk, we will see a method of enhancing the counting invariants using finite groups extracted from the target object. (Received August 03, 2009)

1053-55-114 **Gregory Lupton*** (g.lupton@csuohio.edu), Department of Mathematics, Ceveland State University, 2121 Euclid Avenue, Cleveland, OH 44115, and **Samuel Bruce Smith**. *Fibrewise Rational H-Spaces.* Preliminary report.

A *fibrewise H-space* X is a fibrewise-pointed, fibrewise space X that admits a fibrewise multiplication $m\colon X \times_B X \to X$. In this fibrewise setting, we assume a given (fixed) projection $p\colon X \to B$, and spaces and maps are over B; the *fibrewise product* is then $P\colon X \times_B X \to B$, and the fibrewise multiplication m satisfies $p \circ m = P$. By fibrewise pointed, we mean there is a (fixed, once and for all) section $\sigma\colon B \to X$ of $p\colon X \to B$. Fibrewise-pointed maps and homotopies are assumed to respect fibrewise basepoints, that is, appropriate sections. Noteworthy examples of fibrewise H-spaces are furnished by considering gauge groups of principal bundles.

We study fibrewise H-spaces from a rational homotopy point of view. In the ordinary (non-fibrewise) setting, rational H-spaces are well understood. Fibrewise H-spaces, even from a rational homotopy point of view, are much less well-understood. We prove a result in the setting of fibrewise H-spaces that is essentially an extension of the well-known Leray-Samelson theorem. We give a formula for the Samelson Lie algebra of the space of sections of a fibrewise H-space. (Received August 27, 2009)

1053-55-144 **K. Blake Winter*** (bkwinter@buffalo.edu), 244 Mathematics Bldg, SUNY, Buffalo, NY 14260. *Quandles for Virtual and Higher Dimensional Knots.*

The quandle is a powerful algebraic invariant for classical knots. In particular it has been shown to be equivalent to the knot group and peripheral information. We show that this holds true in the higher dimensional case as well, and consider the consequences for the power of the quandle as an invariant of higher dimensional knots. By using a construction on welded knots which determines a surjection from welded knots to higher dimensional ribbon knots of type $S^1 \times S^n$, it is possible to show that the quandle of a welded (and hence virtual) knot is also determined by its knot group and peripheral subgroups. (Received August 31, 2009)

1053-55-316 **Jonathan A Scott*** (j.a.scott3@csuohio.edu), Cleveland State University, Department of Mathematics, 2121 Euclid Ave, RT 1515, Cleveland, OH 44115-2214, and **Kathryn Hess**. *Twisting cochains and morphisms up to strong homotopy.*

Classically, a strongly homotopy-multiplicative morphism of differential graded algebras is equivalent to a twisting cochain from the bar construction on the domain, into the target. The purpose of this talk is to show how this

phenomenon works on the level of operads. Namely, a twisting cochain from a cooperad to an operad determines a "construction" in the sense of Brown. We show that there is a natural co-ring structure on this construction, that allows us to parametrize a "type" of morphism in the same way that an operad parametrizes a "type" of algebra. One particular construction, the Koszul resolution, leads to morphisms up to strong homotopy.

This is joint work with K. Hess (EPFL). (Received September 08, 2009)

1053-55-334 **Oleg R Musin*** (oleg.musin@utb.edu), Dept. of Mathematics, UTB, 80 Fort Brown, Brownsville, TX. *On rigid Hirzebruch genera.*

The classical multiplicative (Hirzebruch) genera of manifolds have the wonderful property which is called rigidity. Rigidity of a genus h means that if a compact connected Lie group G acts on a manifold X, then the equivariant genus $h^G(X)$ is independent on G, i.e. $h^G(X) = h(X)$. In this paper we are considering the rigidity problem for complex manifolds. In particular, we are proving that a genus is rigid if and only if it is a generalized Todd genus. (Received September 08, 2009)

1053-55-338 **Jerzy Dydak*** (jdydak@utk.edu), **Matija Cencelj** and **Ales Vavpetic**. *Asymptotic dimension, Property A, and Lipschitz maps.* Preliminary report.

It is well-known that a paracompact space X is of covering dimension n if and only if any map f from X to a simplicial complex K can be pushed into its n-skeleton. We use the same idea to define dimension in the coarse category. It turns out the analog of maps f from X to K is related to asymptotically Lipschitz maps, the analog of paracompact spaces are spaces related to Yu's Property A, and the dimension coincides with Gromov's asymptotic dimension. (Received September 08, 2009)

57 ► Manifolds and cell complexes

1053-57-43 **Andrew Elliott*** (elflord@rice.edu), Math Department – MS 136, Rice University, 6100 S. Main St., Houston, TX 77005. *Graph-based methods establishing nontriviality of state cycle Khovanov homology classes.*

We determine when certain state cycles represent nontrivial Khovanov homology classes by analyzing features of the state graph. Using this method, we are able to produce hyperbolic knots with arbitrarily many diagonals containing nontrivial state cycle homology classes. This gives lower bounds on the Khovanov width of knots whose complexity precludes computation of the full homology. (Received July 13, 2009)

1053-57-64 **J.C. Gomez-Larranaga*** (jcarlos@cimat.mx), CIMAT, A.P. 402, 36000 Guanajuato, Gto., Mexico, and **F.J. Gonzalez-Acuna** and **W. Heil**. *Links in the 3-sphere of circular category 2.*

A non-splittable link of circular category 2 is a Burde-Murasugi link. (Received August 05, 2009)

1053-57-74 **Allison K Henrich*** (henricha@seattleu.edu), 901 12th Ave., Seattle, WA 98122. *Pseudodiagrams of classical and virtual knots.* Preliminary report.

Recently, Ryo Hanaki introduced the concept of a pseudodiagram of a knot. A pseudodiagram is a knot diagram containing only partial crossing information. A natural question to ask is how much crossing information is needed in a given pseudodiagram to determine whether the knot is indeed knotted. Building on Hanaki's idea, we propose an analogous theory for virtual knots. (Virtual knot theory is a generalization of knot theory due to Lou Kauffman.) Given a virtual pseudodiagram, how much crossing information is needed to determine whether the diagram represents a classical or non-classical virtual knot? We have begun to address these questions and have used our results to find new bounds for classical and virtual unknotting numbers as well as classical knot genus. This is joint work with students from the Virtual Knot Theory group in the 2009 SMALL REU. (Received August 12, 2009)

1053-57-77 **Charles D Frohman*** (moss1956@gmail.com), The Deparment of Mathematics, The University of Iowa, Iowa City, IA 52242, and **Joanna M Kania-Bartoszynska** (jkaniaba@nsf.gov), National Science Foundation, 4201 Wilson Bvd, Arlington, VA 22230. *Reidemeister Torsion and the A-polynomial.*

We define a seminorm on the coordinate ring of the pillow case using Reidemeister Torsion. When the character variety of a knot is sufficiently regular the radical of the seminorm detects the A-polynomial (Received August 14, 2009)

1053-57-79 **Hao Wu***, Department of Mathematics, GWU, Monroe Hall, Room 240, 2115 G Street, NW, Washington, DC 20902. *A colored $\mathfrak{sl}(N)$-homology for links in S^3.*

I will introduce a generalization of the Khovanov-Rozansky $\mathfrak{sl}(N)$-homology to colored links. I believe that it decategorifies to the quantum $\mathfrak{sl}(N)$-polynomial of links colored by exterior powers of the defining representation. (Received August 17, 2009)

1053-57-117 **Tomasz Mrowka**, **Daniel Ruberman** and **Nikolai Saveliev*** (saveliev@math.miami.edu), Department of Mathematics, Box 249085, Coral Gables, FL 33124. *Seiberg-Witten equations, end-periodic Dirac operators, and a lift of Rohlin's invariant.*

We introduce a gauge-theoretic integral lift of the Rohlin invariant of a smooth 4-manifold X with the homology of $S^1 \times S^3$. The invariant has two terms. One is the Seiberg-Witten invariant of X, and the other is essentially the index of the Dirac operator on a non-compact manifold with end modeled on the infinite cyclic cover of X. Both terms are dependent on the choices of Riemannian metric and perturbation on X but we show that these dependencies cancel as the metric and perturbation vary in a generic 1-parameter family. We also discuss some calculations and possible applications of our invariant to the study of homology cobordisms.

A similar dependency issue in dimension 3 was earlier resolved by Weimin Chen and Yuhan Lim by relating the jumps in the Seiberg-Witten invariant to the spectral flow of the Dirac operator; the resulting invariant is then the Casson invariant. (Received August 27, 2009)

1053-57-137 **J. Scott Carter** and **Masahico Saito*** (saito@math.usf.edu). *Algebraic Structures Derived from Foams.*

Foams are surfaces with branch lines at which three sheets merge. They have been used in the categorification of quantum knot invariants and in physics. The 2D TQFT of surfaces, on the other hand, is characterized by means of Frobenius algebras, where saddle points correspond to multiplication and comultiplication. In this talk, we explore algebraic operations that branch lines derive under TQFT. In particular, we point out that Lie bracket and bialgebra structures can be found in infinitely many examples. Relations to the original Frobenius algebra structures are discussed both algebraically and diagrammatically. Foam skein modules of 3-manifolds are defined. (Received August 30, 2009)

1053-57-140 **Cody L Patterson*** (cpatters@math.utexas.edu), 10610 Morado Circle, Apartment 2401, Austin, TX 78759. *Some Coxeter groups of CAT(0) dimension three.*

The Coxeter FA_n conjecture states that a Coxeter group Γ acts by isometries on a CAT(0) polyhedral cell complex of dimension n without global fixed points if and only if Γ has an infinite special subgroup of rank $n+1$. This conjecture has been proven for $n = 1$ by Serre and for $n = 2$ by A. Barnhill. I will discuss some classes of Coxeter groups with infinite special subgroups of rank 4 that act without global fixed points on CAT(0) cell complexes of dimension 3. (Received August 31, 2009)

1053-57-152 **Maciej Niebrzydowski** and **Jozef H. Przytycki*** (przytyck@gwu.edu), Department of Mathematics, GWU, Monroe Hall, Room 240, 115 G Street NW, Washington, DC 20052. *Homology of Takasaki quandles.*

In 1942 Mituhisa Takasaki introduced an algebraic structure he called Kei (in Joyce terminology – involutive quandle). The main example Takasaki was considering was obtained from an abelian group G by defining the binary operation $*$ by $a * b = 2a - b$. We call such a quandle a Takasaki quandle. We describe several methods to approach homology of Takasaki quandles, in particular by devising homology operations for any extreme chain in ZG^n. We also analyze the second quandle homology of Takasaki quandles and prove, in particular, that $H_2^Q(R_{4k}) = Z_2^2 \oplus Z^2$, where R_{4k} is the Takasaki quandle of the cyclic group Z_{4k} (i.e. dihedral quandle). (Received August 31, 2009)

1053-57-161 **Louis H. Kauffman*** (kauffman@uic.edu), Mathematics Department, University of Illinois at Chicago, 851 South Morgan Street, Chicago, IL 60607-7045. *Categorification of the Arrow Polynomial.*

This talk is joint work with Heather Dye and Vassily Manturov. We will describe our categorifications of the Arrow Polynomial invariant of virtual knots and links. (Received September 01, 2009)

1053-57-199 **Mohamed Elhamdadi*** (emohamed@math.usf.edu), 4202 E Fowler Ave., Tampa, FL 33620. *Embedding tangles in knots and quandle cocycle invariants.*

Quandle cocycle invariants are used to study the problem of embedding tangles in knots. Computations are done to detect which tangles may or may not embed in knots in the tables. The talk will include overview on

the results with coauthors K. Ameur, T. Rose, M. Saito and C. Smudde. We will also discuss new results from work in progress with M. Niebrzydowski. (Received September 03, 2009)

1053-57-202 **Sergei Chmutov*** (chmutov@math.ohio-state.edu), The Ohio State University, 1680 University Drive, Mansfield, OH 44906. *Kamada–Miyazawa polynomial and ribbon graphs.* Preliminary report.

N. Kamada and Y. Miyazawa introduced a two variable polynomial invariant of virtual links generalizing the Jones polynomial. I will show that this polynomial can be derived from the ribbon graph corresponding to a diagram of the link. The construction involves the Bollobás-Riordan polynomial of a ribbon graph which generalizes the Tutte polynomial. (Received September 03, 2009)

1053-57-216 **Heather M. Russell*** (hrussell@math.lsu.edu), Department of Mathematics, Louisiana State University, 303 Lockett Hall, Baton Rouge, LA 70803-4918. *A topological construction for all two-row Springer Varieties.*

Springer varieties are certain subvarieties of the full flag variety in $\mathbb{C}^n$. Given any partition of the number n there is an associated Springer variety. The ones corresponding to partitions of type $(n-k,k)$ are called two-row Springer varieties. For n even Khovanov studies the $(n/2,n/2)$ Springer variety establishing connections between its integral cohomology and a certain invariant of tangles. In doing this he provides a new topological construction of the $(n/2,n/2)$ Springer variety as a subspace of the product of n copies of the two-sphere. We extend Khovanov's construction to all two-row Springer varieties and explore the combinatorial and topological advantages of this new perspective. (Received September 04, 2009)

1053-57-233 **Eric J. Harper*** (harper@math.miami.edu), Department of Mathematics, Ungar Bldg Rm 515, 1365 Memorial Drive, Coral Gables, FL 33146, and **N. Saveliev**. *A Casson-Lin type invariant for links.*

In 1992, Xiao-Song Lin constructed an invariant $h(K)$ of knots $K \subset S^3$ via a signed count of conjugacy classes of irreducible $SU(2)$ representations of $\pi_1(S^3-K)$ with trace-free meridians. Lin showed that $h(K)$ equals one half times the knot signature of K. Using methods similar to Lin's, we construct an invariant $h(L)$ of two-component links $L \subset S^3$. Our invariant is a signed count of conjugacy classes of *projective* $SU(2)$ representations of $\pi_1(S^3-L)$ with a fixed 2-cocycle and corresponding non-trivial w_2. We show that $h(L)$ is, up to a sign, the linking number of L. (Received September 06, 2009)

1053-57-240 **Oleg Viro*** (oleg.viro@gmail.com), Institute for Mathematical Sciences, Stony Brook University, Stony Brook, NY 11794-3660. *Variations on Arnold's Strangeness.* Preliminary report.

In the talk Strangeness of a generic immersion of circle to plane introduced by V. Arnold in 1993 is generalized to generic immersions of a closed 1-manifold to the real projective plane. A similar theory is developed for generic real algebraic plane projective curves zero homologous in the complexification. (Received September 06, 2009)

1053-57-242 **Oleg Viro*** (oleg.viro@gmail.com), Institute for Mathematical Sciences, Stony Brook University, Stony Brook, NY 11794-3660. *Boundary value Khovanov homology.* Preliminary report.

In the talk the Khovanov homology is generalized from links to tangles. Unlike the previous generalizations, which are due to Khovanov and Bar Natan, this one categorifies a well-known generalization of the Jones polynomial, the Reshetikhin-Turaev functor from the category of tangles to the category of $\mathbb{Z}[q,q^{-1}]$-modules, in the same way as the Khovanov homology categorifies the Jones polynomial: we construct homology groups whose graded Euler characteristics are matrix elements of the map corresponding to the tangle. (Received September 06, 2009)

1053-57-250 **Carmen L Caprau*** (ccaprau@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue, M/S PB 108, Fresno, CA 93740. *On the filtered sl(2) foam cohomology for links.* Preliminary report.

The universal sl(2) foam cohomology is a bigraded link cohomology theory that corresponds to a Frobenius algebra structure defined on $\mathbb{Z}[X,i,a,h]/(X^2-hX-a)$, where a and h are formal parameters and i is the primitive fourth root of unity. This theory is constructed via a setup with webs and foams (seamed cobordisms) modulo a finite set of relations.

Given an oriented link L and letting a and h be complex numbers such that $f(X)=X^2-hX-a$ has two distinct roots, we obtain a filtered invariant for L, denoted by $H_{a,h}(L,\mathbb{C})$. In this talk we will focus on the existence of a spectral sequence converging to $H_{a,h}(L,\mathbb{C})$ with E_1-page isomorphic to Khovanov's sl(2) invariant

over $\mathbb{C}$. The E_1 and higher terms of this spectral sequence are invariants of L. Moreover, one can obtain a Rasmussen-type invariant via the foam setting, by using the above spectral sequence. (Received September 07, 2009)

1053-57-252 **Heather A. Dye*** (hadye@mckendree.edu), McKendree University, 701 College Rd, Lebanon, IL 62254. *Bounds on Mosaic Knots.* Preliminary report.

Mosaic knot theory is a version of knot theory, wherein knots are laid out on a grid. A N-mosaic knot is constructed by laying out an $N \times N$ matrix of 11 possible tiles. These tiles contain 1-tangles, 2-tangles, or are blank. The mosaic number of a knot is the smallest n for which the knot can be laid out on an $n \times n$ matrix. In this talk, we present bounds on the mosaic number and the crossing number. (Received September 07, 2009)

1053-57-255 **Uwe Kaiser*** (kaiser@math.boisestate.edu), Department of Mathematics, Boise State University, 1910 University Drive, Boise, ID. *Skein modules and bordism functors.* Preliminary report.

We explain how certain abstract or embedded bordism functors can be used to define skein modules of tangles, graphs or surfaces in 3-manifolds. This will be discussed for the specific way in which open-closed field theory can be used to construct a skein theory extending the Bar-Natan skein theory. (Received September 07, 2009)

1053-57-258 **Uwe Kaiser*** (kaiser@math.boisestate.edu), Department of Mathematics, Boise State University, 1910 University Drive, Boise, ID 83725-1555. *What is Bar-Natan skein theory?* Preliminary report.

We show that the Bar-Natan skein modules of a 3-manifold M with 1-manifold α in its boundary are colimit modules of functors from a certain bordism category of 3-manifolds embedded in $M \times I$ into linear categories constructed from a Frobenius algebra. Those functors have a relatively simple *combinatorial* structure. But actual calculations require deep *topological* information about incompressible surfaces and tunneling invariants between those surfaces. (Received September 07, 2009)

1053-57-270 **J Scott Carter*** (carter@jaguar1.usouthal.edu), Department of Mathematics and Statistics, ILB 325, Mobile, AL 36688. *Non-involutory connected quandle extensions with good involutions.*

This is based on Joint work with Kanako Oshiro and Masahico Saito.

The dihedral group of order $2(2n + 1)$ is naturally covered by a sub-group of the hyper-octahedral group. This extension is a semi-direct product of the dihedral group and the direct sum of $2n$ copies of the cyclic group of order 2. We can use the group extension to define a quandle extension that is connected, not involutory, but has a good involution. The extensions generalize the octahedral quandle that is also known as QS_6.

So far, many knots that are $(2n+1)$-colorable have also been shown by others to be colorable by this quandle extension. In independent work, Silver and Williams have used these lifted colorings to get interesting twisted Alexander polynomials. (Received September 07, 2009)

1053-57-300 **Abhijit Champanerkar*** (abhijit@math.csi.cuny.edu), Departmen of Mathematics, College of Staten Island, CUNY, 2800 Victory Boulevard, Staten Island, NY 10314, and **Ilya Kofman** (ikofman@math.csi.cuny.edu), Department of Mathematics, College of Staten Island, CUNY, 2800 Victory Boulevard, Staten Island, NY 10314. *On Jones polynomials of closed braids with a full twist.*

Let L be a closed n–braid with a full positive twist, and with up to n negative crossings. We show that the Jones polynomial of L satisfies a braid index constraint, which is a gap between the first two non-zero coefficients of $(1 - t^2) \cdot V_L(t)$. (Received September 07, 2009)

1053-57-323 **Julien Paupert*** (paupert@math.utah.edu), Department of Mathematics, University of Utah, 155 South 1400 East, Salt Lake City, UT 84112, and **John R Parker**. *Discrete complex reflection groups in PU(2,1).*

The group PU(n,1) of holomorphic isometries of complex hyperbolic n-space is one of the two occurrences (with PO(n,1)) of a simple real Lie group of rank 1 where Margulis superrigidity does not hold. The only known examples of nonarithmetic lattices in PU(2,1) were constructed by Picard, then Mostow in the 1980's. We will recall the construction of these lattices, which are generated by complex reflections, and we will show how to find new examples of the same kind in a family of configuration polygons. Part of this is joint work with John Parker (Durham). (Received September 08, 2009)

58 ► Global analysis, analysis on manifolds

1053-58-25 **F. Daniel Cibotaru*** (dcibotar@nd.edu), 1512 Rosemary Lane, Apt D, South Bend, IN 46637. *The odd Chern Character and localization formulae.* Preliminary report.

We describe geometric representatives for the generators of the cohomology ring of a model of the classifying space for the odd K-theory functor, K^{-1}. The class corresponding to the degree one generator is closely related to the spectral flow of a 1-parameter family of self-adjoint, Fredholm operators. We use intersection theory to derive localization formulae that express the cohomological index of higher dimensional families of such operators as the Poincare duals of explicit 0-cycles in the parameter space. (Received June 22, 2009)

1053-58-126 **Lev Kapitanski*** (l.kapitanski@math.miami.edu), Department of Mathematics, University of Miami, 1365 Memorial Dr, Coral Gables, FL 33146. *The Pontrjagin-Hopf invariants in nonlinear sigma-models.*

In this talk I will describe the homotopy invariants for maps between a three-dimensional manifold and the two-sphere and consider several nonlinear sigma-models where those invariants are important. I will discuss the corresponding variational and dynamical problems. (Received August 28, 2009)

1053-58-163 **Pierre Albin*** (albin@cims.nyu.edu). *The index of a family of Dirac operators on certain non-compact manifolds.*

I will discuss the issues involved in proving a families index theorem for Dirac-type operators on non-compact, asymptotically regular manifolds. I will discuss joint work with Frederic Rochon where these are worked through, using pseudodifferential techniques and renormalized traces, on manifolds with fibered hyperbolic cusps. (Received September 01, 2009)

1053-58-298 **Thierry Coulhon*** (thierry.coulhon@recherche.gouv.fr). *Riesz meets Sobolev.*

We show that the L^p boundedness, $p > 2$, of the Riesz transform on a complete non-compact Riemannian manifold with upper and lower Gaussian heat kernel estimates is equivalent to a certain form of Sobolev inequality. We also characterize in such terms the heat kernel gradient upper estimate on manifolds with polynomial growth. This is a joint work with Adam Sikora. (Received September 07, 2009)

60 ► Probability theory and stochastic processes

1053-60-9 **Xia Chen*** (xchen@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996, and **Wenbo V Li**, **Michael B Marcus** and **Jay Rosen**. *CLT for L^2 modulus of continuity of Brownian local time.*

In this talk, I will talk about the central limit laws for L^2 modulus of continuity of Brownian local times. The talk is based on collaborative work with Wenbo Li, Michael Marcus and Jay Rosen. (Received April 26, 2009)

1053-60-14 **Jianhui Huang**, **Guangchen Wang** and **Jie Xiong*** (jxiong@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996. *A maximum principle for partial information backward stochastic control problems with applications.*

We consider the partial information control problems of backward stochastic systems. First, we obtain a new stochastic maximum principle for partial information control problems. Our method relies on a direct calculation of the derivative of the cost functional. Second, we introduce two classes of partial information linear-quadratic backward control problems and then investigate them using the maximum principle. Complete and explicit solutions are obtained in terms of some forward and backward stochastic differential filtering equations. Third, we study a class of full information stochastic pension fund optimization problems which can be viewed as a special case of our general partial information ones. Applying the aforementioned maximum principle, we derive the optimal contribution policy in closed-form and present some related economic remarks. (Received May 21, 2009)

1053-60-15 **ARUNAVA MUKHERJEA***, University of Texas - Pan American, Department of Mathematics, Edinburg, TX 78539, and **RICARDO RESTREPO**. *Upper Packing Dimension of a Measure and the Limit Distribution of Products of IID Stochastic Matrices.*

This paper gives sufficient conditions for the limit distribution of products of iid 2 by 2 stochastic matrices to be continuous singular, when the support of the distribution of the individual stochastic matrices is countably infinite. Our methods here use "infinite" analogs of known results available for attractors of finite iterated

function systems. (Joint work with Ricardo Restrepo and will appear in the Proceedings of Indian Academy of Sciences) (Received May 23, 2009)

1053-60-17 **David Nualart*** (nualart@math.ku.edu), The University of Kansas, Department of Mathematics, Lawrence, KS 66045. *Stochastic differential equations driven by a fractional Brownian motion with any Hurst parameter.*

We introduce a new method to construct a rough path above a d-dimensional fractional Brownian motion B^H with any Hurst parameter $H \in (0,1)$. This method has been inspired by the approach of J. Unterberger, and it is based on the representation of the fractional Brownian motion as a Volterra Gaussian process

$$B_t^H = \int_0^t K_H(t,s) dW_s,$$

where $\{W_t\}$ is a d-dimensional standard Wiener process. The main idea is to define iterated integrals

$$\int_{s<u_1<\cdots u_n<t} dB_{u_1}^{H,i_1} \cdots dB_{u_n}^{H,i_n}$$

for $0 \le s < t \le T$, $n \le [1/H]$ and $i_1, \ldots, i_n \in \{1, \ldots, d\}$, in such a way that they satisfy the required properties of Hölder continuity, multiplicativity and geometricity. A compact and simple formula for these iterated integrals is given. The method can be extended to a general class of Gaussian Volterra processes. We will discuss how this construction allows us to solve stochastic differential equations driven by a fractional Brownian motion with any Hurst parameter. This is a joint work with Samy Tindel. (Received May 26, 2009)

1053-60-22 **Tyrone Edward Duncan*** (duncan@math.ku.edu), Mathematics Department, Snow Hall, 1460 Jayhawk Blvd., Lawrence, KS 66045. *Solutions of Stochastic Differential Equations with a Fractional Brownian Motion.* Preliminary report.

Two approaches to solving stochastic differential equations are pathwise and probabilistic. For both of these approaches strong, mild, and weak solutions are considered. The stochastic equations are formulated in both finite dimensional and infinite dimensional Hilbert spaces. The equations are bilinear and semilinear. Some specific equations are given as examples of the results. (Received June 12, 2009)

1053-60-23 **Liqing Yan*** (liqing@ufl.edu), Department Of Mathematics, University of Florida, 358 Little Hall, PO Box 118105, Gainesville, FL 32611. *Discretization Error in simulation of the maximum of a Levy process.* Preliminary report.

Discretization erros for maximum and minumum of a Brownian motion has been found through Spitzer's identity and Riemann Zeta's function. In this paper, we try to establish the discretization errors for a Levy process, epspecially for a stable process.

When the expectatin of some function of the maximum is known, this error is useful to approximate the expetation of the function of the maximum over discrete time points, for example, in pricing the barrier options and digital options.

When the expectatin of some function of the maximum is unknown (most of time), this error is useful to approximate this expetation by Monte Carlo simulation of the function of the maximum over discrete time points. (Received June 15, 2009)

1053-60-24 **Wei Sun*** (wsun@mathstat.concordia.ca), Department of Mathematics and Statistics, Concordia University, 1455 de Maisonneuve Blvd. West, Montreal, Quebec H3G 1M8, Canada. *Uniqueness of solutions of filtering equations via chaos expansions.*

We study the uniqueness of solutions of nonlinear filtering equations via the Wiener and Poisson chaos expansions. The observation function for the Wiener noise case and the intensity function for the Poisson noise case are assumed to be unbounded. (Received June 18, 2009)

1053-60-26 **Yong Zeng*** (zengy@umkc.edu), 5100 Rockhill Rd, Kansas City, MO 64110. *Econometric Analysis via Filtering for Financial Ultra-High Frequency (UHF) Data.*

We propose a general nonlinear filtering framework with marked point process observations for financial UHF data. The signal contains the intrinsic value and the related parameters and is modeled as a general Markov process. Trading times are driven by a generic point process, and the noise is described by a random transformation from the intrinsic value to trading price. Other observable variables (such as initiators of trade, and economic news) are allowed to affect the intrinsic value, the trading intensity and the noise. The proposed model encompasses many important existing models.

We derive SPDEs such as filtering equations to characterize the likelihoods, the posterior, the likelihood ratios and the Bayes factors of the proposed model. We further study the Bayesian inference (estimation and

model selection) via filtering. Especially, we employ the Markov chain approximation method to construct easily-parallelizable, recursive efficient algorithms to compute the posteriors and others, and we prove the convergence of such algorithms. The general theory is illustrated by specific models built for UHF stock prices and UHF Treasury notes data from GovPX. (Received June 24, 2009)

1053-60-29 **Robert B Lund*** (lund@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975. *Changepoint Detection in Autocorrelated Series.*

This talk overviews techniques to detect an undocumented mean shift (changepoint) in time series data. Changepoints are ubiquitous features in climatic series, occurring whenever stations relocate or gauges are changed. As positively autocorrelated series have long sojourns above and below mean levels (and hence mimic a mean shift), applying IID changepoint detection methods to correlated series can produce radically spurious results. CUSUM, likelihood ratio, and F_{max} statistics have been previously proposed to detect changepoints in correlated settings. We quantify the asymptotic distributions of these tests and connect and contrast the three methods. We find that CUSUM procedures work best when the changepoint is near the center of the data record, and F_{max} procedures are better otherwise. The methods are illustrated in several applications. (Received June 26, 2009)

1053-60-53 **Michael A Kouritzin*** (mkouritz@math.ualberta.ca), Mathematical and Statistical Sciences, University of Alberta, Edmonton, Alberta , Canada, and **Douglas Blount**. *On separation, tightness and weak convergence of cadlag processes.*

We will discuss the use of homeomorphic methods to separate, establish tightness of and prove weak convergence for probability measures on completely regular topological spaces. In the process, we will extend and generalize classical results in masterful texts, like Billingsley (1999) and Ethier and Kurtz (1986). Moreover, motivated by the work of Bhatt and Karandikar (1993), we will also discuss an alternative external method for establishing weak convergence that imbeds processes into a larger compact space instead of restricting them to a smaller space like compact containment does. (Received July 28, 2009)

1053-60-58 **Winston Buckley***, Dept of Mathematical Sciences, Boca Raton, FL. *Asymmetric Information in Fads Models in Levy Markets.*

Fads models for stocks under asymmetric information in a purely continuous (GBM) market were first studied by P.Gausoni (2006), where optimal portfolios and maximum expected logarithmic utilities, including asymptotic utilities, for informed and uninformed investors are presented. We generalize this theory to Levy markets, where stock prices and the process modeling the fads jump. We employ stochastic calculus and optimization to obtain analogous results. We link the random portfolios of investors under asymmetric information, to the purely deterministic optimal portfolio under symmetric information. (Received July 30, 2009)

1053-60-62 **Bin Xie*** (bxie@shinshu-u.ac.jp), Department of Mathematical Sciences, Faculty of Science, Shinshu University, Matsumoto, Nagano 390-8621, Japan, and **Tadahisa Funaki**. *A singular Stochastic partial differential equation and its invariant measures.*

We are gong to consider a linear heat equation on a half line with an additive noise chosen properly in such a manner that its invariant measures are a class of distributions of Lévy processes. Our assumption on the corresponding Lévy measure is, in general, mild except that we need its integrability to show that the distributions of Lévy processes are the only invariant measures of the stochastic heat equation. This is joint work with Professor T. Funaki. (Received August 03, 2009)

1053-60-129 **Yunwei Cui*** (cuiy@uhd.edu), One Main Street #S705, Houston, TX 77002. *A class of integer-valued long memory time series.* Preliminary report.

This work proposes a new model for stationary time series of integer counts. It uses renewal processes to generate correlated Bernoulli series. By simple operations on the identical and independent copies of such processes, we are able to generate a class of long memory count series. To our best knowledge, this is the only known method about how to generate long memory integer-valued time series with Binomial, Poisson, Negative Binomial, and Geometric marginal distributions. The method proposed is simple and approachable to anyone with knowledge in stochastic renewal processes. (Received August 28, 2009)

1053-60-175 **Xiaoping Shen*** (shen@math.ohiou.edu), Department of Mathematics, 1 Ohio University, Athens, OH 45701. *Characterize long-range dependency of piecewise 1/f noise.*

1/f noise is random process which has been observed as fluctuations in many artificial or natural systems such as stock prices, the frequency of quartz crystal oscillators, annual amount of rainfall to name a few. Many numerical methods have been developed to synthesize and analyze such type of noise. In this talk, we will introduce local

Holder exponent based algorithms for modeling long-range dependency of piecewise 1/f noise and illustrate the method via numerical examples. (Received September 02, 2009)

1053-60-284 **Ivan Nourdin*** (inourdin@gmail.com). *Density formula and concentration inequalities with Malliavin calculus.*

We will show how to use the Malliavin calculus to obtain a new exact formula for the density of the law of any random variable Z which is measurable and differentiable with respect to a given isonormal Gaussian process. We will also explain how to derive concentration inequalities for Z in our framework. The talk is based on a joint work with Frederi Viens (Purdue). (Received September 07, 2009)

1053-60-290 **Franck Barthe*** (barthe@math.univ-toulouse.fr). *Some isoperimetric inequalities in high dimension.*

We plan to present a survey talk about isoperimetric inequalities for two kinds of measures in high dimensions: product measures and uniform measures on convex sets. The case of product measures, motivated by the study of iid sequences of random variables is by now well understood. On the other hand the Kannan-Lovasz-Somonivits conjecture for convex sets is still open, but recent progress have been made by several authors. (Received September 07, 2009)

1053-60-292 **Michel Ledoux*** (ledoux@math.univ-toulouse.fr). *From concentration to isoperimetry: semigroup proofs.*

In a remarkable series of works, E. Milman recently showed how to go back from measure concentration inequalities to dimension free isoperimetric type inequalities in spaces with non-negative curvature. The results cover two basic instances, linear isoperimetry under arbitrarily slow concentration, logarithmic strenghtenings above the linear case under exponential decays of the concentration function. The proofs are developed in a Riemannian (with densities) context making use of isoperimetric minimizers and refined tools from geometric measure theory. In this talk, we present simple semigroup arguments to cover the superlinear case, of potential usefulness in more general settings. A particular emphasis is put on functional inequalities for heat kernel measures. (Received September 07, 2009)

62 ► Statistics

1053-62-10 **Yanqing Sun**, **Rajeshwari Sundaram** and **Yichuan Zhao*** (matyiz@langate.gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303. *Empirical Likelihood Inference for the Cox Model with Time-dependent Coefficients via Local Partial Likelihood.*

The Cox model with time-dependent coefficients has been studied by a number of authors recently. In this paper, we develop empirical likelihood (EL) pointwise confidence regions for the time-dependent regression coefficients via local partial likelihood smoothing. The EL simultaneous confidence bands for a linear combination of the coefficients are also derived based on the strong approximation methods. The EL ratio is formulated through the local partial log-likelihood for the regression coefficient functions. Our numerical studies indicate that the EL pointwise/simultaneous confidence regions/bands have satisfactory finite sample performances. Compared with the confidence regions derived directly based on the asymptotic normal distribution of the local constant estimator, the EL confidence regions are overall tighter and can better capture the curvature of the underlying regression coefficient functions. Two data sets, the gastric cancer data and the Mayo Clinic primary biliary cirrhosis data, are analysed using the proposed method. (Received April 27, 2009)

1053-62-11 **Gong Yun**, **Zhouping Li** and **Liang Peng*** (peng@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160. *Empirical likelihood intervals for conditional VaR.*

Conditional Value-at-Risk is of importance in risk management when volatility models are employed. In this paper, we propose an empirical likelihood method to construct confidence intervals for the conditional VaR. Simulation study shows that the proposed method works well in practice. (Received April 30, 2009)

1053-62-16 **Hira L. Koul*** (koul@stt.msu.edu), Professor Hira L. Koul, Department of Statistics & Probability, Michigan State University, East Lansing, MI 48824. *Model Diagnostics via Martingale Transforms.*

Classical problems in statistics are to fit a distribution up to unknown location-scale parameters and to fit a parametric model to the regression - autoregressive function. The first problem is generic to many other statistical models including the celebrated regression and autoregressive and generalize autoregressive conditionally heteroscedastic (ARCH-GARCH) models where one is testing that innovations are from a given distribution. It will be argued that the Khamaladze's martingale transformation of the residual empirical process that yields asymptotically distribution free tests for the one sample location-scale model does the same thing for a parametric heteroscedastic regression model, and ARCH-GARCH models. Analogous tests for the second problem will be also discussed.

This talk is based on some ongoing joint work with Estate Khmaladze. (Received May 26, 2009)

1053-62-18 **Nicole A. Lazar*** (nlazar@stat.uga.edu), Department of Statistics, University of Georgia, Athens, GA 30602. *On the Use of Empirical Likelihood for the Analysis of Longitudinal Data.* Preliminary report.

Longitudinal data are commonplace in medical, psychological, and sociological applications. As such, many methods, both parametric and non-parametric, have been developed for their analysis. In this talk, I discuss the use of the non-parametric method of empirical likelihood (EL) for analyzing longitudinal data. This topic has generated interest of late, with several authors exploring EL in the longitudinal data setting. The connections are clear, as estimating equations play a critical role in EL and in longitudinal data analysis. I will discuss these connections, as well as the ways they have been exploited thus far in the recent literature in the first part of the talk. In the second part of the talk, I will focus on the use of EL specifically for selecting the covariance structure imposed on the model for longitudinal data.

This is joint work with Jien Chen. (Received May 27, 2009)

1053-62-50 **J, Jian-Jian Ren*** (jren@mail.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Full Likelihood Inferences in the Cox Model.*

We derive the full likelihood function for regression parameter β_0 and baseline distribution function F_0 in the continuous Cox model. Using the empirical likelihood parameterization, we explicitly profile out nuisance parameter F_0 to obtain the full-profile likelihood function and the maximum likelihood estimator (MLE) for β_0. We show that the log full-likelihood ratio has an asymptotic chi-squared distribution, while the simulation studies indicate that for small or moderate sample sizes, the MLE performs favorably over Cox's partial likelihood estimator. Moreover, we show that the estimation bias of the MLE is asymptotically smaller than that of Cox's partial likelihood estimator. In a real dataset example, our full likelihood ratio test and Cox's partial likelihood ratio test lead to statistically different conclusions. Part of this work is joint with Mai Zhou. (Received July 22, 2009)

1053-62-55 **Suojin Wang*** (sjwang@stat.tamu.edu), Department of Statistics, Texas A&M University, College Station, TX 77843, and **Samiran Sinha**, Department of Statistics, Texas A&M University, College Station, TX 77843. *A New Semiparametric Procedure for Matched Case-Control Studies with Missing Covariates.*

In this work we propose an easy-to-use semiparametric method for analyzing matched case-control data when one of the covariates of interest is partially missing. Missing covariate information in matched case-control study may create bias and reduce efficiency of the parameter estimates. In order to cope with this situation we consider a robust approach which is comprised of estimating some functionals of the distribution of the partially missing covariate using a kernel regression technique in a conditional likelihood framework. The large sample theory of the proposed estimator is investigated and the asymptotic normality is obtained. A simulation study is conducted to assess the performance of the proposed method in terms of robustness and efficiency. The proposed method is also applied to a real dataset which motivates this work. (Received July 29, 2009)

1053-62-63 **Soumendra Nath Lahiri*** (snlahiri@stat.tamu.edu), Dept of Statistics, 525J Blocker, College Station, TX 77845. *On pooled block bootstrap estimation.*

The choice of appropriate block length is a critically important issue in construction of block bootstrap estimators. Typically, one chooses a block size that minimizes the mean squared error (MSE) of the estimator. However, in many cases, the block bootstrap estimator is very sensitive of the choice block size and may change dramatically even for a small change in block length. In this paper, we construct pooled bootstrap estimators by combining estimates for several block sizes and investigate asymptotic properties of such estimators. It is shown that for a

large class of pooled bootstrap estimators, the MSE optimal rate can be attained, without the need to preselect an optimal block size. Further, we show that with proper choice of the weights, the pooled bootstrap method can achieve a better rate than the original block bootstrap method. Results from a simulation study are also presented to illustrate finite sample properties of the proposed method.

This is a joint work with Arnab Maity (Received August 04, 2009)

1053-62-67 **Arthur Berg*** (berg@ufl.edu), Division of Biostatistics, Cancer Institute, H069, 500 University Drive, P.O. Box 850, Hershey, PA 17033-0850, and **Dimitris Politis**. *Improving the Kaplan-Meier Estimator.*

The Kaplan-Meier (KM) estimator is improved through smoothing with infinite-order kernels. Asymptotic relative deficiency provides a measure of comparison of the proposed estimator to the original KM estimator. Improvements even in terms of asymptotic relative efficiency (ARE) are present under specified assumptions on the data. The deficiency analysis introduces a deficiency rate that provides a continuum between classical deficiency analysis and efficiency analysis. An automatic bandwidth selection algorithm, specially tailored to the infinite-order kernels, is incorporated into the estimators. In small sample sizes these estimators can significantly improve the estimation of the CDF and survival function as is illustrated through the deficiency analysis and computer simulations.

Additionally, I will remark on the use of infinite-order kernels in nonparametric censored density estimation with comparisons in terms of mean square error (MSE) improvement.

This talk will be exciting and accessible to undergraduates with interest in statistics. It is based on two manuscripts that will appear in print in the coming months. Arxiv preprints are accessible that provide more details of this talk: 0903.3014 and 0704.3281. (Received August 10, 2009)

1053-62-68 **M Shakil***, Department of Mathematics, Miami Dade College, Hialeah Campus, Hialeah, FL 33012, **J. N. Singh**, Miami Shores, Miami Shore, FL 33161, and **B. M. Golam Kibria** (kibriag@fiu.edu), 11200 SW 8th Street, Miami, FL 33193. *On a new class of Pearsonian distributions and its properties.*

This paper derives a new class of continuous probability distributions generated from the generalized Pearson differential equation. Some characteristics of the distribution are defined. It is observed that the new distribution is skewed to the right and carries most of the properties of skewed distributions. Further, the proposed distributions contains many other distributions obtained by taking the product of gamma-Rayleigh pdf, exponential-Rayleigh pdf, gamma-Rice pdf, gamma-normal, and gamma-halfnormal p.d.f.'s. It is expected that the findings of the paper will be useful for researchers in various fields. (Received August 13, 2009)

1053-62-73 **B. M. Golam Kibria*** (kibriag@fiu.edu), Florida International University, Department of Mathematics and Statistics, University Park, Miami, FL 33199, and **M. Shakil**, Hialeah, FL 33012. *ON THE PRODUCT AND RATIO DISTRIBUTIONS OF TWO RANDOM VARIABLES WHEN THEY BELONG TO DIFFERENT FAMILIES.*

The distributions of the product and ratio of two independent random variables, when they belong to the same family have been studied by many researchers. In recent years, there has been a great interest in the study of the above kind when the two independent random variables belong to different families. In this paper, the exact distributions of the product and ratio of Maxwell and Rayleigh random variables have been investigated when they are distributed independently of each other. The associated cdfs, pdfs, moments, entropies, etc., have been derived. To describe the possible shapes of the associated pdfs and entropies, the respective plots are provided. The percentage points associated with the cdfs of the product and ratio have been tabulated. It is hoped that the findings of the paper will be useful for researchers in various fields (Received August 11, 2009)

65 ► Numerical analysis

1053-65-5 **Florentina Tone*** (ftone@uwf.edu), Department of Mathematics and Statistics, University of West Florida, 11000 University Parkway, Pensacola, FL 32514. *On the long time stability of the implicit Euler scheme for the 2d space-periodic Navier-Stokes equations.*

In this talk we discretize the two-dimensional space-periodic Navier-Stokes equations in time using the implicit Euler scheme and, with the aid of the discrete Gronwall lemma and the uniform discrete lemma, we prove that the scheme is H2-uniformly stable in time. (Received February 13, 2009)

1053-65-91 **Craig Rogers**, University of Central Florida, Orlando, FL, **Alain J. Kassab*** (kassab@mail.ucf.edu), Department of Mechanical, Materials, and Aerospace Engineering, Orlando, FL 32816-2450, **Eduardo A. Divo**, University of Central Florida, Orlando, FL, **Ryzsard Bialecki**, Selisian Technical University, Gliwice, Poland, and **Ziemowit Ostrowski**, Selisian Technical University, Gliwice, Poland. *Identification of Non-Homogeneous Heat Conductivity by a POD-based Inverse Approach.*

A trained proper orthogonal decomposition (POD)-based inverse approach is developed to estimate the unknown spatially varying thermal conductivity of a non-homogeneous heat conducting material. A sequence of direct problems is solved for several known spatial variations of the conductivity and the corresponding temperature field is sampled at a predefined set of points. Each such sample constitutes a snapshot, and the assembly of snapshots is utilized to construct a cofactor correlation matrix from which an orthogonal set of basis vectors (POD) are extracted and utilized to optimally expand the temperature field. By a discrete analog to the variation of parameters method for PDEs, we employ radial basis functions to train the POD basis and obtain a general response of the temperature as a function of non-homogenous conductivity. This trained POD expansion serves as the direct solver for the inverse problem. To this end, the Levenberg-Marquardt method minimizes a regularized quadratic functional evaluating the discrepancy between the measured temperatures and values calculated from the model utilizing the current estimate for the non-homogeneous thermal conductivity. Several numerical examples are provided to illustrate the robustness and numerical stability of the scheme. (Received August 21, 2009)

1053-65-155 **Alexandre Timonov*** (atimonov@uscupstate.edu), University of South Carolina Upstate, Division of Mathematics and Computer Science, 800 University Way, Spartanburg, SC 29303. *New algorithms for reconstructing the conductivity from the interior data.*

Recent findings (see A.Nachman, A.Tamasan, and A.Timonov, Inverse Problems, 23 (2007), 25 (2009)) have shown that utilizing the magnitude of the current density available from MRI measurements allows for significant improving the resolution of the conductivity images. In this talk,two new algorithms for reconstructing the conductivity from the interior data are presented. The first algorithm is based on an original procedure for constructing minimizing sequences for a functional whose Euler-Lagrange equation is a nonlinear degenerate elliptic PDE governing the voltage potential. The second algorithm reconstructs locally the planar conductivity using the BVP for the system of the second order ODEs for geodesics and partial interior data. The computational feasibility of the proposed algorithms is demonstrated in numerical experiments. (Received September 01, 2009)

1053-65-189 **Beyza C Aslan*** (beyza.aslan@unf.edu), University of North Florida, Department of Mathematics and Statistics, 1 UNF Dr., Bldg 14/2731, Jacksonville, FL 32224, **William Hager**, Universityof Florida, Department of Mathematics, 358 Little Hall, Gainesville, FL 32611, and **Richard Sonnenfeld**, **John Battles**, **Michael Holborn** and **Ruth Ron**. *Three Dimensional Current Generator of a Mountain Thunderstorm.*

Recently, wide band measurements of the electric field near a lightning flash have been obtained by a balloon-borne electric field sonde or Esonde. The data from the Esonde can be combined with simultaneous Lightning Mapping Array (LMA) measurements of VHF pulses emitted during lightning breakdown processes to estimate the charge transport associated with lightning. In this paper, we further enhance the techniques we have developed to process Esonde data by taking better account of instrument ro- tation, and by computing the local horizontal electric field, not just the lightning induced electric field change. Using these techniques, we analyze lightning charge transport for a thunderstorm which occurred on August 18, 2004, near Langmuir Laboratory, New Mexico. The analysis yields the three- dimensional current generator structure of the thunderstorm. (Received September 03, 2009)

1053-65-231 **Alexander E Labovsky*** (alabovsky@fsu.edu), 400 Dirac Science Library, Tallahassee, FL 32306, and **Jeffrey M Connors**. *A semi-implicit spectral deferred correction method for a parabolic two domain problem.*

A numerical approach to estimating solutions to coupled systems of equations is partitioned time stepping methods, an alternative to monolithic solution methods, recently studied in the context of fluid-fluid and fluid-structure interaction problems. Few analytical results of stability and convergence are available, and typically such methods have been limited to first order accuracy in terms of discretization parameters. Many proposed higher-order schemes are unstable, or their stability is yet to be proven analytically. We consider two heat equations in $\Omega_1, \Omega_2 \subset \mathbb{R}^2$ adjoined by an interface $I = \Omega_1 \cap \Omega_2 \subset \mathbb{R}$ - as a simplified model for the fluid-fluid or fluid-structure interactions. We present the family of semi-implicit spectral deferred correction (SISDC) methods for the partial differential equations. We prove stability and the desired second-order accuracy of the two-step

SISDC method (one simpler method from this family), and we also perform computational tests which verify the second-order time accuracy of the two-step method. (Received September 05, 2009)

76 ► Fluid mechanics

1053-76-93 **Adam Larios***, 6502 Adobe Cir., Irvine, CA 92617, and **Edriss S Titi**, Dept. of Mathematics, UC Irvine - 340 Rowland Hall, Irvine, CA 92697. *A New Hydrodynamic Alpha-Model With Applications To Ocean Modeling.*

The equations which govern the motions of fluids are notoriously difficult to handle both mathematically and computationally. Understanding their solutions is widely considered to be one of the most challenging problems in all of mathematics and physics. Over the last decade, a class of equations called alpha-models have been developed to hopefully alleviate this situation; however, they introduced difficulties of their own. We will discuss a new alpha-model which overcomes some of the problems present in other alpha-models, and discuss its possible application to ocean modeling. (Received August 24, 2009)

1053-76-169 **Xiaoming Wang*** (wxm@math.fsu.edu), 208 James J. Love Building, Florida State University, Tallahassee, FL 32306. *Asymptotic behavior of the Brinkman-Boussinesq system at small Darcy number.* Preliminary report.

We investigate the asymptotic behavior of the solutions to the infinite Darcy-Prandtl number Brinkman-Boussinesq system for convection in porous media at small Darcy number. We show that the limit is the infinite Darcy-Prandtl number Darcy-Boussinesq system for convection in porous media. The limit is a singular one with a viscous boundary layer. (Received September 01, 2009)

1053-76-230 **Peter Constantin** and **Gautam Iyer*** (gautam@math.cmu.edu), Dept. of Math. Sci, Room 6113, Wean Hall, Carnegie Mellon University, Pittsburgh, PA 15213, and **Jonathan 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. Time permitting I will discuss the analogue in bounded domains. (Received September 05, 2009)

1053-76-232 **Iuliana Stanculescu*** (is162@nova.edu). *Leray-Tikhonov Deconvolution Models of Fluid Motion.*

We study a new family of turbulence models, Leray-Tikhonov Deconvolution Models of fluid motion. This new family of models is based on a modification (consistent with the large scales) of Tikhonov-Lavrentiev regularization.

We introduce the modified Tikhonov deconvolution operator and study its mathematical properties.We also perform rigorous numerical analysis of a computational attractive algorithm for the considered family of models. Numerical experiments that support our theoretical results are presented. (Received September 05, 2009)

81 ► Quantum theory

1053-81-377 **William G. Harter*** (wharter@uark.edu), Department of Physics, University of Arkansas, Fayetteville, AR 72701. *Title Spacetime vs per-Spacetime: Coherent optical wave development of relativistic quantam mechanics and Fourier transformed Dirac manifolds.* Preliminary report.

A simple and revealing development of relativity and quantam mechanics may be done using coherent waves (CW) to define manifolds in spacetime and their dual reciprocal manifolds in per-spacetime (frequency ω, wavevector ck) with one being a hyper-Fourier transform of the other. (x, ct)-coordinate lines are real wavefunction zeros.

A laser cavity mode, for example, yields a physical Minkowski manifold in flat spacetime. Wave zeros in this case are found by first factoring 2D Fourier sums into group and phase factors.

$$e^{ia} + e^{ib} = e^{\frac{i(a+b)}{2}}(e^{\frac{i(a-b)}{2}} + e^{\frac{-i(a-b)}{2}}) = 2e^{\frac{i(a+b)}{2}} cos\frac{a-b}{2}.$$

The dual per-spacetime picture provides direct insight into how simple wave interference geometry gives the relations between relativistic quantities in both the classical and quantam domains and demystifies several formalistic points beginning with the famous axiom of invariance for light speed $c = 2.79982458ms^{-I}$ The development includes a geometric nomogram that calculates and displays extrinsic quantities such as Doppler shifts, k-aberration, Lorentz transformation, energy-momentum dispersion and Hamiltonian-Lagrangian contact transformation with a clarity that did not exist before. Intrinsic quantities such as Dirac spin and Feynman diagram geometry may have similar clarifying geometry. (Received September 15, 2009)

83 ► Relativity and gravitational theory

1053-83-105 **Lydia R Bieri*** (lbieri@math.harvard.edu), Harvard University, Department of Mathematics, Science Center, 1 Oxford Street, Cambridge, MA 02138. *Energy Estimates in an Extension of the Stability Theorem of the Minkowski Space in General Relativity.*

This talk addresses the issue of energy estimates in the initial value problem for the Einstein vacuum equations in GR. The famous result by D. Christodoulou and S. Klainerman proving the global nonlinear stability of the Minkowski space in GR, was a major breakthrough in the study of the Cauchy problem in GR. In the proof of an extension of this result, we use energy estimates of the type used in the original work. In our situation, where we assume less conditions on the initial data, and therefore the spacetime curvature is no longer bounded in L^∞, we first have to find the appropriate energies which then have to be controlled. These energies are used in a comparison argument to bound the curvature terms. This procedure takes place within a bootstrap argument, on which the main proof is based. In contrast to the original result, we encounter borderline terms, indicating that the conditions in our main theorem are sharp in so far as the assumptions on the decay at infinity on the initial data are concerned. In particular, these borderline cases appear also in some of the energy estimates. (Received August 25, 2009)

1053-83-118 **Willie Wai-Yeung Wong*** (wwong@math.princeton.edu). *On rigidity of charged black-holes, part 1.*

In these two talks, we discuss how to extend the recent works of Ionescu-Klainerman and Alexakis-Ionescu-Klainerman on the rigidity of vacuum black-hole solutions to the charged case. Here we first describe the preliminary setup and provide a generalization of the Mars-Simon tensor to characterize Kerr-Newman metrics among stationary electrovac solutions. Ionescu-Klainerman's Carleman inequality can then be used to reduce the problem of black-hole uniqueness to a question of rigidity of the bifurcate event horizon. (Received August 27, 2009)

1053-83-119 **Pin Yu*** (pinyu@math.princeton.edu). *On rigidity of charged black-holes, part 2.*

In these two talks, we discuss how to extend the recent works of Ionescu-Klainerman and Alexakis-Ionescu-Klainerman on the rigidity of vacuum black-hole solutions to the charged case. Here we examine the local rigidity of the bifurcate event horizon, and show how Hawking's rigidity theorem can be recovered in the smooth category if the space-time is assumed to be "close" to a Kerr-Newman solution in a suitable sense. If time permits, we'll also describe some other applications of this method to "perturbations" of the Kerr-Newman solution. (Received August 27, 2009)

1053-83-124 **Luc Nguyen*** (Luc.Nguyen@maths.ox.ac.uk), Mathmatical Institute, University of Oxford, 24-29 St Giles', Oxford, OX1 5LB, England. *Regularity of harmonic maps with prescribed rate of singularity and axially symmetric stationary electro-vacuum spacetimes.*

According to the Ernst-Geroch reduction, to each axially symmetric stationary vacuum/electro-vacuum spacetime, one can associate an axially symmetric harmonic map with singular boundary behavior. This idea has been exploited in the literature to construct asymptotically flat, axially symmetric stationary spacetimes with disconnected horizons, i.e. having multiple black holes. This family of spacetimes is uniquely parameterized by the "masses", the "momenta", the "charges" of the black holes and the "distances" between them. I'll discuss the regularity of the corresponding reduced harmonic maps and its implication on the regularity of those spacetimes. (Received August 27, 2009)

1053-83-142 **Gustav H Holzegel*** (holzegel@math.princeton.edu), Fine Hall, Washington Road, Princeton, NJ 08544. *The massive wave equation on slowly rotating Kerr-AdS spacetimes.*

We present a proof of boundedness for solutions of the massive wave equation on slowly rotating Kerr-anti de Sitter spacetimes, provided the mass-parameter satisfies the Breitenlohner Freedman bound. The proof relies on the vectorfield method. It uses a new Hardy inequality, the existence of a globally (on the black hole exterior) causal Killing vectorfield for these spacetimes and techniques recently developed by Dafermos and Rodnianski. (Received August 31, 2009)

1053-83-157 **Marcus A. Khuri*** (khuri@math.sunysb.edu), Department of Mathematics, Stony Brook University, Stony Brook, NY 11794. *The Static Metric Extension Problem.*

There are several competing definitions of quasi-local mass in General Relativity. A very promising and natural candidate, proposed by Bartnik, seeks to localize the ADM or total mass. Fundamental to understanding Bartnik's construction, is the question of existence for a canonical geometric boundary value problem associated with the static vacuum Einstein equations. In this talk we report on joint work with M. Anderson, which answers this question affirmatively under the hypothesis of a certain nondegeneracy condition. (Received September 01, 2009)

1053-83-285 **Gregory J Galloway***, Department of Mathematics, Univ of Miami, Coral Gables, FL 33124. *Aspects of marginally trapped surfaces in 2+1 and higher dimensional gravity.* Preliminary report.

Marginally outer trapped surfaces (MOTSs) have long been associated with the development of singularities in spacetime and the existence of black holes. In recent years a number of mathematically rigorous properties of MOTSs have been established. We will discuss some of these properties in connection with the existence of black holes in 2+1 dimensions, as well as the topology of black holes in higher dimensions. The work in 2+1 dimensions is joint with Kristin Schleich and Don Witt. (Received September 07, 2009)

90 ► Operations research, mathematical programming

1053-90-101 **Jai N Singh*** (jsingh@mail.barry.edu), Department of Mathematics & Computer Science, Barry University, 11300 Northeast Second Avenue, Miami Shores, FL 33161, and **Dashrath Singh**, Ahmadu Bello University, Samaru, Zaria, Kaduna , Nigeria. *On the Computational Complexity of Linear Programming.*

Abstract: In this paper we present some new results on the computational complexity of linear programming based on recently introduced notion of disjoint crossover events and curvature of central path. Keywords: Computational complexity, Disjoint crossover events, Curvature of central path. Mathematics Subject Classification: 65K05, 68Q25, 90C05, 90C51, 90C60. (Received August 25, 2009)

91 ► Game theory, economics, social and behavioral sciences

1053-91-314 **Stephanie Alexander**, **Richard Bishop** and **Robert Ghrist*** (ghrist@math.upenn.edu), 200 S. 33rd St., Philadelphia, PA 19104. *Geometry in games of pursuit and evasion.*

We show how circumradius and asymptotic behavior of curves in spaces of curvature bounded above (e.g., CAT(0) spaces) are controlled by growth rates of total curvature. We apply our results to pursuit and evasion games of capture type with simple pursuit motion, generalizing results that are known for convex Euclidean domains, and obtaining results that are new for convex Euclidean domains and hold on playing fields vastly more general than these. In the continuous-time games, interesting questions concerning existence and uniqueness of solutions to gradient-like fields on metric spaces arise, to which recent results of Chanyoung Jun apply. (Received September 08, 2009)

92 ► Biology and other natural sciences

1053-92-2 **Eduardo D. Sontag***, Rutgers University, Department of Mathematics, New Brunswick, NJ. *Systems Biology as a source of interesting problems in mathematics.*

The Life Sciences are in the midst of a major revolution in quantitative theoretical formulations, perhaps not unlike the transformation that physics underwent starting in the 17th century. It is widely recognized by leading biologists that the typical "reductionist" approach is not powerful enough to describe, analyze, and interpret the complex behaviors of networks involving DNA, RNA, proteins, metabolites, and small molecules in cells, including the signal transduction pathways that play a central role in cancers and other diseases.

Quantitative (i.e, mathematical) formalisms, concepts, tools, and models are required, and there is a major role to be played by mathematicians in applying and adapting known theory to model and understand specific systems. Conversely, the study of problems in molecular systems biology leads naturally to new mathematical questions in established areas of mathematics (probability, theoretical computer science, control theory, PDE's, and algebraic geometry, to name a few). The talk will introduce the general topic, and discuss an example of new theoretical developments. (Received June 11, 2008)

1053-92-6 **Alan A Veliz-Cuba*** (alanavc@vt.edu) and **Brandilyn Stigler**. *Network Topology as a Driver of Bistability in the Lac Operon.*

The lac operon in Escherichia coli has been studied extensively and is one of the earliest gene systems found to undergo both positive and negative control. The lac operon is known to exhibit bistability, in the sense that the operon is either induced or uninduced. Many dynamical models have been proposed to capture this phenomenon. While most are based on complex mathematical formulations, it has been suggested that for other gene systems network topology is sufficient to produce the desired dynamical behavior. We present a Boolean network as a discrete model for the lac operon. We include the two main glucose control mechanisms of catabolite repression and inducer exclusion in the model and show that it exhibits bistability. Further we present a reduced model which shows that lac mRNA and lactose form the core of the lac operon, and that this reduced model also exhibits the same dynamics. This work corroborates the claim that the key to dynamical properties is the topology of the network and signs of interactions. (Received March 06, 2009)

1053-92-7 **Michael Reed*** (reed@math.duke.edu), Department of Mathematics, 3000 Science Drive, Duke University, Durham, NC 27708, and **Janet Best** and **H Frederik Nijhout**. *Dopamine, Serotonin, and Diet.* Preliminary report.

We will describe mathematical models for the synthesis, release and reuptake of dopamine and serotonin in the neurons of specific brain regions. A model of transport of amino acids across the blood-brain barrier allows us to examine the influence of diet, both protein and carbohydrate, on the availability of dopamine and serotonin. Since both dopamine and serotonin influence a variety of behaviors, the model may permit us to make causal connections between diet and behavior in the the presence of certain neurodegenerative diseases or neuropsychiatric illnesses. (Received April 01, 2009)

1053-92-34 **Jemal S Mohammed-Awel*** (jmohammedawel@valdosta.edu), P.O.Box 5743, Valdosta, GA 31603, and **Kbenesh W Blayneh** and **Abdul-Aziz Yakubu**. *Discrete hierarchical competition with reward and cost of dispersion.*

The dynamics of asymmetric dispersion between two patches, where the local populations are structured into m-age classes, are considered. The population in one of the patches is assumed to have age-hierarchical organization and the local population practices contest competition while the population in the other habitat is not organized and practices scramble competition. Using analytical and numerical methods,comparison of the two populations (prior to dispersion), the effects of dispersion on the persistence and extinction of the local and the metapopulation are studied as key parameters change. (Received July 08, 2009)

1053-92-319 **Robert Stephen Cantrell** and **Chris Cosner*** (gcc@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33124, and **Yuan Lou**. *Evolution of dispersal and the ideal free distribution.*

A general question in the study of the evolution of dispersal is what kind of dispersal strategies can convey competitive advantages and thus will evolve. We consider a two species competition model in which the species are assumed to have the same population dynamics but different dispersal strategies. Both species disperse by random diffusion and advection along certain gradients, with the same random dispersal rates but different advection coefficients. We find a conditional dispersal strategy which results in the ideal free distribution of species, and show that it is a local evolutionarily stable strategy. (A population has an ideal free distribution if

all individuals have the same fitness and no individual can increase its fitness by moving.) We further show that this strategy is also a convergent stable strategy under suitable assumptions, and our results illustrate how the evolution of conditional dispersal can lead to an ideal free distribution. The underlying biological reason is that the species with this particular dispersal strategy can perfectly match the environmental resources, which leads to its ﬁtness being equilibrated across the habitats. (Received September 08, 2009)

1053-92-321 **John Cleveland**, Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010, and **Azmy S. Ackleh*** (ackleh@louisiana.edu), Department of Mathematics, University of Louisiana at Lafayette, Lafayette, LA 70504-1010. *A replicator-mutator model on the space of measures.* Preliminary report.

We formulate a general replicator-mutator model as a dynamical system on the state space of finite signed measures. We establish well-posedness, and show that by choosing appropriate payoff kernels this model can be rigorously reduced to a pure replicator model and to a discrete replicator-mutator system. We then prove that the model has a compact attractor and that for pure replicator dynamics the solution converges to a Dirac measure centered at the fittest trait. We also prove that in the discrete case for pure replicator dynamics and even for small perturbation of pure replicator dynamics there exists a globally asymptotically stable equilibrium. (Received September 08, 2009)

1053-92-324 **Janet A Best*** (jbest@math.ohio-state.edu), Department of Mathematics, 231 West 18th Ave, Columbus, OH 43065, and **H. Frederik Nijhout** and **Michael C Reed**. *A Mathematical Model of Dopamine Homeostasis.*

Dysregulation of the neurotransmitter dopamine is associated with disorders such as Parkinson's disease, schizophrenia, Tourette's syndrome, and drug addiction. These consequences of dopamine dysfunction highlight the importance of maintaining dopamine functionality through homeostatic mechanisms: dopaminergic systems must respond robustly to important biological signals such as bursts in firing, while at the same time maintaining homeostasis in the face of routine fluctuations in inputs, expression levels, and firing rates. Here we describe a mathematical model for the synthesis, release and reuptake of dopamine at a nerve terminal; the model includes several known feedback mechanisms and allows us to make predictions concerning their relative contributions to dopamine homeostasis. (Received September 08, 2009)

1053-92-357 **Sergei S Pilyugin*** (pilyugin@ufl.edu), Sergei Pilyugin, Department of Mathematics, University of Florida, Gainesville, FL 32611-8105, and **Patrick De Leenheer** (deleenhe@ufl.edu), Patrick De Leenheer, Department of Mathematics, University of Florida, Gainesville, FL 32611-8105. *Some notes on mutation models.*

The question of convergence for a class of multi-state dynamical models for structured populations will be discussed. Some special properties of such class of models allow to reduce the dynamics to a lower-dimensional case and make the question of convergence analytically tractable. (Received September 10, 2009)

1053-92-360 **Andrew L Nevai*** (anevai@math.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816, **Kevin M Passino**, Department of Electrical and Computer Engin, The Ohio State University, Columbus, OH 43210, and **Parthasarathy Srinivasan**, Department of Mathematics, Cleveland State University, Cleveland, OH 44115. *Stability of choice in the honey bee nest-site selection process.*

A pair of compartment models for the honey bee nest-site selection process is introduced. The first model represents a swarm of bees deciding whether a site is viable, and the second characterizes its ability to select between two viable sites. The one-site assessment process has two equilibrium states: a disinterested equilibrium (DE) in which the bees show no interest in the site and an interested equilibrium (IE) in which bees show interest. In analogy with epidemic models, basic and absolute recruitment numbers (R_0 and B_0) are defined as measures of the swarm's sensitivity to dancing by a single bee. If R_0 is less than one then the DE is locally stable, and if B_0 is less than one then it is globally stable. If R_0 is greater than one then the DE is unstable and the IE is stable under realistic conditions. In addition, there exists a critical site quality threshold Q* above which the site can attract some interest (at equilibrium) and below which it can not. There also exists a second critical site quality threshold Q** above which the site can attract a quorum (at equilibrium) and below which it cannot. The two-site discrimination process has a stable DE if and only if both sites' individual basic recruitment numbers are less than one. (Received September 10, 2009)

93 ► Systems theory; control

1053-93-21 **Michael Malisoff*** (malisoff@lsu.edu), Department of Mathematics, 303 Lockett Hall, Louisiana State University, Baton Rouge, LA 70803-4918, and **Frederic Mazenc** (mazenc@supagro.inra.fr), EPI MERE INRIA-INRA, UMR Analyse des Systemes et Biometrie, INRA, 2, pl. Viala, 34060 Montpellier, France. *Strict Lyapunov Function Constructions Under LaSalle Conditions with an Application to Lotka-Volterra Systems.*

Mathematical control theory provides the theoretical foundations that undergird many modern technologies. During the past fifteen years, there have been numerous exciting developments at the interface of control engineering and mathematical control theory. Many were based on new Lyapunov function methods. Constructing strict Lyapunov functions is a central and challenging problem. On the other hand, non-strict Lyapunov functions are often constructed easily. Even when we know a system to be globally asymptotically stable, it is often still important to have an explicit global strict Lyapunov function, e.g., for robustness analysis.

One important framework for designing strict Lyapunov functions is the so-called strictification approach. This entails transforming given non-strict Lyapunov functions into explicit global strict Lyapunov functions. This talk presents two recent strictification methods. The first relies on a nondegeneracy condition on the higher order Lie derivatives of the nonstrict Lyapunov function in the direction of the system dynamics, and the second gives a general procedure for choosing the auxiliary functions in Matrosov's theorem. We illustrate our work using the Lotka-Volterra model, which is important in bioengineering. (Received September 11, 2009)

94 ► Information and communication, circuits

1053-94-92 **Lixin Shen*** (lshen03@syr.edu), Department of Mathematics, Syracuse University, Syracuse, NY 13244. *Eigengaps of Hub and Hub-dominant Matrices.*

The notion of hub matrices was first proposed by Kung and Suter. Many communications and network systems can be represented by hub matrices. The properties of the systems are characterized by the leading eigenvalues of the Gram matrices of the hub matrices. In this talk, we will give an accuracy estimation of those eigenvalues in terms of the entries of the underlying hub matrices. (Received August 22, 2009)

1053-94-335 **M. Zuhair Nashed** (znashed@mail.ucf.edu), Department of Mathematics, University of Central Florida, Orlando, FL 32816, and **Qiyu Sun***, Department of Mathematics, University of Central Florida, Orlando, FL 32816. *Sampling and Reconstruction of Signals in Reproducing Kernel Subspaces.* Preliminary report.

In this talk, we consider sampling and reconstruction of signals in a reproducing kernel subspace of $L^p, 1 \le p \le \infty$, associated with an idempotent integral operator whose kernel has certain off-diagonal decay and regularity. The space of p-integrable non-uniform splines and the shift-invariant spaces generated by finitely many localized functions are our model examples of such reproducing kernel subspaces of L^p. We show that a signal in such reproducing kernel subspaces can be reconstructed in a stable way from its samples taken on a relatively-separated set with sufficiently small gap. We also study the exponential convergence, consistency, and the asymptotic pointwise error estimate of the iterative approximation-projection algorithm and the iterative frame algorithm for reconstructing a signal in those reproducing kernel spaces from its samples with sufficiently small gap. (Received September 08, 2009)

00 ► General

1054-00-26 **Shane A. Gibson*** (weezel515@yahoo.com), 3708 Woodview Drive, Ceres, CA 95307. *The Minkowski and Hausdorff Dimensions of Related Fractal Strings.*

The geometric zeta function of a fractal string and the Minkowski dimension of its boundary depend only on the sequence of lengths of the open intervals which make up the string. However, the Hausdorff dimension of the boundary depends on the arrangement of the intervals and not just their lengths. In this talk, it is shown that for certain related fractal strings, the topological zeta function yields the Hausdorff dimension of the boundary of a given string in much the same way that the geometric zeta function determines the Minkowski dimension. (Received August 03, 2009)

1054-00-103 **Kate E Ellis*** (darkwriter06@yahoo.com). *Zeta Functions of a Measure on a Cantor String.*

Measures supported on the complement of a fractal string have been shown to have multifractal structure, even when supported on a countable set. In this talk, the regularity values and resulting families of partition and multifractal zeta functions of such a measure (supported on the complement of a type of Cantor string) are described and analyzed. These results are expected to yield a spectrum of dimensions associated with the measure. (Received September 08, 2009)

1054-00-168 **John A Rock*** (jrock@csustan.edu), 275 E Minnesota Ave, Apt 242, Turlock, CA 95382. *Multifractals, Zeta Functions, and Spectra of Complex Dimensions.* Preliminary report.

The study of ordinary fractal strings via geometric zeta functions and complex dimensions has been generalized and expanded into the realm of multifractal analysis. With regularity (course Hölder exponent) of Borel sets, the multiscale behavior of multinomial and various multifractal measures can be analyzed through use the of multifractal and partition zeta functions. Results of such analysis include determining both the Hausdorff and the Minkowski dimensions associated with certain fractal strings as well as the multifractal spectra of certain multinomial measures. In this talk, we discuss several examples involving these zeta functions, compare them to one another, and shine a light on current related projects. (Received September 13, 2009)

1054-00-223 **Michael C Mackenzie*** (fenderbites@aol.com), Modesto, CA. *Partition Zeta Functions of a Trinomial Measure.*

The binomial measure on the Cantor set has a multifractal spectrum which yields a full family of real-valued dimensions associated with the multiscale behavior of the measure. One way to derive this multifractal spectrum is to analyze the partition zeta functions of the measure. In this talk, the collections of regularity values and partition zeta functions of a trinomial measure are derived and considered, potentially laying the groundwork for the determination of its multifractal spectrum. (Received September 14, 2009)

01 ► History and biography

1054-01-17 **Francine F. Abeles*** (fabeles@kean.edu), 1000 Morris Avenue, Union, NJ 07083. *Hugh MacColl and Charles L. Dodgson on Axioms and Non-Euclidean Geometry.* Preliminary report.

Hugh MacColl (1837-1909), who initiated the modern history of modal logic and Charles L. Dodgson (1832-1898), the unswerving supporter of Euclid's Elements for teaching purposes communicated indirectly about Dodgson's axiom, a closed form equivalent to Euclid's parallel postulate in his book, Curiosa Mathematica. Part I. A New Theory of Parallels, through the pages of The Athenaeum where MacColl critically reviewed the several editions of this book. In this paper, I will describe Dodgson's responses to MacColl and the changes he made in subsequent editions of his book in response to MacColl's comments which reflect their different ideas about the nature of axioms, and their generally negative opinions about the non-Euclidean geometries. (Received July 28, 2009)

1054-01-21 **Victor L. Shapiro*** (shapiro@math.ucr.edu), Department of Mathematics, University of California, Riverside, Riverside, CA 92521-0001. *On Green's Theorem.*

S. Bochner, one of the leading mathematical analysts of the 20th century, published a new result about Green's theorem in the 1955 Math. Zeit. His new result went as follows: Let D be a simply connected domain in the plane with rectifiable boundary C. Let V=(A,B) be a continuous vector field defined in D+C. Suppose A and B have total differentials at all the points of D. Also, suppose divV is Lebesgue integrable on D and mean-continuous everywhere in D. Then Green's theorem holds for V on D+C. Using his method, Bochner could not eliminate the mean-continuity assumption. Using double trigonometric series,which was a method completely different than Bocner's, we were able to prove his theorem without the mean-continuity assumption. Our paper was published in J. London Math Soc. 1957. (Received July 15, 2009)

1054-01-40 **Lawrence A. D'Antonio*** (ldant@ramapo.edu), Ramapo College of New Jersey, Mahwah, NJ 07430. *Gauss and the Sums of Three Squares.* Preliminary report.

A common theme in 19th century number is counting the number of representations of a number as the sum of squares. In his Disquisitiones Arithmeticae, Gauss computes the number of primitive representations of an integer as a sum of three squares. In this talk we discuss how Gauss uses the methods of quadratic forms to solve this problem. We also briefly consider further developments of Gauss's method by Eisenstein, Hermite, and Minkowski. (Received August 17, 2009)

1054-01-41 **James T Smith*** (smith@math.sfsu.edu), 1363 27th Avenue, San Francisco, CA 94122. *Definitions and Nondefinability in Geometry: Legacies of Mario Pieri and Alfred Tarski.*

This talk traces development of the modern axiomatic method by Pasch, Peano, Pieri, and Tarski, and their efforts to minimize the number and complexity of primitive concepts sufficient for a foundation of geometry. By 1900, Peano and Pieri had reduced that number to two: point and direct motion. But the latter is an involved set-theoretic concept. Veblen tried point and betweenness of point triples in 1904, but his system seemed inadequate. Pieri succeeded in 1908 with point and equidistance of a point from two others. His axioms were frightfully complicated but laid bare the logic required for their manipulation and used sets only sparingly. He avoided projective methods. Pieri's work attracted little attention except in Poland. In the late 1920s, applying modern logical techniques to geometry, Tarski followed Pieri's approach to develop a much simpler system that has since become a standard in foundations of geometry. It permitted formulation of a theory of definition, which Tarski used to show clearly that Veblen's 1904 attempt had to fail. Further, he showed that Pieri's single ternary primitive relation among points was in a sense optimal: no family of binary relations could suffice. Tarski's work has led to deeper recent studies, particularly by Pambuccian. (Received August 24, 2009)

1054-01-56 **Janet L. Beery*** (janet_beery@redlands.edu). *Sums of Powers of Integers.*

Fermat's and Pascal's work on sums of powers of integers is relatively well known, while that of Thomas Harriot (c. 1560-1621) and Johann Faulhaber (1580-1635) remains little known. In this presentation, we review the history of sums of integer powers from the Pythagoreans (6th century BCE) through Jakob Bernoulli (1654-1705), focusing on Harriot's and Faulhaber's contributions. (Received August 31, 2009)

1054-01-71 **John C. Baez*** (baez@math.ucr.edu), John C. Baez, Department of Mathematics, University of California, Riverside, CA 92521. *Who Discovered the Icosahedron?*

It has been suggested that the regular icosahedron, not being found in nature, is the first example of a geometrical object that is the free creation of human thought. Regardless of the truth of this, it is interesting to try to track down the origin of the icosahedron. A scholium in Book XIII of Euclid's *Elements* speaks of "the five so-called Platonic figures which, however, do not belong to Plato, three of the five being due to the Pythagoreans, namely the cube, the pyramid, and the dodecahedron, while the octahedron and the icosahedron are due to Theaetetus." More recently, Atiyah and Sutcliffe have claimed that a regular icosahedron appears among a collection of stone balls in the Ashmolean Museum — balls that were unearthed in Scotland and may date back to 2000 BC. However, Lieven le Bruyn has argued that these authors are the victims of a hoax. We examine the evidence with a critical eye. (Received September 02, 2009)

1054-01-74 **Ricie Dimatatac Bulanhagui*** (rcdbulanhagui@yahoo.com), Alalum, 4202 San Pascual, Batangas, Philippines. *Ancient Numeral System and The Great Pyramid.* Preliminary report.

The Rhind Mathematical Papyrus is named after Alexander Henry Rhind, a Scottish antiquarian, who purchased the papyrus in 1858 in Luxor Egypt. Assuming the details of the Rhind of Papyrus is true. The exact dimensions

of Great Pyramid can be computed. Using the measuring instruments like seked and old calculation method I rediscovered in old Babylonian Mathematics.

Ancient System Given: Height: 280 cubits Base: 440 Cubits Half of the base: 220 Cubits Solution: 280/220 = 1.272

English System Given: Height: 480.97 Feet Base: 756.2 Feet Half of the Base: 378.1 Feet

Solution: 480.97/378.1 = 1.272

Seked Used: 7/5.5 = 1.272

The tangent in Ancient System and English System is approximately equal to 1.272 which is equal to ratio of the seked 7/5.5.

In our present time we don't use seked, cubit and palm in measurement. We use meter, inch, and feet. How can we calculate the dimensions? There is another method that they use to calculate the height and base of the Great Pyramid.This procedure can calculate the dimensions of the Great Pyramid without the use of seked. The numeral system I rediscovered can bring light to understand the ancient civilization cultures and abilities. (Received September 04, 2009)

1054-01-99 **Mario U Martelli*** (mario.martelli@cgu.edu), School of Mathematical Sciences, 710 N. College, Claremont, CA 91711. *Vito Volterra.* Preliminary report.

Volterra was born in 1860 and died in 1940. Umberto D'Ancona, a biologist, and the son in law of Volterra, observed the dramatic increase of the percent of selachians captured during the first World War in the top portion of the Adriatico sea. Unable to explain the significant change, he decided to ask father in law, who proposed the well-known Lotka-Volterra system of differential equations. Volterra was one of 12 professors who refused to sign the oath of loyalty to the Fascist regime. He was deprived of his job at the university. In this brief contribution I shall illustrate the life and merits of Volterra, one of the greatest representative of the Italian mathematics. (Received September 08, 2009)

1054-01-110 **James J Tattersall*** (tat@providence.edu), Department of Mathematics, Providence College, Providence, RI 02918. *Benjamin Finkel and the Ohio Normal University Herald.* Preliminary report.

In 1893, in an attempt to improve the teaching of elementary mathematics in rural schools, Benjamin Finkel (1865-1947) published the *A Mathematical Solutions Book*. At the time, he was teaching at the Kidder Institute in Missouri. A year later, in an effort to improve secondary school teaching, he founded the *American Mathematical Monthly*. The journal eventually led to the establishment of the Mathematical Association of America in 1915. During his senior year at Ohio Normal University, he edited the mathematical department in the *University Herald*. We focus on the contributors and their contributions to the mathematical column of the *University Herald* that appeared from 1887 to 1888 when Finkel was the editor. (Received September 09, 2009)

1054-01-128 **Paul R. Wolfson*** (pwolfson@wcupa.edu), Department of Mathematics, West Chester University, West Chester, PA 19383. *Resolvents of Polynomial Equations.* Preliminary report.

In 1771 Lagrange published an analysis of the known methods of solving polynomial equations of degrees two, three, and four, showing how all of these methods could be understood in terms of resolvents of the equation, certain polynomials in the equation's roots. Lagrange's work influenced Abel and Galois, but it also contributed to a parallel line of research, on resolvents, that runs through the nineteenth and twentieth centuries up to today. I will present some background on resolvents and will give some reasons why mathematicians continued to study resolvents after major questions about solvability had been answered. (Received September 10, 2009)

1054-01-141 **Harriet M Lord*** (hlord@csupomona.edu), Dept. of Mathematics, Cal Poly Pomona, 3801 W. Temple Ave., Pomona, CA 91768. *Henri Lebesgue and Arc Length.* Preliminary report.

In this talk we present Lebesgue's work on *arc length*. We present his definition of arc length and then compare this to previous definitions and to various definitions of surface area. (Received September 11, 2009)

03 ► Mathematical logic and foundations

1054-03-197 **Daryl Cooper*** (cooper@math.ucsb.edu), Math Dept, UCSB, Santa Barbara, CA 93106. *A non-standard interpretation of the Thurston boundary of Teichmuller Space.* Preliminary report.

We give an interpretation of the Thurston boundary of Teichmuller Space in terms of non-standard hyperbolic structures. (Received September 14, 2009)

05 ► Combinatorics

1054-05-14 **Hung-ping Tsao*** (hptsao@hotmail.com), 1151 Highland Drive, Novato, CA 94949.
Expressing the kth power sum of the nature numbers as a polynomial in the first power sum.
Set S=S(1), where S(k) is the sum of the kth powers of 1, 2, 3,..., n. It is well-known that S(3) is the square of S, namely CS(3)=(1,0,0), where CS(2k-1) is the coefficient (k+1)-tuple of the polynomial in S for S(2k-1). From CS(5)=(4/3,-1/3,0,0), CS(7)=(2,-4/3,1/3,0,0), CS(9)=(16/5,-4,12/5,-3/5,0,0), CS(11)=(16/3,-32/3,34/3,-20/3,5/3,0,0),..., we form a triangular array TO. We also have S(4)/S(2)=(6/5)S-1/5. Let C(S(2k)/S(2)) denote the coefficient (k-1)-tuple of the polynomial in S for S(2k)/S(2). From C(S(6)/S(2))=(12/7,-6/7,1/7), C(S(8)/S(2))=(8/3,-8/3,6/5,-1/5), C(S(10)/S(2))=(48/11,-80/11,68/11,-30/11,5/11),..., we form another triangular array TE. Among other things, we found a keen relationship between TO and TE. (Received June 22, 2009)

1054-05-55 **Steven Butler*** (butler@math.ucla.edu), UCLA Mathematics Department, Box 951555, Los Angeles, CA 90095-1555, and **Kevin Costello** (kcostell@math.gatech.edu) and **Ronald Graham** (graham@ucsd.edu). *Finding patterns avoiding many monochromatic constellations.*
Given fixed $0 = q_0 < q_1 < q_2 < \cdots < q_k = 1$ a constellation in $[n]$ is a scaled translated realization of the q_i with all elements in $[n]$, i.e.,

$$p, p + q_1 d, p + q_2 d, \ldots, p + q_{k-1} d, p + d.$$

We consider the problem of minimizing the number of monochromatic constellations in a two coloring of $[n]$. We show how given a coloring based on a block pattern how to find the number of monochromatic solutions to a lower order term, and also how experimentally we might find an optimal block pattern. We also show for the case $k = 2$ that there is always a block pattern that beats random coloring. (Received August 31, 2009)

1054-05-137 **Péter P. Varjú*** (pvarju@princeton.edu), Princeton University, Department of Mathematics, Fine Hall,Washington Road, Princeton, NJ 08544-1000. *Expansion in $SL_d(\mathbf{Z}/q\mathbf{Z})$, q square-free.*
I discuss the problem whether certain Cayley graphs form an expander family. A family of graphs is called an expander family, iff the number of edges needed to be deleted from any of the graphs to make it disconnected is at least a constant multiple of the size of the smallest component we get. Let S be a subset of $SL_d(\mathbf{Z})$ closed for taking inverses. For each square-free integer q consider the graph whose vertex-set is $SL_d(\mathbf{Z}/q\mathbf{Z})$ two of which is connected by an edge precisely if we can get one from the other by left multiplication by an element of S. Bourgain, Gamburd and Sarnak proves that if $d = 2$ and S generates a Zariski dense subgroup of SL_2, then these graphs form an expander family. In the talk I outline a modification of their argument which leads to a simpler proof and allows a generalization to $d = 3$ or to general numberfields. Techniques from arithmetic combinatorics are used, sum-product theorems and Helfgott's product theorems in particular. (Received September 11, 2009)

1054-05-158 **Ron Graham*** (graham@ucsd.edu), 1555 Coast Walk, La Jolla, CA 92037. *Some remarks on van der Waerden's theorem.* Preliminary report.
In this talk I will describe a few new results and some old problems related to van der Waerden's classic theorem on arithmetic progressions. (Received September 12, 2009)

1054-05-253 **Alex Iosevich*** (iosevich@gmail.com), Alex Iosevich, Department of Mathematics, University of Missouri, Columbia, MO 6520365211. *Finite point configurations in Euclidean and arithmetic settings.*
We will show that a sufficiently large subsets of the Euclidean space or a vector space over a finite field determines a large number of distinct finite configurations. Fourier and combinatorial methods play an important role. (Received September 15, 2009)

1054-05-257 **Yaotsu Chang*** (ytchang@isu.edu.tw), No.1, Sec. 1, Syuecheng Rd., Dashu Township, Kaohsiung, 840, Taiwan, **Chong-Dao Lee** (chongdao@isu.edu.tw), No.1, Sec. 1, Syuecheng Rd., Dashu Township, Kaohsiung, 840, Taiwan, **Peter JS Shiue** (shiue@nevada.edu), Department of Mathematical Sciences, University of Nevada, Las Vegas, NV 89154-4020, and **Hao Shen** (haoshen@sjtu.edu.cn), Department of Mathematics, Shanghai Jiaotong University, Shanghai, 200240, Peoples Rep of China. *A construction of group divisible designs.*
In this talk, we present a construction of group divisible designs with block sizes 3, 4, and 5 respectively. This work is motivated from the decoding of binary quadratic residue codes. (Received September 15, 2009)

1054-05-264 **Fan Chung*** (fan@ucsd.edu), 1555 coast walk, La jolla, CA 92037. *Sparse quasi-random graphs and sequences.* Preliminary report.

It is now known that many properties of the objects in certain combinatorial structures are equivalent, in the sense that any object possessing any of the properties must of necessity possess them all. These properties, termed quasi-random, have been described for a variety of structures such as graphs, hypergraphs, tournaments, Boolean functions, and subsets of Z_n. We will discuss some extension of these ideas to sparse graphs and sequences.

This is a joint work with Ron Graham. (Received September 15, 2009)

1054-05-286 **Karsten O. Chipeniuk*** (karstenc@math.ubc.ca), Room 121, 1984 Mathematics Road, Vancouver, BC V6T 1Z2, Canada. *Sums and Products of Distinct Sets in* $\mathbb{C}$.

Let k and l be integers, and let A and B be large finite subsets of $\mathbb{C}$. We show that if the productset $|AB| < \alpha|A|$ for some α, which is not too big, and if A and B have comparable size, then the iterated sumset $kA + lB$ is large. The proof generalizes an argument of Chang for the case $A = B$. (Received September 15, 2009)

1054-05-298 **Jozsef Solymosi*** (solymosi@math.ubc.ca), 1984 Mathematics Road, Vancouver, BC. V6T1Z2, Canada, and **Endre Szemeredi**. *On sumsets which have large subsets with small doubling.* Preliminary report.

Let A be a finite subset of an abelian group. The sumset $A + A$ is the set of all pairwise sums $a + b$ where a and b are elements of A. One of the central results in additive combinatorics is Freiman's theorem which describes the structure of sets with small sumsets. In this talk we consider the following problem; suppose that $|A + A| \leq |A|^{3/2}$. Under what conditions can we guarantee that a large subset $B \subset A + A$ has small doubling? (i.e. $|B + B| \leq C|B|$ where C is a slow-growing function of $|B|$) We will see that this is the case when A is uniform enough. We will illustrate the result with applications to the sum-product conjecture and some related problems. (Received September 15, 2009)

1054-05-302 **Endre Szemeredi***, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019, and **Jozsef Solymosi**. *Convexity and sumsets.* Preliminary report.

Let $B = \{b_1 < b_2 < \ldots < b_n\}$ an increasing sequence of real numbers and suppose that $b_i - b_{i-1} < b_{i+1} - b_i$ for any $1 < i < n$. We call such sequences *convex*. Erdős conjectured that convex sequences have large difference (and sum) sets. Elekes, Nathanson, and Ruzsa proved that $|B-B| \geq c|B|^{3/2}$. It is not known if $|B-B| \geq c|B|^{2-\varepsilon}$ holds for convex sequences or not. In this talk we show that there is a constant $\delta > 0$ such that for any convex sequence B $|B - B| \geq c|B|^{3/2+\delta}$. (Received September 15, 2009)

11 ► Number theory

1054-11-5 **Victor Garcia*** (garci@matmor.unam.mx), Gregor Mender Strasse 33, 1180 Vienna, Austria. *On the sum of two products of sumsets in prime fields.* Preliminary report.

In this talk, I am planning to show how in prime fields F_p combinatorial arguments and trigonometric sum techniques can be combined to obtain results of the form

$$S_1S_2 + S_3S_4 = F_p,$$

where S_1, S_2, S_3, S_4 are sumsets. (Received April 03, 2009)

1054-11-54 **Kent G Slinker*** (kslinker@pima.edu), 1033A North 3rd Ave, Tucson, AZ 85705. *An Infinitude of Primes of the Form b squared plus one.*

If $b^2 + 1$ is prime then b must be even, hence we examine the form $4u^2 + 1$. Rather than study primes of this form we study composites where the main theorem of this paper establishes that if $4u^2 + 1$ is composite, then u belongs to a set whose elements are those u such that $u^2 + t^2 = n(n+1)$, where t has a upper bound determined by the value of u. This connects the composites of the form $4u^2 + 1$ with numbers expressible as the sum of two squares equal to the product of two consecutive integers. A result obtained by Gauss concerning the average number of representations of a number as the sum of two squares is then used to show that an infinite sequence of u for which $u^2 + t^2 = n(n+1)$ is impossible. This entails the impossibility of an infinite sequence of composites, and hence an infinitude of primes of the form $b^2 + 1$. (Received August 31, 2009)

1054-11-73 **Driss Essouabri*** (driss.essouabri@univ-st-etienne.fr), University Jean Monnet (Saint-Etienne), Department of Mathematics, 23 rue du Dr Paul Michelon, 42023 Saint-Etienne, France. *Arithmetic, Fractality and zeta functions.* Preliminary report.

Spectral zeta functions and their complex dimensions are important tools in the study of fractal strings and their multivariate analogues. In this talk we will give some results on analytic continuation and will describe the complex dimensions of a suitable family of zeta functions associated to a class of "self-similar arithmetic" sets. As an application, we will give some geometric and spectral information of these sets. (Received September 03, 2009)

1054-11-94 **Michelle Manes*** (mmanes@math.hawaii.edu), University of Hawaii, Department of Mathematics, 2565 McCarthy Mall, Keller Hall, Honolulu, HI 96822. *Arboreal Galois representations arising from dynamical systems.* Preliminary report.

Let G be the absolute Galois group of $\mathbb{Q}$, and let T be the complete rooted d-ary tree, where $d \geq 2$. Building on the work of Boston and Jones, and in parallel to the well-developed and powerful theory of linear p-adic representations of G, we study "arboreal" representations of G into the automorphism group of T. These arboreal representations arise from iteration of a degree-d rational map on the projective line. The question of which subgroups of $\mathrm{Aut}(T)$ may appear as the image of an arboreal representation is of particular interest. Recent work focuses on rational maps with a nontrivial PGL_2 automorphism, in analogy with the case of elliptic curves having complex multiplication. (Received September 07, 2009)

1054-11-153 **Julia Wolf*** (julia.wolf@cantab.net). *High-rank polynomial phase decompositions, with number-theoretic applications.*

When trying to count a certain type of arithmetic structure inside a set of integers, it is common to proceed by decomposing the indicator function of that set into a structured and a "random-looking" part.

We shall describe new decomposition theorems in the model setting of $\mathbb{F}_p^n$, where the random-looking part is small in the U^k norm for some $k > 3$, and the structured part consists of high-rank polynomial phases of degree at most $k-1$. These decomposition theorems are based on the recently proved inverse theorem for the U^k norm in this setting by Bergelson, Tao and Ziegler. We conclude by discussing some number-theoretic applications.

This is joint work with Tim Gowers. (Received September 12, 2009)

1054-11-161 **Vsevolod F Lev*** (seva@math.haifa.ac.il), Department of Mathematics, The University of Haifa at Oranim, 36006 Tivon, Israel. *Character-free approach to progression-free sets.* Preliminary report.

We present a purely combinatorial argument leading to Meshulam's bound for the density of a progression-free set in a finite vector space. (Received September 13, 2009)

1054-11-191 **Pär M Kurlberg*** (kurlberg@math.kth.se), Department of Mathematics, KTH, 10044 Stockholm, Sweden, and **R. L. Benedetto**, **D. Ghioca**, **T. J. Tucker** and **U. Zannier**. *Dynamical analogues of the Mordell-Lang Conjecture and the Mumford gap principle.*

We prove a special case of a dynamical analogue of the classical Mordell- Lang conjecture. In particular, let ϕ be a rational function with no super- attracting periodic points other than exceptional points. If the coefficients of ϕ are algebraic, we show that the orbit of a point outside the union of proper preperiodic subvarieties of $(P_1)^g$ has only finite intersection with any curve contained in $(P_1)^g$. The result can viewed a non-linear version of the Skolem-Mahler-Lech theorem (namely that the zero set of a linear recurrence set is eventually periodic.) Time permitting, we will also discuss the general case (e.g., ϕ having superattracting periodic points); in particular, showing very rapid rate of growth of indices in case the zero set is not periodic. (Received September 14, 2009)

1054-11-201 **Melvyn B. Nathanson*** (melvyn.nathanson@lehman.cuny.edu), Department of Mathematics, Lehman College (CUNY), 250 Bedford Park Boulevard West, Bronx, NY 10468. *Phase transitions in groups with a prescribed infinite set of generators.*

Let G be a group and let A be an infinite set of generators for G. The length of an element $x \in G$ with respect to the generating set A, denoted $\ell_A(x)$, is the length of the shortest representation of x as a finite product of elements in $A \cup A^{-1}$. For every nonnegative integer r, the sphere $S_A(r)$ is the set of all elements $x \in G$ of length exactly r. It is proved that either $|S_A(r)| = \infty$ for all r, or there exists a unique integer r such that $S_A(r')$ is empty for all $r' > r$, $S_A(r')$ is infinite for all $r' < r$, and $S_A(r)$ is nonempty. The integer r is called the *phase transition* of the pair (G, A) and the set $S_A(r)$ is called the *transition set*. A complete description of phase transitions and transition sets can be given for the integers and for certain other abelian groups. (Received September 14, 2009)

1054-11-233 **Jean-Louis Verger-Gaugry*** (jlverger@ujf-grenoble.fr), Institut Fourier, CNRS, Université de Grenoble I, BP 74, 38402 Saint-Martin d'Heres, France. *Equidistribution of Galois and beta-conjugates of Parry numbers near the unit circle.*

A Parry number $\beta > 1$ (ex - beta-number) is an algebraic integer for which the β-expansion of β in the sense of Rényi is finite or eventually periodic. Let (β_i) be a sequence of Parry numbers. We present a new equidistribution theorem for the conjugates of the Parry numbers β_i near the unit circle in Solomyak's fractal set based on a suitable notion of convergence of (β_i), and upon the theory of Erdős-Turán, improved by Amoroso and Mignotte, applied to the analytical function $f_{\beta_i}(z) = -1 + \sum_{j_i \geq 1} t_{j_i} z^i$, called Parry Upper function, associated with the Rényi β-expansion $d_{\beta_i}(1) = 0.t_{i_1} t_{i_2} t_{i_3} \dots$ of unity. In the context of the dynamics of the beta-transformation, the Parry Upper function is simply correlated to the Artin-Mazur zeta function $\zeta_{\beta_i}(z)$, and is a rational fraction by a result of Szegő. This theorem is addressed to the union of the Galois conjugates and the beta-conjugates of all the β_is, not only to the Galois conjugates. When convergence occurs and the limit is 1, analogs in Arithmetic Geometry are Bilu's Theorem for the 1-dimensional torus and equidistribution Theorems for sets of conjugates in adelic conditions. (Received September 14, 2009)

1054-11-265 **Jean Bourgain** and **Alex Kontorovich***, Institute for Advanced Study, 1 Einstein Drive, Princeton, NJ 08540. *On representations of integers in thin subgroups of SL(2,Z).*

The Affine Linear Sieve extends sieve methods to thin orbits of non-abelian group actions. The fundamental work of Bourgain-Gamburd-Sarnak showed in great generality that one may obtain an infinitude of R-almost primes (numbers with at most R prime factors), but without specifying R. Some explicit values of R were obtained in specific thin situations by Kontorovich and Kontorovich-Oh, but unconditionally were still in the teens (i.e. R = 14). In this work, we obtain an infinitude of actual primes in such an orbit. We show that not only do infinitely many primes appear, but that almost every number appears, as long as it is not excluded by congruence conditions; moreover the number of exceptions has a power savings. The main ingredients are the circle method, estimates for certain bilinear forms, the spectral gap, and effective sector estimates for hyperbolic isometries. (Received September 15, 2009)

1054-11-271 **Thai Hoang Le*** (leth@math.ucla.edu), UCLA MAthematics Department, Box 951555, Los Angeles, CA 90095-1555. *Intersective polynomials and the primes.*

Intersective polynomials are polynomials in $\mathbf{Z}[x]$ having roots every modulo. For example, $P_1(n) = n^2$ and $P_2(n) = n^2 - 1$ are intersective polynomials, while $P_3(n) = n^2 + 1$ is not. We show, using results of Green-Tao and Lucier, that for any intersective polynomial h, inside any subset of positive relative density of the primes, we can find distinct primes p_1, p_2 such that $p_1 - p_2 = h(n)$ for some integer n. Such a conclusion also holds in the Chen primes (where by a Chen prime we mean a prime number p such that $p + 2$ is the product of at most 2 primes). (Received September 15, 2009)

1054-11-288 **Mariah Hamel*** (mhamel@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Karsten Chipeniuk**. *Sums of sets of primes with positive relative density.*

We will show that if A is a subset of the primes with positive relative density, then $A + A$ must have comparable positive density in $\mathbb{Z}$. Our proof combines Fourier analytic techniques of Green and Green-Tao with a combinatorial result on sumsets of subsets of the multiplicative group of integers modulo m. (Received September 15, 2009)

13 ► Commutative rings and algebras

1054-13-9 **Michael Siddoway*** (msiddoway@coloradocollege.edu), Department of Mathematics, Colorado College, 14 E. Cache Le Poudre Street, Colorado Springs, CO 80903, and **Pham Ngoc Anh** (anh@renyi.hu), Renyi Institute of Mathematics, Hungarian Academy of Sciences, 1364 Budapest, Pf. 127, Budapest, Hungary. *"Divisibility Theory of Semi-Hereditary Bezout Rings".*

The "divisibility theory" of a commutative ring is the semigroup of finitely generated ideals partially ordered by inverse inclusion. For a Bezout ring this amounts to the semigroup of principal ideals. The semi-hereditary property insures that all such ideals are projective. A semigroup S is Bezout if it admits "greatest common divisors," and is "semi-hereditary" if for each a in S there is an idempotent in S that generates the annihilator of a. Our main result states that a semigroup is a semi-hereditary Bezout semigroup if and only if it is isomorphic to the semigroup of principal ideals in a semi-hereditary Bezout ring partially ordered by reverse inclusion. This

work recalls the studies of Krull on valuation domains and Kaplansky, Jaffard, and Ohm on Bezout domains. Our results are the first major developments along these lines for rings with zero divisors. (Received May 12, 2009)

1054-13-192 **David A. Jorgensen**, University of Texas at Arlington, **Graham J. Leuschke*** (gjleusch@math.syr.edu), 215 Carnegie Library, Syracuse University, Syracuse, NY 13244, and **Sean Sather-Wagstaff**, North Dakota State University. *Gorenstein presentations and semidualizing modules.* Preliminary report.

The trivial extension of an artin algebra Λ by the injective module $D(\Lambda)$ is of course a symmetric algebra. Extended to commutative Noetherian rings, possibly of positive Krull dimension, this fact characterizes dualizing modules: a Cohen–Macaulay local ring admits a dualizing module if and only if it is a homomorphic image of a Gorenstein local ring. We augment this result by showing that such a ring R admits a nontrivial *semi*dualizing module if and only if it admits a presentation $R \cong Q/I$ with Q Gorenstein and such that the ideal I has a nontrivial decomposition $I = I_1 + I_2$ with Tor-independent totally reflexive quotients Q/I_j. Even in the artinian case, this is new. (Received September 14, 2009)

1054-13-220 **Jack R Bennett*** (jack@math.ucr.edu), 900 Big Springs Road, Surge Bldg, Math Department, Riverside, CA 92521. *Inside Factorial Domains and Related Non-Unique Factorization Topics.*

In this talk, we will explore the connections between inside factorial domains and related topics of Non-Unique Factorization in Integral Domains. (Received September 14, 2009)

14 ► Algebraic geometry

1054-14-22 **Veniamin Kisunko*** (vkisunko@math.toronto.edu). *The Converse of Abel's theorem.* Preliminary report.

I investigate an algebraization problem. The analogous problems were raised by Lie and Darboux in connection with the classification of surfaces of double translation;by Poincare and Mumford in connection with the Schottky problem;by Griffiths and Henkin in connection with a converse of Abel's theorem;by Bol and Akivis in the connection with the algebraization problem in the theory of webs. Interestingly, the complex-analytic technique developed by Griftiths and Henkin for the holomorphic case failed to work in the real smooth setting.

I develop a technique of,what I call,complex moments.Together with a differentiation rule it provides a unified approach to all the algebraization problems considered so far (both complex-analytic and real smooth). As a result I prove two variants ('polynomial' and 'rational') of a converse of Abel's theorem which significantly generalize results of Griffiths and Henkin. Already the 'polynomial' case is nontrivial leading to a new relation between the algebraization problem in the theory of webs and the converse of Abel's theorem. (Received July 18, 2009)

1054-14-47 **Alina Marian** and **Dragos Oprea*** (doprea@math.ucsd.edu). *On the strange duality conjecture for elliptic K3 surfaces.*

We consider moduli spaces of semistable sheaves on an elliptically fibered K3 surface, so that the first Chern class of the sheaves is a numerical section. For pairs of complementary such moduli spaces, we establish the "strange duality" isomorphism on sections of theta line bundles. (Received August 26, 2009)

1054-14-53 **Vladimir Baranovsky*** (vbaranovs@math.uci.edu), 340 Rowland Hall, Department of Mathematics, UC Irvine, Irvine, CA 92697. *Deformations of line bundles on coisotropic subvarieties.*

We consider a smooth coisotropic subvariety Y in a smooth algebraic variety X with an algebraic Poisson structure, and a line bundle L on Y. Our first result explains when L admits a first order deformation as a left module over the first order deformation quantization of O_X, and a similar statement for second order deformations. We further explain the relation with bundles that admit an algebraic connection and applications to constructing BV differentials on the Tor and Ext sheaves associated to a pair of smooth coistotropic subvarieties Y and Z. Joint work with Victor Ginzburg and Jeremy Pecharich. (Received August 31, 2009)

1054-14-59 **Zhuang-dan Daniel Guan*** (zguan@math.ucr.edu), Dept. of Math, UCR, Riverside, CA 92521. *Some Remarks on Simply Connected Calabi Yau Threefolds.*

Using the Hilbert schemes of the hyperelliptic surfaces we obtain simply connected Calabi Yau threefolds with height h=h11+h12=12 and 14. Recently, more and more compact simply connected projective Calabi Yau

threefolds have been found. But the region of possible Hodge plots is seemly unchanged over the years. Let k=h11 -h12 be the algebraic generation, then the region is been bounded by $|k| = 480$, h=502, $h = |k|$ and $(h - 246)^2 - (|k| - 240)^2 = 4 \times 1986$. (Received September 07, 2009)

1054-14-66 **Paolo Aluffi** and **Matilde Marcolli*** (matilde@caltech.edu), 1200 E California Blvd, Pasadena, CA 91125. *Feynman integrals and algebraic geometry.*

The parametric form of Feynman integrals in perturbative quantum field theory gives rise to periods of algebraic variety, whose complexity depends on how complicated the cohomology of these varieties is from the point of view of Grothendieck's theory of motives. To some extent this can be controlled in terms of determinant hypersurfaces, whose motivic nature is well undertsood. This circle of ideas also leads to the construction of algebro-geometric Feynman rules. (Received September 01, 2009)

1054-14-114 **Paolo Aluffi*** (aluffi@math.fsu.edu), Math Dept, Florida State University, Tallahassee, FL 32306. *Chern classes identities from weak coupling limits.*

This is joint work with Mboyo Esole (Harvard). We generalize a construction of Ashoke Sen of 'weak coupling limits' for certain types of elliptic fibrations. Physics arguments involving tadpole anomaly cancellations lead to conjectural identities of Euler characteristics. We generalize these identities to identities of Chern classes, which we are able to verify mathematically in several instances. For this purpose we propose a generalization of the so-called "Sethi-Vafa-Witten identity". We also obtain a classification of configurations of smooth branes satisfying the tadpole condition. (Received September 09, 2009)

1054-14-129 **Mark W Gross*** (mgross@math.ucsd.edu), UCSD Mathematics, 9500 Gilman Drive, La Jolla, CA 92093-0112, and **Rahul Pandharipande** and **Bernd Siebert**. *The Tropical Vertex.*

Elements of the tropical vertex group, introduced by Kontsevich and Soibelman, are formal families of symplectomorphisms of the 2-dimensional algebraic torus. We prove ordered product factorizations in the tropical vertex group are equivalent to calculations of certain genus 0 relative Gromov-Witten invariants of toric surfaces. The relative invariants which arise have full tangency to a toric divisor at a single unspecified point. The method uses scattering diagrams, tropical curve counts, degeneration formulas, and exact multiple cover calculations in orbifold Gromov-Witten theory. (Received September 10, 2009)

1054-14-130 **Mark W Gross*** (mgross@math.ucsd.edu), UCSD Mathematics, 9500 Gilman Drive, La Jolla, CA 92093-0112, and **Paul Hacking** and **Sean Keel**. *On a conjecture of Looijenga on smoothability of cusp singularities.* Preliminary report.

Cusp surface singularities come in dual pairs. Looijenga conjectured that a cusp singularity (Y, p) is smoothable if and only if there is a rational surface S with a singular point $p' \in S$ such that (S, p') is the cusp singularity dual to (Y, p).

We demonstrate that this conjecture is a special case of mirror symmetry, and give a proof of it using techniques of scattering diagrams and the tropical vertex group. (Received September 10, 2009)

1054-14-139 **Anthony Licata***, Dept. of Mathematics, Stanford University, Stanford, CA 94305, and **Sabin Cautis** and **Joel Kamnitzer**. *Categorification via Quiver Varieties.*

H. Nakajima gave a geometric construction of representations of Kac-Moody Lie algebras on the cohomology of quiver varieties. We categorify this construction using derived categories of coherent sheaves on quiver varieties. (Received September 11, 2009)

1054-14-231 **Charles F Doran*** (doran@math.ualberta.ca), Edmonton, AB , Canada. *Normal Forms for K3 Surfaces and the Kuga-Satake Hodge Conjecture via Mirror Symmetry.* Preliminary report.

The Kuga-Satake abelian variety of a given lattice-polarized K3 surface is constructed transcendentally from the data of the polarizing lattice. It is extremely difficult to determine the simple components of this abelian variety in general, even when a nice algebraic normal form is known for the K3 surfaces.

The *Kuga-Satake Hodge Conjecture* posits the existence of an algebraic correspondence between lattice-polarized K3 surfaces and their associated Kuga-Satake abelian varieties. We use normal forms for lattice-polarized K3 surfaces realized as anticanonical hypersurfaces in Gorenstein toric Fano threefolds and mirror symmetry for both these K3 surfaces and for curves of genus ≥ 1 to explore the conjecture. (Received September 14, 2009)

1054-14-250 **Luke Cherveny*** (cherveny@math.ucla.edu), UCLA Mathematics Dept, Box 951555, Los Angeles, CA 90095. *A Mirror Principle Approach To Calculating Genus Zero Gromov-Witten Invariants With One Or Two Primary Field Insertions.*

We calculate genus 0 Gromov-Witten invariants in the case of one or two inserted primary fields by studying a generalization of Euler data. This constitutes a complete extension of the Lian-Liu-Yau Mirror Principle program to the case of one and two marked points, allowing certain series of multiplicative equivariant Euler classes twisted by the pullbacks of equivariant classes on P^n to be expressed in terms of hypergeometric series. The methods yield a simple proof of the multiple covering formula and often lead to closed formulas for Gromov-Witten invariants for local Calabi-Yau manifolds. More generally, the procedure holds in full for concavex bundles and may be exploited in some instances to calculate Gromov-Witten invariants with descendents as well. (Received September 15, 2009)

1054-14-311 **Karen A Chandler*** (chandler@math.ucr.edu), University of California, Riverside, Math Department, Riverside, CA 92521-0135. *Multiple points in higher dimensions.*

Given a point $p \in \mathbb{P}^n$ with maximal ideal $\mathfrak{m}$ the **k-uple fat point scheme** at p is the scheme defined by $\mathfrak{m}^k$. We consider the natural extension of the Lagrange-Hermite theorem on the line to a (general) collection of points in higher dimensions. Further, we examine the Hilbert function of such a scheme to determine, geometrically, when a polynomial of lower degree cannot meet the specified criteria. This problem has been examined in $\mathbb{P}^2$, according to conjectures of Nagata and of Segre-Harbourne-Hirschowitz. Results since the 1990's include those of Hirschowitz, Ciliberto-Miranda, and Yang on points of orders at most 19 in the plane.

We have been studying this problem in higher dimensions in which, by contrast, one sees more subtle phenomena. Here we apply our geometric interpretation of conjectures of Iarrobino and methods to obtain:
Theorem. Take d general points in n-dimensional space. We may specify the partial derivatives up to orders two at each point to a polynomial of degree m at least 7 provided that: $\binom{n+2}{2}d \leq \binom{n+m}{m}$. Similarly for a union of double points and triple points. (Received September 16, 2009)

16 ► Associative rings and algebras

1054-16-2 **Birge Huisgen-Zimmermann***, Department of Mathematics, University of California, Santa Barbara, CA 93106. *Representations of quivers with relations. Geometric aspects.*

We discuss the classification goal for the representations of a quiver (directed graph) with relations, and introduce/exemplify the concepts of finite, wild, and tame representation type. Classical results by Gabriel and Gelfand-Ponomarev in this connection have demonstrated the usefulness of parametrizing the isomorphism classes of representations of a fixed dimension d by the points of an affine variety; this variety carries an algebraic group action, the orbits of which are in one-to-one correspondence with the isomorphism classes of d-dimensional representations. Attempts to factor out the group action to obtain a fine moduli space for the representations – or doing so for interesting action-stable subvarieties – rarely succeed. The reason for failure lies in the fact that the orbits of the mentioned action are hardly ever closed. On the other hand, this obstacle gives rise to an alternate road towards understanding representations: Namely, the representations corresponding to the points in the orbit closure of a given representation M, the "degenerations" of M, provide an interesting venue for analyzing M by unravelling its structure in a geometry-guided process. We illustrate this approach, and present some old and new results. (Received September 15, 2009)

1054-16-11 **Chelsea M Walton*** (notlaw@umich.edu), 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109. *Generalizing Twisted Homogeneous Coordinate Rings.*

Sklyanin algebras play an important role in the study of physical phenomenon. Hence, we will first review techniques of Artin-Tate-van den Bergh (ATV) that describe the ring-theoretic and homological behavior of these structures. In particular, we highlight the significance of twisted homogeneous coordinate rings.

The focus of the talk, however, is to introduce a generalized twisted homogeneous coordinate ring P associated to a degenerate version of the three-dimensional Sklyanin algebra. The surprising geometry of these algebras yields an analogue to a result of ATV; namely that P is a factor of the corresponding degenerate Sklyanin algebra. (Received June 01, 2009)

1054-16-23 **Jonathan Brundan*** (brundan@uoregon.edu), Department of Mathematics, Eugene, OR 97403. *Some level two representations of quiver Hecke algebras.*

I'll talk about recent joint work with Catharina Stroppel, in which we construct a diagrammatic cellular basis for level two cyclotomic quotients of the quiver Hecke algebras of Khovanov, Lauda and Rouquier in finite type A. (Received July 20, 2009)

1054-16-43 **Edward S. Letzter** (letzter@temple.edu), Department of Mathematics, Temple University, Philadelphia, PA 19122, and **Linhong Wang*** (lwang@selu.edu), Department of Mathematics, SLU10687, Southeastern Louisiana University, Hammond, LA 70402. *Goldie ranks of skew power series rings of automorphic type.* Preliminary report.

Let A be a noetherian ring equipped with an automorphism α, and let $B := A[[y;\alpha]]$ denote the corresponding skew power series ring. We prove that A is semiprime if and only if B is semiprime. Next, assuming A is semiprime, we prove that the Goldie rank of B is equal to the Goldie rank of A. The same conclusions hold true when B is replaced by the skew Laurent series ring $A[[y^{\pm 1};\alpha]]$. (Received August 24, 2009)

1054-16-48 **Yevgenia Kashina**, DePaul University, **M. Susan Montgomery***, University of Southern California, and **Siu-hung Richard Ng**, Iowa State University. *Frobenius-Schur indicators of representations of Hopf algebras and the trace of the antipode.*

We connect properties of the trace of the anitpode S of a Hopf algebra H to the Frobenius-Schur indicators of its irreducible representations.

First assume that H is a finite-dimensional semisimple Hopf algebra over $\mathbb{C}$. Then $S^2 = id$, and so $Tr(S)$ is an integer. We ask when in fact $\mathrm{Tr}(S) > 0$. This is true if H is a bismash product constructed from a matched pair of groups, but if cocycles are present, it is possible for $Tr(S) < 0$. We show that $Tr(S) \geq 0$ in some other cases, such as when H is modular, for example if H is factorizable.

We apply some of these results to prove a Hopf analog of a main preliminary step in the Brauer-Fowler theorem for finite groups. That is, if $\dim(H)$ is even, we prove there is some self-dual irreduclble representation V of H such that

$$dim(V) \leq \frac{n-1}{|Tr(S)-1|}.$$

Moreover if $Tr(S) > 1$ then $\nu_2(V) = 1$, and if $Tr(S) < 1$ then $\nu_2(V) = -1$ (necessarily $Tr(S) \neq 1$ if $dim(H)$ is even). Here $\nu_2(V)$ denotes the Frobenius-Schur indicator of V; $\nu_2(V) = 1$ (resp. -1) when V admits a non-degeenrate H-invariant symmetric (resp skew) bilinear form. (Received August 27, 2009)

1054-16-60 **Richard Vale*** (rvale@math.cornell.edu), Department of Mathematics, Malott Hall, Ithaca, NY 14853. *A noncommutative completion of the prime spectrum.*

We describe a way of completing a ringed space with respect to a distinguished base of open sets. The completion of $\mathrm{Spec}(R)$ with respect to its usual base of open sets yields a contravariant functor from the category of commutative rings to the category of ringed spaces, which has a faithful extension to the category of all rings. (Received August 31, 2009)

1054-16-62 **Aaron D Lauda*** (lauda@math.columbia.edu), Department of Mathematics, 2990 Broadway, New York, NY 10027. *Categorifying Quantum Groups.*

I will explain joint work with Mikhail Khovanov introducing families of graded algebras that are diagrammatically defined. The graded category of modules over these algebras categorifies the negative half of the quantum universal enveloping algebra for any simple Lie algebra. (Received September 01, 2009)

1054-16-72 **Thomas Cassidy** and **Michaela Vancliff*** (vancliff@uta.edu), Math Dept, Box 19408, University of Texas at Arlington, Arlington, TX 76019-0408. *Graded Skew Clifford Algebras and their Associated Geometry.*

Graded Clifford algebras are non-commutative algebras that have been known since at least the 1980s, and one can read off certain properties of such an algebra from certain commutative geometric data associated to the algebra. Recently, T. Cassidy and the speaker introduced a generalization of such an algebra, called a graded skew Clifford algebra, and they found that most of the results concerning graded Clifford algebras can be extended to graded skew Clifford algebras, provided the appropriate non-commutative geometric data is defined. In this talk, the main focus will be this algebra-geometry correspondence and examples. (Received September 02, 2009)

1054-16-81 **Harm Derksen** (hderksen@umich.edu), Department of Mathematics, 2074 East Hall, 530 Church Street, University of Michigan, Ann Arbor, MI 48109, and **Jiarui Fei*** (jiarui@umich.edu), 1833 Lake Lila Dr. #B3, Ann Arbor, MI 48105. *General Presentations of Algebras.*

For any finite dimensional basic associative algebra, we study subrepresentations and the canonical decomposition of a general presentation. As a special case, we consider rigid presentations. We construct a simplicial complex governing the canonical decompositions of rigid presentations. We show how to complete a rigid presentation and study the number of nonisomorphic direct summands and different complements. (Received September 05, 2009)

1054-16-92 **Nguyen Viet Dung*** (nguyend2@ohio.edu), Department of Mathematics, Ohio University-Zanesville, Zanesville, OH 43701. *A key module over pure semisimple rings.*

Let R be a left pure semisimple ring, i.e. a ring R such that every left R-module is a direct sum of finitely generated modules. It is an open problem whether such a ring R has finite representation type. In 1990, B. Huisgen-Zimmermann proved the existence of a strong preinjective partition and introduced preinjective modules in the category R-mod of finitely generated left R-modules. In 2007, L. Angeleri Hügel introduced and studied a "key module" W over a hereditary left pure semisimple ring R, where W is the direct sum of non-isomophic non-preinjective indecomposable direct summands of direct products of preinjective left R-modules. In this talk we discuss various properties of a key module W over a left pure semisimple ring R satisfying the condition that there are no non-zero homomorphisms from preinjective modules to non-preinjective indecomposable modules in R-mod. In particular, W is a finitely generated product-complete module and W is endofinite if and only if R is of finite representation type. (This is joint work with José Luis García). (Received September 07, 2009)

1054-16-95 **Dan Zacharia*** (zacharia@syr.edu), Department of Mathematics, Syracuse University, Syracuse, 13244. *Auslander-Reiten theory for modules of finite complexity over self-injective algebras.*

I will talk about recent work with Otto Kerner. Let R be a finite dimensional self-injective algebra over an algebraically closed field. Roughly speaking, the complexity of a module measures the growth of a minimal projective resolution of the module. Let M be an indecomposable non projective finitely generated R-module having finite complexity, and let $\mathcal{C}_s$ be the stable component of the Auslander-Reiten quiver containing it. We describe the possible shapes of $\mathcal{C}_s$. (Received September 08, 2009)

1054-16-104 **Arkady Berenstein*** (arkadiy@math.uoregon.edu), 4936 Mahalo Drive, Eugene, OR 97405, and **Vladimir Retakh** (vretakh@math.rutgers.edu), 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. *Lie algebras and Lie groups over noncommutative rings.*

In my talk I will introduce a version of Lie algebras and Lie groups over noncommutative rings.

For any Lie sub-algebra g of an associative algebra A and any associative ring F, I will define a Lie algebra (g, A)(F) functorially in F and A. In particular, if F is commutative, the Lie algebra (g, A)(F) is simply the loop Lie algebra of g with coefficients in F.

In the case when g is semisimple or Kac-Moody, I will explicitly compute (g, A)(F) in terms of commutator ideals of F (surprisingly, these ideals have previously emerged as building blocks in M. Kapranov's approach to noncommutative geometry).

To each Lie algebra (g, A)(F) one associates a "noncommutative algebraic" group of automorphisms. I will conclude my talk with examples of such groups and with the description of "noncommutative root systems" of rank 1. (Received September 15, 2009)

1054-16-109 **Ryan Kinser*** (ryan.kinser@uconn.edu). *The rank of a quiver representation.*

We will discuss a notion of rank for quiver representations which generalizes the rank of a linear map. Using quiver Grassmannians, it can be proven to give a constructible function on representation spaces of a quiver. (Received September 09, 2009)

1054-16-113 **Jose A. Velez*** (jvelezma@math.uiowa.edu), University of Iowa, Department of Mathematics, 14 MacLean Hall, Iowa City, IA 52242. *Universal deformation rings of modules over self-injective algebras.* Preliminary report.

Let Λ be a finite dimensional self-injective algebra over an algebraically closed field, and let V be a finitely generated Λ-module. We first give a sufficient criterion for V to have a universal deformation ring. We then turn to a particular self-injective algebra Λ and determine the universal deformation rings for some of the Λ-modules V that satisfy this criterion. (Received September 09, 2009)

1054-16-116 **Milen Yakimov*** (yakimov@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *Spectra of quantum Schubert cells and quantum flag varieties.*

De Concini, Kac, and Procesi defined a family of subalgebras U_q^w of a quantized universal enveloping algebra $U_q(g)$, associated to the elements of the corresponding Weyl group W. They are deformations of universal enveloping algebras of nilpotent Lie algebras and can be considered as quantized algebras of functions on Schubert cells. We will describe explicitly all torus invariant prime ideals of the algebras U_q^w, construct efficient generating sets, and describe the poset of those ideals. We will then apply these results to classify the torus invariant prime ideals of quantum partial flag varieties. (Received September 09, 2009)

1054-16-127 **Mitja Mastnak** and **Julia Pevtsova***, University of Washington, Department of Mathematics, Seattle, WA 98195, and **Peter Schauenburg** and **Sarah Witherspoon**. *Cohomology of pointed Hopf algebras.*

Finite generation of the cohomology ring of a group algebra for a finite group G with coefficients in a field of positive characteristic is a classical result dating back to the 60th due to Golod, Venkov, and Evens (independently). Towards the end of the last century, Friedlander and Suslin vastly generalized this result proving that the cohomology ring of any finite dimensional cocommutative Hopf algebra with coefficients in a field of positive characteristic is finitely generated.

An analogous result for cohomology of a small quantum group at a root of unity with complex coefficients is due to Ginzburg and Kumar (with some restrictions on the order of the root of unity) and Bendel-Nakano-Parshall-Pillen in a more general case. In this talk, I shall describe a theorem from a joint work with Mastnak, Schauenburg and Witherspoon: the (Hochschild) cohomology ring of a finite dimensional pointed complex Hopf algebra with abelian group of group-like elements is finitely generated. The result uses in an essential way the recent classification of pointed Hopf algebras by Andruskiewitsch and Schneider. (Received September 10, 2009)

1054-16-136 **Andrea Jedwab*** (jedwab@usc.edu), 3620 S Vermont Ave, KAP 116B, Los Angeles, CA 90089. *A trace-like invariant for representations of Hopf algebras.*

Given a complex Hopf algebra H, we consider a trace-like invariant determined by the antipode on each finite dimensional representation of H. When H is semisimple this invariant is closely related to the Frobenius-Schur indicator of the representation and can be used to compute the indicator. For Hopf algebras that are not semisimple this invariant provides a new tool to study their representation theory. In this case the trace is an algebraic integer that is not necessarily an integer.

We study some of its properties and determine the values of this trace for the representations of some families of Hopf algebras, including $u_q(sl_2)$, the Drinfeld doubles of the Taft algebras and nilpotent liftings of quantum planes. Part of this is joint work with Leonid Krop. (Received September 11, 2009)

1054-16-138 **Anthony Licata***, Dept. of Mathematics, Stanford University, Stanford, CA 94305, and **Tom Braden**, **Nick Proudfoot** and **Ben Webster**. *Gale Duality and Koszul Duality.*

Given an arrangement of affine hyperplanes in a real Euclidean space, we construct a finite dimensional Koszul algebra. Gale Dual arrangements give rise to Koszul Dual algebras. (Received September 11, 2009)

1054-16-140 **Ibrahim Assem** (schiffler@math.uconn.edu), **Thomas Bruestle** (schiffler@math.uconn.edu) and **Ralf Schiffler*** (schiffler@math.uconn.edu), Department of Mathematics 196 Auditorium Road, University of Connecticut, U-3009, Storrs, CT 06269-3009. *Cluster-tilted algebras without clusters.* Preliminary report.

Cluster-tilted algebras are by definition endomorphism algebras of cluster-tilting objects in the cluster category. The module category of a cluster-tilted algebra is known to be equivalent to the quotient of the cluster category by the (additive hull) of the cluster-tilting object.

In this talk, we will describe a different approach to cluster-tilted algebras that does not involve the cluster category. We will define cluster-tilted algebras as certain trivial extensions of tilted algebras, and present an algorithm that in finite type computes the Auslander-Reiten quiver of the cluster-tilted algebra from the Auslander-Reiten quiver of the tilted algebra. (Received September 11, 2009)

1054-16-143 **Edward S. Letzter***, letzter@temple.edu. *Q-Commutative Power Series Rings at Roots of Unity.* Preliminary report.

Given a field k and multiplicatively antisymmetric parameters $q_{ij} \in k^\times$, we can construct the noncommutative formal power series ring $R := k_q[[x_1, \ldots, x_n]]$, where $x_i x_j = q_{ij} x_j x_i$. It then follows from well-known theory that R is a local, regular, noetherian, zariskian domain having Krull and global dimension equal to n. In recent

joint work with Linhong Wang, we studied the two-sided ideal theory of R, obtaining our most precise results in the case when the q_{ij}, for $i < j$, are algebraically independent. In the present talk I will discuss the "extreme opposite scenario" – the case when the q_{ij} are all roots of unity. The focus will be on two-sided ideal theory and, in particular, catenarity of the prime spectrum. (Received September 11, 2009)

1054-16-149 **Pavel Etingof** and **Travis Schedler*** (trasched@math.mit.edu). *Poisson Traces and D-Modules.*

A Poisson trace on a Poisson variety is a functional which is invariant under the flow of Hamiltonian vector fields. Such traces are defined only globally, not locally. In this talk, I will consider the local approach, by studying the D-module which is the quotient of all differential operators by the Hamiltonian vector fields. Using this, one can prove that the space of Poisson traces is finite-dimensional when the variety has finitely many symplectic leaves, and that quantizations in this case have finitely many irreducible representations.

If time permits, I will explain how to use related ideas to prove a conjecture of Alev, that the space of Poisson traces is equal to the space of Hochschild traces of the quantization in the case when the variety is a symmetric power of a surface in three-dimensional space cut out by a quasihomogeneous polynomial, which has an isolated singularity at the origin. This includes the Kleinian singularities, which are the quotients of two-dimensional space by finite subgroups of SL(2). (Received September 12, 2009)

1054-16-164 **Helene R Tyler*** (helene.tyler@manhattan.edu), Department of Mathematics and Comp. Science, Manhattan College, Riverdale, NY 10471. *Slices, Tilting Sets, and Annihilating Sequences of BGP-Reflection Functors.*

This talk concerns preprojective representations of a connected quiver without oriented cycles. For each such representation, there is a shortest sequence of reflection functors that annihilates it, which is unique up to a certain equivalence. This combinatorial invariant reveals an interesting connection between slices in the module category of the quiver's path algebra and tilting sets in its Auslander-Reiten quiver. (Received September 13, 2009)

1054-16-170 **Joseph Hirsh***, 365 5th Avenue, Department of Mathematics, Room 4208, New York, NY 10016. *A Resolution of the unital-Associative Operad.* Preliminary report.

One of the main approaches to understanding homotopy versions of algebraic structures is to describe the structure of interest via an operad, and then to find a free or projective resolution of the operad. This approach has been successful in producing resolutions of many operads, but there have been difficulties in using standard techniques to resolve operads that encode algebraic structures with specified elements, such as units. In this talk I will present a generalization of the "Koszul Duality" technique to obtaining resolutions of operads with 0-ary operations (specified elements). As an application, I will present a resolution for the unital-Associative operad obtained via this machinery. (Note: The subject of this talk is a work in progress, joint with Joan Millès). (Received September 13, 2009)

1054-16-183 **B Daugherty Zajj*** (daughert@math.wisc.edu), Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706. *Two Boundary Graded Centralizer Algebras.* Preliminary report.

Two boundary diagram algebras (e.g. graded braid groups, Hecke algebras, Brauer algebras) arise as tensor power centralizer algebras, algebras of commuting operators for a Lie algebra action on a tensor space. This work explores centralizers of the actions of finite dimensional complex reductive Lie algebras on tensor spaces of the form $M \otimes N \otimes V^{\otimes k}$. As an example, we study in detail the combinatorics of special cases corresponding to $\mathfrak{gl}_n$ and $\mathfrak{sl}_n$ and explain how this could be applied to the study of the combinatorial representation theory of graded Hecke algebras of type C. (Received September 13, 2009)

1054-16-184 **Calin Ioan Chindris*** (cchindri@math.uiowa.edu). *On the representation type of quivers.*

In this talk, I will explain how to detect the tameness of a quiver by imposing certain conditions on fields of rational invariants and moduli spaces of representations for the quiver in question. I will also talk about extending these results to other classes of finite-dimensional algebras. (Received September 14, 2009)

1054-16-186 **Tom Howard*** (thoward@math.ucsb.edu). *Complexity of finitely generated modules.*

Let A be a finitely generated module over a finite dimensional algebra Λ, and fix a minimal projective resolution. In case Λ is a group algebra, the asymptotic growth of the projective resolution is polynomial, but outside of the group algebra case different growths are possible. We investigate invariance of this asymptotic growth under stable, derived, and stable derived equivalences. Monomial algebras are used to showcase these concepts. (Received September 14, 2009)

1054-16-199 **Jason P Bell*** (jpb@math.sfu.ca), 8888 University Dr., Burnaby, BC V5A1S6, Canada, **Karel Casteels**, 8888 University Dr., Burnaby, BC V5A1S6, Canada, and **Stephane Launois**, Canterbury, Kent CT27NF, England. *Enumeration of torus-invariant primitive ideals in quantum matrices.*

Goodearl and Letzter showed that the prime ideals of the ring of $m \times n$ quantum matrices that are invariant under the natural action of the torus $(\mathbb{C}^*)^{m+n}$ is finite; moreover, they showed that the prime spectrum breaks up into strata that are paramaterized by these torus-invariant primes. Cauchon later gave an explicit formula for the number of torus-invariant primes in $m \times n$ quantum matrices. We show how one can do an even finer enumeration, in which one counts the number of torus-invariant primes in $m \times n$ quantum matrices whose stratum is d-dimensional. More generally, we give an explicit characterization of the torus-invariant primes whose stratum is d-dimensional. This is joint with Karel Casteels and Stephane Launois. (Received September 14, 2009)

1054-16-203 **Ellen Kirkman*** (kirkman@wfu.edu), Dept of Mathematics, Wake Forest University, Box 7388, Winston-Salem, NC 27109, and **James Kuzmanovich** and **James Zhang**. *Invariants of AS-Regular Algebras: Complete Intersections.* Preliminary report.

Let G be a finite group acting on an Artin-Schelter regular $\mathbb{C}$-algebra A. Extending results of Watanabe we give conditions when the invariant subring A^G is an Artin-Schelter Gorenstein algebra. When $A = \mathbb{C}[x_1, \cdots, x_n]$ Gordeev (1986) and Nakajima (1984) independently determined when A^G is a complete intersection. We discuss extending these results to other Artin-Schelter regular algebras. (Received September 14, 2009)

1054-16-205 **Tatyana S Chmutova*** (chmutova@umich.edu), University of Michigan, Department of Mathematics, 530 Church St, Ann Arbor, MI 48103. *Verma modules for continuous Cherednik algebras.*

In this talk we will discuss continuous Cherednik algebras, standard modules over these algebras and a way of thinking about such modules. We will consider in details the GL_2-type algebra and describe all the submodules of Verma modules over this algebra for different values of the parameter. (Received September 14, 2009)

1054-16-206 **Harm Derksen*** (hderksen@umich.edu), 530 Church Street, Ann Arbor, MI 48103, and **Jerzy Weyman** and **Andrei Zelevinsky**. *Quivers with Potentials: the E-invariant.*

Quivers with Potentials (or QP) can be used to prove results for cluster algebras with coefficients. QP's and their representations can be mutated at any given vertex of the quiver. For a QP-representation M we will define a number E(M) which is invariant under mutation. This E-invariant plays an important role in the proofs of various conjectures for cluster algebras. (Received September 14, 2009)

1054-16-214 **Greg Kuperberg*** (greg@math.ucdavis.edu). *Denseness and Zariski denseness of Jones braid representations.*

The question of computing the closed image of braid and mapping class group representations that come from quantum invariants has attracted interest lately from quantum computation. Aa dense generation result can imply that an invariant is very hard to approximate to a precision useful for topology; but also that a certain coarser approximation is universal for quantum computation.

We will discuss the Zariski closure of Jones representations of braid groups and colored Jones representations. Zariski denseness is a weaker result than analytic denseness, but in some cases it is not much weaker, while in others it is ultimately equivalent. If time permits, we will also discuss the connections to theoretical computer science. (Received September 14, 2009)

1054-16-215 **David E Radford*** (radford@uic.edu), University of Illinois at Chicago, Department of Mathematics, SEO 322 (m/c 249), 851 South Morgan, Chicago, IL 60607-7045, and **Louis H Kauffman** (kauffman@uic.edu), University of Illinois at Chicago, Department of Mathematics, SEO 322 (m/c 249), 851 South Morgan, Chicago, IL 60607-7045. *Oriented Quantum Algebras and Coalgebras, Invariants of 1-1 Tangles, Knots, and Links.* Preliminary report.

Oriented quantum algebras give rise to oriented quantum coalgebras. Both account for invariants. We develop a general theory for oriented quantum coalgebras, relate them to oriented quantum algebras, and describe how invariants arise from them.

Oriented quantum coalgebras may very well hold an advantage over oriented quantum algebras in computation of invariants. We note that the dual of a quasitriangular Hopf algebra has an oriented quantum coalgebra structure. (Received September 14, 2009)

1054-16-230 **Gordana G Todorov*** (g.todorov@neu.edu), Mathematics Department, Northeastern University, 360 Huntington Avenue, Boston, MA 02115, **Claire Amiot** (clairean@math.ntnu.no), Mathematics Department, Trondheim, Norway, and **Idun Reiten** (idunr@math.ntnu.no), Mathematics Department, Trondheim, Norway. *Module categories associated to the words in Coxeter groups.*

Module categories associated to the words in Coxeter groups Gordana Todorov, Northeastern University, Boston, MA Abstract: Categories with some of the essential properties of cluster categories were already defined by several authors, in particular, certain categories of modules over preprojective algebras associated to the words in the Coxeter group are such categories. We further describe properties of those categories in terms of mutations/approximations over hereditary algebras, filtrations over preprojective algebra and also give relation to Amiot generalized cluster categories. (Received September 14, 2009)

1054-16-251 **Jerzy M Weyman*** (j.weyman@neu.edu), Department of Mathematics, Northeastern University, 360 Huntington Avenue, Boston, MA 02115. *Quivers with potentials and their mutations.*

In this talk I will discuss the basics of quivers with potentials and their mutations. This talk is based on joint work with Harm Derksen and Andrei Zelevinsky. (Received September 15, 2009)

1054-16-252 **Susan J. Sierra*** (ssierra@princeton.edu), Mathematics Department, Princeton University, Fine Hall, Washington Road, Princeton, NJ 08544, and **Jason Bell** (jpb@sfu.ca) and **Daniel Rogalski** (drogalsk@math.ucsd.edu). *The Dixmier-Moeglin equivalence for twisted homogeneous coordinate rings.*

Given a projective scheme X over $\mathbb{C}$, an automorphism σ of X, and a σ-ample invertible sheaf $\mathcal{L}$, one may form the twisted homogeneous coordinate ring $B = B(X, \mathcal{L}, \sigma)$, one of the most fundamental constructions in noncommutative projective algebraic geometry. We study the primitive spectrum of B, and prove that that in many situations the primitive ideals of B are characterized by the usual Dixmier-Moeglin conditions. This holds if X is a curve or a surface, or if the GK-dimension of B is $\dim X + 1$. (Received September 15, 2009)

1054-16-256 **Pete Goetz*** (pdg11@humboldt.edu), Department of Mathematics, Humboldt State University, 1 Harpst St., Arcata, CA 95521. *K_2 algebras and A_∞ structures.*

I will discuss recent joint work with Andy Conner at the University of Oregon which attempts to understand the connection between a K_2 algebra A and A_∞ structures on the Ext algebra $E(A)$. (Received September 15, 2009)

1054-16-260 **S. Paul Smith*** (smith@math.washington.edu), Dept. of Mathematics, University of Washington, Seattle, WA 98195. *Some twisted homogeneous coordinate rings related to superpotential algebras.*

The representation theory of certain quivers with relations derived from a superpotential are of interest in string theory. Typically, the associated path algebra with relations, which is called a superpotential algebra, is a noetherian algebra over the complex numbers and is a finite module over its center. An interesting case is that when the center is the coordinate ring of the "canonical cone" over a smooth projective surface S. We show that in some special cases the category of modules over the superpotential algebra is equivalent to the category of G-equivariant modules over a twisted homogeneous coordinate ring of the projective surface S for a suitable finite cyclic group G. In those cases, it is very easy to show that the center of the superpotential algebra is, as desired, the the coordinate ring of the canonical cone over S. (Received September 15, 2009)

1054-16-274 **Emre Coskun**, Department of Mathematics, Middlesex College, The University of Western Ontario, London, Ontario N6A 5B7, Canada, and **Rajesh S Kulkarni***, Department of Mathematics, Michigan State University, East Lansing, MI 48824. *Clifford algebras of ternary forms and vector bundles on cubic surfaces.* Preliminary report.

We consider representations of Clifford algebras of ternary forms over complex numbers. We prove that these representations can be constructed in arbitrary dimensions using the arithmetically Cohen-Macaulay bundles on cubic surfaces. This is joint work with Emre Coskun. (Received September 15, 2009)

1054-16-277 **Dag Madsen*** (dmadsen@syr.edu). *Orbit closures in varieties parametrizing the objects in the derived category.* Preliminary report.

A famous theorem by Zwara and Riedtmann gives an algebraic characterization of orbit closure (degeneration) in module varieties. In joint work with Jensen and Su we have proved an analogous theorem for varieties of A_∞-modules. Our result should be seen as the derived category version of the Zwara-Riedtmann Theorem, and contains that theorem as a special case. In this talk I will describe the varieties and orbit closures involved and

show how they gives us new insight into the derived category of a finite dimensional algebra. I will also explain why new techniques might be needed for obtaining a characterization of orbit closures in varieties of algebras. (Received September 15, 2009)

1054-16-290 **Samson Ephraim Black*** (sblack1@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *A Statesum Formula for the Alexander-Conway Polynomial.* Preliminary report.

In the spirit of Kauffman's statesum formula for the Jones polynomial, we define certain resolutions of a braid diagram into colored states. By associating certain weights to each state and summing over all admissible states, we recover the Alexander-Conway polynomial. (Received September 15, 2009)

1054-16-303 **Babson*** (babson@math.ucdavis.edu) and **Huisgen-Zimmermann**. *Spaces of representaions of path algebras.*

The geometry of spaces of quotient modules of a fixed projective will be discussed. This is joint work with Birge Huisgen-Zimmermann. (Received September 15, 2009)

17 ► Nonassociative rings and algebras

1054-17-79 **Alistair Savage*** (alistair.savage@uottawa.ca), Department of Mathematics, University of Ottawa, Ottawa, Ontario K1N 6N5, and **Peter Tingley**. *Quiver grassmannians, quiver varieties and the preprojective algebra.*

Quivers play an important role in the representation theory of algebras with a key ingredient of the theory being the path algebra and the preprojective algebra. Quiver grassmannians are varieties of submodules of a fixed module of the path or preprojective algebra. We study these objects in detail. We show that the quiver grassmannians corresponding to submodules of certain injective modules are homeomorphic to the lagrangian quiver varieties of Nakajima which have been well studied in the context of geometric representation theory. We then refine this result by finding quiver grassmannians which are homeomorphic to Demazure quiver varieties, and others which are homeomorphic to graded/cyclic quiver varieties. The Demazure quiver grassmannians allow us to construct injective objects in the category of locally nilpotent modules of the preprojective algebra. We conclude by relating our construction to a similar one of Lusztig using projectives in place of injectives. (Received September 15, 2009)

1054-17-84 **Jianjun Paul Tian*** (jptian@math.wm.edu), Mathematics Department, College of William and Mary, Williamsburg, VA 23187, **Carolyn Troha**, Mathematics Department, College of William and Mary, Williamsburg, VA 23187, and **David Lutzer**, Mathematics Department, College of William and Mary, Williamsburg, VA 23187. *Braid groups and evolution algebras.* Preliminary report.

Evolution algebras are non-associative, but commutative algebras. They seem have many relations or connections with other mathematical subjects. We here established relationships between braid groups and evolution algebras. For each element of braid group B_n, we assign an evolution algebra. The image of B_n under this map is a sub-category of $n-$dimensional evolution algebra category. It may be called evolution algebra representation of braid groups. (Received September 06, 2009)

1054-17-150 **Konstantina Christodoulopoulou*** (christod@math.ucr.edu), Department of Mathematics, University of California, Riverside, Riverside, CA 92521. *On modules over affine Kac-Moody algebras at the critical level induced from Whittaker modules.* Preliminary report.

We describe the algebra of endomorphisms of a module over a non-twisted affine Kac-Moody algebra at the critical level induced from an irreducible Whittaker module for the underlying simple finite-dimensional Lie algebra. (Received September 12, 2009)

1054-17-151 **Dimitar Grantcharov*** (grandim@uta.edu), Department of Mathematics, UT Arlington, Arlington, TX 76019, and **Ivan Dimitrov**. *Simple weight modules of affine Lie algebras.*

The problem of classifying irreducible weight modules with finite dimensional weight spaces over affine Lie algebras has been studied actively for the last 20 years. Remarkable results include the classification of integrable modules by V. Chari, the study of parabolically induced modules by V. Futorny, and the study of weight modules with bounded weight multiplicities by D. Britten and F. Lemire. There are two important classes of irreducible weight modules with finite dimensional weight spaces: the parabolically induced modules and the loop modules.

Several authors made conjectures that would imply that these exhaust all irreducible weight modules with finite dimensional weight spaces. In a joint work with I. Dimitrov we confirm that these conjectures are correct and as a result obtain the classification. In this talk the main ideas and results from our joint work will be presented. (Received September 12, 2009)

1054-17-176 **Gizem Karaali*** (gizem.karaali@pomona.edu), Department of Mathematics, Pomona College, 610 N. College Ave., Claremont, CA 91711. *On the quantization of super dynamical r-matrices of zero weight.*

Solutions of the classical dynamical Yang-Baxter equation on a Lie superalgebra are called *super dynamical r-matrices*. A super dynamical r-matrix r satisfies the *zero weight condition* if:

$$[h \otimes 1 + 1 \otimes h, r(\lambda)] = 0 \text{ for all } h \in \mathfrak{h}, \lambda \in \mathfrak{h}^*.$$

In this talk we consider the problem of explicitly quantizing all zero-weight super dynamical r-matrices (with any coupling constant). (Received September 13, 2009)

1054-17-195 **RJ Dolbin*** (rjdolbin@math.ucr.edu), 12241 Carnation Lane, Unit B, Moreno Valley, CA 92557. *Ideals in parabolic subalgebras of simple Lie algebras.*

We study ad–nilpotent ideals of a parabolic subalgebra of a simple Lie algebra. Any such ideal determines an antichain in a set of positive roots of the simple Lie algebra. We give a necessary and sufficient condition for an antichain to determine an ad–nilpotent ideal of the parabolic. We write down all such antichains for the classical simple Lie algebras and in particular recover the results of D. Peterson. (Received September 14, 2009)

1054-17-198 **Karel Casteels*** (kcasteel@sfu.ca), Dept of Math, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada. *Finding generators of H-prime ideals in $O_q(M_{m,n}(C))$ using graph theory.*

Launois has shown that every $\mathcal{H}$-prime ideal in $O_q(M_{m,n}(\mathbb{C}))$ has a generating set consisting of quantum minors and has given an algorithm to find them.

We modify an old method of Lindstrom and Gessel-Viennot to show that Launois' algorithm is equivalent to finding sets of disjoint paths on the Cauchon diagram associated with the $\mathcal{H}$-prime in question. (Received September 14, 2009)

1054-17-240 **Apoorva Khare*** (apoorva@math.uchicago.edu), Yale University, Mathematics Dept., PO Box 208283, New Haven, CT 06520-8283, and **Vyjayanthi Chari** and **Tim Ridenour**. *Faces of polytopes and Koszul algebras.*

Given a reductive Lie algebra $\mathfrak{g}$ and a finite-dimensional simple $\mathfrak{g}$-module V, we study the category $\mathcal{G}$ of graded finite-dimensional modules over $\mathfrak{g} \ltimes V$. This includes truncated current Lie algebras as well as those associated to folding of complex simple Lie algebras. Given a face of the polytope formed by the weights of V, we introduce a partial order on the simple objects in $\mathcal{G}$. Using this, for certain finite subsets of the affine weight lattice, we produce quasi-hereditary Koszul algebras of finite global dimension. (Received September 15, 2009)

1054-17-296 **Prasad Senesi*** (senesi@cua.edu), Department of Mathematics, Catholic University of America, 620 Michigan Ave NE, Washington, DC 20064. *Finite-dimensional irreducible representations of equivariant map algebras.*

Let $\mathfrak{g}$ be a finite-dimensional simple Lie algebra and A an affine algebraic variety defined over an algebraically closed field of characteristic 0. Let G be a finite group which acts via automorphisms upon $\mathfrak{g}$ and A. The Lie algebra of regular maps from A to $\mathfrak{g}$ which are equivariant under the the action of G is called an *equivariant map algebra*. Examples of such algebras include current algebras, multiloop algebras (in particular, the untwisted loop algebras $\mathfrak{g} \otimes k\left[t^{\pm 1}\right]$ and their twisted subalgebras), and the Onsager algebras.

In this talk we will classify the finite–dimensional irreducible representations of an arbitrary equivariant map algebra, and describe some conditions which ensure that all such representations are given by evaluation representations of $\mathfrak{g}$.

This is joint work with Erhard Neher and Alistair Savage. (Received September 15, 2009)

18 ► Category theory; homological algebra

1054-18-19 **Ahmet Emin Tatar*** (atatar@math.fsu.edu), 356 Pennell Circle Apt. 8, Tallahassee, FL 32310. *Abelian Sheaf Complexes and Picard 2-Stacks.*

In SGA4 Exposé XVIII, Deligne studies the relation between Picard stacks and length 2 complexes of abelian sheaves, as well as the relation between the morphisms of such objects. He proves that the functor

$$\mathrm{D}^{[-1,0]}(\mathsf{S}) \longrightarrow \mathrm{Pic}^{\flat}(\mathsf{S})$$

is an equivalence. $\mathrm{D}^{[-1,0]}(\mathsf{S})$ is the subcategory of the derived category of category of complexes of abelian sheaves $A^{\bullet}$ over a site S with $H^{-i}(A^{\bullet}) \neq 0$ only for $i = 0, 1$ and $\mathrm{Pic}^{\flat}(\mathsf{S})$ is the category of Picard stacks over S with 1-morphisms isomorphism classes of additive functors.

The purpose of this talk is to generalize the above result to Picard 2-stacks. We give a definition of Picard 2-stack and define their 3-category $2\mathrm{Pic}(\mathsf{S})$. We also introduce a tricategory $\mathrm{T}^{[-2,0]}(\mathsf{S})$ of length 3 complexes of abelian sheaves. Then we construct a trihomomorphism

$$\mathrm{T}^{[-2,0]}(\mathsf{S}) \longrightarrow 2\mathrm{Pic}(\mathsf{S}),$$

which we prove to be a triequivalence. From this triequivalence, we deduce a generalization of Deligne's analogous result about Picard stacks. (Received July 11, 2009)

1054-18-90 **Radmila Sazdanovic*** (radmila@gwmail.gwu.edu), George Washington University, Department of Mathematics Monore Hall Rm 240, 2115 G street NW, Washington, DC, DC 20052, and **Mikhail Khovanov**. *Categorification of Orthogonal Polynomials.*

We introduce a categorification of the ring of polynomials $Z[x]$, viewed as a Grothendieck ring of a suitable category of projective modules over geometrically defined ring. This construction is generalized to the categorification of some basic special functions, such as Chebyshev polynomials. (Received September 07, 2009)

1054-18-135 **Christopher L Douglas*** (cdouglas@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA 94720, and **Andre Henriques**. *3-Categories for the Working Mathematician.*

We present a definition of tricategories that is finite, transparent, and completely explicit. We prove that categories internal to the 3-category 2CAT, and also bicategories internal to the 2-category CAT have underlying tricategories in this sense, and discuss the relationship of tricategories to other models of weak higher categories, such as weak complicial sets. Time permitting we will mention natural examples, studied in joint work with Bartels, fitting our model of tricategories, such as conformal nets and tensor categories. (Received September 10, 2009)

1054-18-144 **Alexander E Hoffnung*** (alex@math.ucr.edu), 600 Central Ave #324, Riverside, CA 92507. *A categorification of the Hecke algebra.*

Given a Dynkin diagram and the finite field F_q, where q is a prime power, we get a finite algebraic group G_q. I will explain joint work with John Baez where we show how to construct a categorification of the Hecke algebra $H(G_q)$ associated to this data. This is an example of the Baez/Dolan/Trimble program of "Groupoidification", a method of promoting vector spaces to groupoids and linear operators to spans of groupoids. For example, given the A_2 Dynkin diagram, for which $G_q = SL(3, F_q)$, the spans over the G_q-set of complete flags in F_q^3 encode the relations of the Hecke algebra associated to $SL(3, F_q)$. Further, we will see how the 2-morphisms proving the relations for the Hecke algebra correspond to incidence relations in projective plane geometry. (Received September 11, 2009)

1054-18-216 **Ahmet Emin Tatar*** (atatar@math.fsu.edu), 356 Pennell Cir Apt8, Tallahassee, FL 32310. *Abelian Sheaf Complexes and Picard 2-Stacks.*

In SGA4 Exposé XVIII, Deligne studies the relation between Picard stacks and length 2 complexes of abelian sheaves, as well as the relation between the morphisms of such objects. He proves that the functor

$$\mathrm{D}^{[-1,0]}(\mathsf{S}) \longrightarrow \mathrm{Pic}^{\flat}(\mathsf{S})$$

is an equivalence. $\mathrm{D}^{[-1,0]}(\mathsf{S})$ is the subcategory of the derived category of category of complexes of abelian sheaves $A^{\bullet}$ over a site S with $H^{-i}(A^{\bullet}) \neq 0$ only for $i = 0, 1$ and $\mathrm{Pic}^{\flat}(\mathsf{S})$ is the category of Picard stacks over S with 1-morphisms isomorphism classes of additive functors.

The purpose of this talk is to generalize the above result to Picard 2-stacks. We give a definition of Picard 2-stack and define their 3-category $2\mathrm{Pic}(\mathsf{S})$. We also introduce a tricategory $\mathrm{T}^{[-2,0]}(\mathsf{S})$ of length 3 complexes of abelian sheaves. Then we construct a trihomomorphism

$$\mathrm{T}^{[-2,0]}(\mathsf{S}) \longrightarrow 2\mathrm{Pic}(\mathsf{S}),$$

which we prove to be a triequivalence. From this triequivalence, we deduce a generalization of Deligne's analogous result about Picard stacks. (Received September 14, 2009)

1054-18-227 **David I. Spivak*** (dspivak@uoregon.edu), University of Oregon, Eugene, OR 97403, and **Daniel Dugger** (ddugger@uoregon.edu), University of Oregon, Eugene, OR 97403.

Mapping spaces in quasi-categories.

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Quasi-categories constitute one model for the theory of so called ∞-categories, in which each ∞-category is represented by a simplicial set. The vertices correspond to objects, the 1-simplices correspond to morphisms, the 2-simplices correspond to commuting triangles, etc. Quasi-categories were invented by Boardman and Vogt, illuminated by Joyal, and made a central tool and language for derived algebraic geometry by Lurie.

The difficulty that one seems to constantly run into is that there is no composition law in a quasi-category S. One can turn S into a simplicial category $\mathfrak{C}(S)$ (and hence get a composition law) using a Quillen equivalence, but it is difficult to compute mapping spaces in $\mathfrak{C}(S)$.

In this presentation, I will discuss joint work with Dan Dugger in which we make these mapping spaces explicit. I will also present some other models for the mapping spaces, and explain how they are all related. (Received September 14, 2009)

1054-18-276 **Christopher Walker*** (cwalker66@math.ucr.edu). *A Categorification of Hall Algebras.*
In 1990 Ringel first proved that given any simply-laced Dynkin diagram, the Hall algebra of this diagram is isomorphic to the positive part of Uq(g), where g is the lie algebra associated to the same Dynkin diagram. Hall algebras turn out to be one of the most natural applications of the Baez/Dolan program of "groupoidification". In this talk we will describe the pieces of groupoidification necessary for this example, and then show how to apply the process to Hall algebras. (Received September 15, 2009)

1054-18-279 **Scott Morrison*** (scott@tqft.net), **Emily Peters** and **Snyder Noah**. *Discovering knot polynomial identities using the D_{2n} planar algebras.*
I'll tell you about the D_{2n} planar algebras, which are $\mathbb{Z}/2\mathbb{Z}$ quotients of the Temperley-Lieb planar algebras. These planar algebras aren't braided, but have a braiding on the 'even part'. We use this to define some knot invariants, which we can recognise as being related to two different quantum knot polynomials. This provides a new source of identities between knot polynomials. I'll also explain these identities in terms of isomorphisms between certain small modular tensor categories. These isomorphisms come from three sources: Kirby-Melvin symmetry, triality for $SO(8)$, and a degenerate case of level-rank duality for $SO(3) - SO(k)$. (Received September 15, 2009)

1054-18-289 **Scott Morrison*** (scott@tqft.net) and **Kevin Walker**. *Blob homology 1.* Preliminary report.
We define a chain complex $\mathcal{B}_*(\mathcal{C}, \mathcal{M})$ (the "blob complex") associated to an n-category C and an n-manifold M. This can be thought of as the 'derived' category version of a TQFT. I'll have time to give the definition, and mention some specialisations which recover familiar objects: Hochschild homology, and skein modules. The second talk, 'Blob Homology 2', will describe in more detail our approach to weak n-categories with duals, and some nice formal properties of blob homology. (Received September 15, 2009)

1054-18-291 **Luchezar L. Avramov*** (avramov@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588, **Srikanth B. Iyengar** (iyengar@math.unl.edu), Department of Mathematics, University of Nebraska, Lincoln, NE 68588, **Joseph Lipman** (jlipman@purdue.edu), Purdue University, Department of Mathematics, West Lafayette, IN 47907, and **Suresh Nayak** (snayak@cmi.ac.in), Chennai Mathematical Institute, Siruseri, 603103, India. *Reduction of derived Hochschild functors.*
For commutative algebras of finite type over noetherian rings, it will be shown that derived Hochschild functors with coefficients in certain bimodules can be expressed as compositions of derived functors over the algebra itself. Such decompositions are used to construct, in the commutative case, a theory of rigid dualizing complexes for that extends those of Van den Bergh (for finite-dimensional algebras over a field) and of Yekutieli and Zhang (for algebras of finite type over rings of finite global dimension). (Received September 15, 2009)

1054-18-300 **Alissa S. Crans*** (acrans@lmu.edu), Loyola Marymount University, Department of Mathematics, One LMU Drive, Suite 2700, Los Angeles, CA 90045. *2-Quandles: Categorified Quandles.* Preliminary report.

A quandle is a set equipped with two binary operations satisfying axioms that capture the essential properties of group conjugation and algebraically encode the three Reidemeister moves. Quandles have been studied extensively in connection with applications to knots and knotted surfaces. A 2-quandle is a categorified version of a quandle, in which the underlying set has been replaced by a category and the two binary operations have been replaced by functors. We will discuss relationships between 2-quandles and various categorified structures, including 2-groups, and Lie 2-algebras, and we will explore the possibility of knot and 2-knot invariants arising from 2-quandles. This is work in progress with J. Scott Carter, Mohamed Elhamdadi, and Masahico Saito. (Received September 15, 2009)

1054-18-305 **Alexander Rosenberg*** (rosenber@math.ksu.edu), Kansas State University, Department of Mathematics, Cardwell Hall, Manhattan, KS 66506. *Geometry of 'spaces' represented by triangulated categories.*

The purpose of the talk is to sketch the first notions and facts of (the form of) derived noncommutative geometry, in which 'spaces' are represented by svelte Karoubian triangulated categories (we call them *t-'spaces'*) and morphisms by isomorphism classes of *triangle* functors. We start with a triangulated version of descent proving that every continuous morphism of t-'spaces' is the composition of a localization and a comonadic morphism and finish with a geometric realization of a triangulated Karoubian category as a stack of local triangulated categories over its spectrum. Its *geometric center* is a locally ringed topological space. The functorialities (covariant and contravariant) of this geometric realization have direct relation with representation theory and K-theory.

References

[R1] A.L. Rosenberg, Topics in Noncommutative Algebraic Geometry, Homological Algebra and K-Theory, preprint MPIM, 2008(57), 105 pp.
[R2] A.L. Rosenberg, Trieste Lectures, in "Some Recent Developments in Algebraic K-Theory, ICTP Lecture Notes, v. 23, 2008, 307–428
[R3] A. L. Rosenberg, Geometry of Noncommutative 'Spaces', 298 pp, a monograph in preparation (Received September 16, 2009)

19 ► K-theory

1054-19-228 **T Benedict Williams***, Department of Mathematics, Stanford University, Stanford, CA 94305. *An Application of Equivariant $\mathbb{A}^1$-Homotopy Theory to Problems in Commutative Algebra.*

Denote by S the (graded) ring $k[x_1, \ldots, x_n]$, where k is a field. There are several open problems in commutative algebra concerning free resolutions of artinian S-modules, or, more generally, concerning differential graded modules over S which have artinian homology. We recast these problems as problems of finding k^*-equivariant maps from an $\mathbb{A}^1$-theoretic sphere to certain moduli spaces, and then we begin the search for obstructions to such maps. (Received September 14, 2009)

1054-19-255 **Christian Haesemeyer***, Dept. of Mathematics, UCLA, Los Angeles, CA 90095, and **Guillermo Cortinas**, **Mark E Walker** and **Charles A. Weibel**. *On the K-theory of toric varieties.*

We present computations of the (algebraic) K-theory of singular toric varieties. The arguments needed are algebraic-geometric, combinatorial and homotopy theoretic. At the core lie some calculations of cyclic nerves of monoids, building on work by Hesselholt and Madsen. (Received September 15, 2009)

20 ► Group theory and generalizations

1054-20-77 **Frauke M. Bleher** (fbleher@math.uiowa.edu), Department of Mathematics, The University of Iowa, 14 MacLean Hall, Iowa City, IA 52242-1419, **Jennifer B. Froelich*** (froelicj@dickinson.edu), Department of Mathematics, Dickinson College, P.O. Box 1773, Carlisle, PA 17013, and **Giovanna Llosent** (gllosent@csusb.edu), Department of Mathematics, 370 Jack Brown, California State University, San Bernardino, 5500 University Pkwy, San Bernardino, CA 92407. *Universal deformation rings and dihedral blocks with two simple modules.* Preliminary report.

Let k be an algebraically closed field of characteristic 2 and let G be a finite group. Let B be a block of the group algebra kG with dihedral defect groups and precisely two isomorphism classes of simple modules. The goal of this work is to find all indecomposable B-modules whose stable endomorphism ring is given by scalars and then determine their universal deformation ring. In this talk, we will discuss the initial findings of our work. (Received September 04, 2009)

1054-20-124 **Jon F Carlson*** (jfc@math.uga.edu), Department of Mathematics, University of Georgia, Athens, GA 30602, and **Nadia Mazza** and **Jacques Thévenaz**. *Endotrivial modules.* Preliminary report.

This is a report on efforts to classify the endotrivial modules over the modular groups algebras of groups which are not p-groups. A classification of the endotrivial modules over p-groups was completed by the speaker and Thévenaz a few years ago, building on the work of many others, notably Dade and Alperin. The endotrivial modules form an important part of the Picard group of self equivalences of the stable category of modules over the group algebra. For groups which are not p-groups, the problem of determining the endotrivial modules often reduces to discovering when the Green correspondent of an endotrivial module is endotrivial. This investigation often involves a detailed study of the representation theory of the groups in question. Here we present some recent results on endotrivial modules over solvable and p-nilpotent groups as well as groups with quaternion Sylow p-subgroup. (Received September 10, 2009)

1054-20-166 **Stephen Bigelow***, Department of Mathematics South Hall, Room 66, University of California, Santa Barbara, CA 93106. *New from old representations of braid groups.*

I will describe an algorithm that, given a representation of the braid groups, produces a new and often more interesting representation. It uses a single universal representation from braid groups to groups of matrices with entries in a group ring. This should be easy and (I hope) interesting for a general audience. I will then discuss hidden motivations and future applications. This is joint work with Jianjun Tian, and extends work of Long and Moody. (Received September 13, 2009)

1054-20-194 **Benjamin F Jones***, Department of Mathematics, University of Georgia, Athens, GA 30602-7403. *Support Varieties for Demazure Modules.* Preliminary report.

We report on preliminary joint work with Daniel Nakano on support varieties for Demazure modules. Specifically, if $\mathcal{L}(\lambda)$ is a line bundle on the flag variety G/B corresponding to a dominant weight λ and $X_w \subset G/B$ is a Schubert variety, consider the B-modules $M_{w,\lambda} = H^0(X_w, \mathcal{L}(\lambda))$. We examine the support variety $\mathcal{V}_{B_1}(M_{w,\lambda})$ over the first Frobenius kernel B_1 and its dependence on w and λ using tools developed in the work of Nakano-Parshall-Vella. We present general results on the calculation of support varieties for certain X_w as well as explicit calculations in rank 2. (Received September 14, 2009)

1054-20-242 **Arkady Berenstein*** (arkadiy@math.uoregon.edu), 4936 Mahalo Drive, Eugene, OR 97405, and **Yuri Bazlov** (y.bazlov@warwick.ac.uk), Mathematics Institute, University of Warwick, Coventry, England. *q-commuting Dunkl operators and braided Cherednik algebras.*

In my talk I will introduce q-commuting analogues of Dunkl operators that are acting on q-symmetric algebras. I will explain the q-commutation phenomenon by constructing braided Cherednik algebras for which the above operators form a representation.

The classification of braided Cherednik algebras is achieved in terms of braided doubles that Yuri Bazlov and myself introduced earlier. Besides ordinary rational Cherednik algebras and their braided tensor products, we obtained new algebras with triangular decomposition attached to an infinite family of subgroups of even elements in complex reflection groups, so that the corresponding Dunkl operators pairwise anti-commute. (Received September 15, 2009)

22 ► Topological groups, Lie groups

1054-22-51 **Nitu R Kitchloo*** (nitu@math.ucsd.edu), 9500 Gilman Drive, Department of Mathematics, UCSD, AP&M Building, La Jolla, CA 92093. *Universal Bott Samelson resolutions.* Preliminary report.

The flag varieties for algebraic groups over the complex numbers have desingularizations known as Bott-Samelson resolutions. It is basic question to inquire how various invariants of these flag varieties depend on the choice of resolution. Given an algebraic group G, we will construct a universal Bott-Samelson resolution which can be interpreted as the flag variety of a universal lift $\tilde{G}$ of G. We then describe the map from $\tilde{G}$ to G in detail. Our methods work for more general flag varieties like the affine flag variety. (Received August 30, 2009)

28 ► Measure and integration

1054-28-133 **Yuichiro Kakihara*** (ykakihar@csusb.edu), Department of Mathematics, California State University, 5500 University Parkway, San Bernardino, CA 92407-2397. *Weak Radon-Nikodým derivative for Hilbert space valued measures.*

Let $(\Theta, \mathfrak{A})$ be a measurable space and H be a separable Hilbert space. Let ξ be a H-valued measure on $\mathfrak{A}$ and ν be a finite positive measure on $\mathfrak{A}$ such that $\xi \ll \nu$. Since H has the Radon-Nikodým property, if ξ is of bounded variation, then there exists a unique (in the ν-*a.e.* sense) Radon-Nikodým derivative $d\xi/d\nu \in L^1(\Theta, \nu : H)$. If ξ is not of bounded variation, a weak Radon-Nikodým derivative of ξ with respect to ν is defined. The existence and uniqueness of weak Radon-Nikodým derivative will be shown under a fairly general condition. Using this weak Radon-Nikodým derivative an integral of a complex valued measurable function with respect to ξ is defined, which reduces to the Dunford-Schwartz integral. (Received September 10, 2009)

1054-28-146 **Nishu Lal*** (nishul@math.ucr.edu), University of California, Riverside, Department of Mathematics, 261 Surge Building, Riverside, CA 92521. *Spectral Analysis on self-similar sets and spectral zeta function.* Preliminary report.

The Laplacian operator is one of the most important operators studied in the theory of analysis on manifolds. To define a differential operator like the Laplacian on fractals is not possible from the classical viewpoint of analysis. We construct the Laplacian on finitely ramified self-similar fractals, such as the Sierpinski gasket and discuss its spectrum. The decimation method is a process that describes the relationship between the spectrum of the Laplace operator and the dynamics of the iteration of a certain polynomial on $\mathbb{C}$. Furthermore, we discuss the spectral zeta function of the Laplacian. Teplyaev discovered the product structure of the spectral zeta function in the case of Sierpinski gasket that involves a geometric part and a new zeta function of a polynomial induced by the decimation method. An interesting feature of the product structure is the cancellation phenomenon between the poles of the zeta function of a polynomial and the zeros of the geometric part of the spectral zeta function of the Laplacian. Initially, M. Lapidus illustrated a similar product structure for self similar fractal strings. (Received September 11, 2009)

1054-28-229 **Mark Burgin** and **Dongxin (Tony) Chen*** (tonypomona@yahoo.com), 3801 W. Temple Avenue, Department of Mathematics and Statistics, Pomona, CA 91768, and **Alan Krinik**. *Extending the Radon-Nikodym Theorem to Hypermeasures.* Preliminary report.

A simplified derivation of the classical Radon-Nikodym Theorem appeared in an interesting article written by Anton R. Schep in the American Mathematical Monthly, (Vol. 110, No. 6, June-July 2003, pp. 536-538). We use this approach to extend the Radon-Nikodym Theorem to the hypermeasure setting. The ideas of hypernumbers, hypermeasures and hyperintegration are briefly summarized. Standard real analysis results are re-visited and re-interpreted for hypermeasures in order to generalize Schep's derivation of the Radon-Nikodym Theorem. (Received September 15, 2009)

1054-28-268 **Stephane Jaffard*** (jaffard@univ-paris12.fr), LAMA, Université Paris 12 - Val de Marne, 61, avenue du Général de Gaulle, 94010 Creteil, France. *A grandcanonical multifractal formalism.*

Multifractal analysis, in its usual form, deals with the determination of the size of the sets of points where a measure or a function has a given Hölder exponent (the term "size" usually referring either to the Hausdorff or the Packing dimension). In the present contribution, two exponents are attached at each point: the usual Hölder exponent, but also an oscillation exponent(by example, for "typical" chirp singularities $x^\alpha \sin(x^{-\beta})$, the Hölder exponent is α and the oscillation exponent is β). The grandcanonical multifractal formalism addresses

the problem of determining the dimensions of the sets of points where this couple of exponents takes a given value. Applications to signal processing will be given. (Received September 15, 2009)

30 ► Functions of a complex variable

1054-30-222 **Luke G Rogers*** (rogers@math.uconn.edu), 196 Auditorium Rd, Unit 3009, Storrs, CT 06269-3009. *Estimates for the resolvent kernel of the Laplacian on p.c.f. fractals.*

Building on recent work with Ionescu, Pearse, Ruan and Strichartz, I will describe a method for using an explicit formula for the resolvent kernel of the Laplacian on a pcf fractal to obtain sub-Gaussian estimates for this kernel. These coincide with those that may be computed in a half-plane from the heat kernel estimates of Hambly and Kumagai, but have a larger domain of validity, as they hold on any sector of the complex plane that omits the ray containing the Laplacian eigenvalues. In particular they may be used to recover the heat kernel estimates. (Received September 14, 2009)

35 ► Partial differential equations

1054-35-61 **David M. Ambrose***, Department of Mathematics, 3141 Chestnut Street, Philadelphia, PA 19104, and **Jon Wilkening**. *Computation of Time-Periodic Interfacial Fluid Flows.*

We introduce a numerical method for the computation of special solutions of evolution equations. The method can be applied as long as there is an efficient method for numerical solution of the initial value problem. We apply this method to find time-periodic solutions of problems from interfacial fluid dynamics; in particular, the method has been used so far to find time-periodic solutions of the Benjamin-Ono equation and of the vortex sheet with surface tension. (Received September 01, 2009)

1054-35-75 **Vera Mikyoung Hur*** (verahur@math.uiuc.edu), 1409 W Green Street, University of Illinois at Urbana-Champaign, Department of Mathematics, Urbana, IL 61801. *Rotational Stokes waves.*

I will speak on traveling waves on the surface of a liquid body under the influence of gravity. I will begin by giving a precise account of the formulation of the surface water-wave problem and discuss its defining features. Particular emphasis is on the effects of the vorticity. Stokes waves refer to as traveling periodic waves whose profile rises and falls exactly once per wavelength. I will describe my recent work on their existence of all amplitudes for a general class of vorticities with some ideas of proof. If time permits, I will discuss on the limiting wave. (Received September 04, 2009)

1054-35-80 **Thomos Y. Hou*** (hou@acm.caltech.edu), Applied and Comput. Math, 217-50, Caltech, Pasadena, CA 91125. *Recent Progress on Dynamic Stability and Global Regularity of 3D Incompressible Euler and Navier-Stokes Equations.*

Whether the 3D incompressible Euler and Navier-Stokes equations can develop a finite time singularity from smooth initial data with finite energy has been one of the most long standing open questions. We review some recent theoretical and computational studies which show that there is a subtle dynamic depletion of nonlinear vortex stretching due to local geometric regularity of vortex filaments. Our studies also reveal a surprising stabilizing effect of convection for the 3D incompressible Euler and Navier-Stokes equations. Finally, we prove nonlinear stability and the global regularity of a class of solutions which exhibit interesting dynamic growth. (Received September 05, 2009)

1054-35-179 **Benoit Pausader*** (benoit.pausader@math.brown.edu), Mathematics department, Box 1917, Providence, RI 02912. *Scattering for fourth-order wave equations.*

We consider the fourth-order wave equation $u_{tt} + \Delta^2 u + mu + |u|^{p-1}u = 0$ in dimensions $n = 2, 3, 4$. This model was introduced by Bretherton to understand nonlinear interaction between waves. We prove that any initial data with finite energy leads to a global solution that approaches a linear solution asymptotically in time. (Received September 13, 2009)

1054-35-180 **Thomas C Sideris*** (sideris@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *Spreading of free boundaries in hydro- and elasto-dynamics.* Preliminary report.

We consider the initial free boundary value problem for certain classes of ideal fluids and elastic solids in bounded regions of space. It will be shown that the diameter of the region containing the material grows at least linearly in time, as long as the local solution exists and is regular. (Received September 13, 2009)

1054-35-182 **Igor Kukavica** (kukavica@usc.edu), University of Southern California, 3620 South Vermont Ave., Los Angeles, CA 90089, and **Vlad Vicol*** (vicol@usc.edu), University of Southern California, 3620 South Vermont Ave., Los Angeles, CA 90089. *Gevrey-class regularity for the Euler equations on a domain with boundary.*

We estimate the domain of analyticity and Gevrey-class regularity of solutions to the Euler equations on the half-space, and on a three-dimensional bounded domain. We obtain new lower bounds for the rate of decay of the real-analyticity radius of the solution, which depend algebraically on the Sobolev norm. In the case of the bounded domain, using Lagrangian coordinates, we prove the persistence of the non-analytic Gevrey-class regularity. (Received September 13, 2009)

1054-35-212 **Anna L Mazzucato*** (alm24@psu.edu), Mathematics, Penn State University, University Park, PA 16802, and **Michael E Taylor**. *On the vanishing viscosity limit in incompressible flows.*

We study the vanishing viscosity limit for certain Taylor-Couette flows in pipes and channels. We establish convergence of the Navier-Stokes solution to the corresponding Euler solution as viscosity vanishes in various norms. The boundary layer is studied via singular perturbation for variable-coefficient heat equations with small diffusion. (Received September 14, 2009)

1054-35-213 **Mohammed B Ziane*** (ziane@usc.edu), USC-Math Department, KAP 108, 3620 Vermont Avenue, Los Angeles, CA 90089, and **Nathan Glatt-Holtz**. *Well posedness of some stochastic geophysical models.*

The talk will focus on several geophysical models forced by a multiplicative noise, including the hydrostatic primitive equations. Local as well as global existence results of path-wise solutions will be given. (Received September 14, 2009)

1054-35-254 **Juhi Jang***, Courant Institute, 251 Mercer Street, New York, NY 10012, and **Nader Masmoudi**. *Vacuum in Gas and Fluid Dynamics.*

The study of vacuum is important in understanding the motion of gaseous stars or shallow water. We propose some interesting problems described by compressible Euler equations with vacuum and present the rigorous framework on how to study, in particular, in one space dimension. (Received September 15, 2009)

1054-35-261 **Thomas Laurent*** (laurent@math.ucla.edu), CA. *Blowup in multidimensional aggregation equations.* Preliminary report.

Aggregation equations are continuum models for interacting particle systems with attractive pairwise interaction potentials. The main phenomenon of interest is that, even with smooth initial data, the solutions can concentrate mass in finite time (i.e. a Dirac delta function appears in the solution). We show local well-posedeness of L^p solutions and global well-posedness of weak measure solutions. For the latter, our approach is based on the theory of gradient flows in the space of probability measures endowed with the Wasserstein metric. The interplay between the L^p theory and the measure theory give a good understanding of the mechanism by which a Dirac delta function appears in the solution. (Received September 15, 2009)

1054-35-270 **Jonathan J Sarhad*** (jjs@math.ucr.edu), 1055 W. Blaine St. #28, Riverside, CA 92507. *A Solution to the Nonlinear Poisson Boundary Value Problem via a Newton-imbedding Prodedure.* Preliminary report.

This presentation considers the semilinear boundary value problem given by the Poisson equation, $-\Delta u = f(u)$. Under suitable assumptions on the domain, and the forcing term f, the Newton-imbedding procedure yields a continuous solution. This study is inspired by an independant work which uses this procedure to solve the Poisson problem, assuming in particular, that f' maps the Sobolev space $H^1(\Omega)$ to the space of Hölder continuous functions $C^\alpha(\bar{\Omega})$. In the first part of the presentation, we show that if Ω is a domain in $\mathbb{R}^{n>2}$, then any mapping of $H^1(\Omega)$ to $C^0(\bar{\Omega})$, the space of continuous functions, via composition with a real function, is constant. In this case, f is linear and the scope of the procedure, in higher than two dimensions, is reduced to linear equations.

In the second part of the article, we show that with weaker assumptions on f' , the procedure works, producing a continuous solution when $n = 3$. (Received September 15, 2009)

1054-35-275 **M Li*** (cli@colorado.edu) and **T H Hou**. *Some models related to the stabilizing effect of convection in Fluid.* Preliminary report.

We present some preliminary results about the role of convection on the dynamic stability property of the 3D incompressible Euler and Navier-Stokes equations. Some special models have been studied with some preliminary results. (Received September 15, 2009)

1054-35-283 **Jennifer Burke Loftus*** (jenn@math.ucr.edu), University of California, Riverside, Math Dept./Surge Building 2nd Floor, Riverside, CA 92521. *Gaussian Upper Bound of a Parabolic Equation Arising in the study of the Navier-Stokes Equations.* Preliminary report.

We apply Moser's iteration to obtain an $L^2 - L^\infty$ estimate on solutions to the equation

$$\Delta\Gamma - b \cdot \nabla\Gamma - \frac{2}{r}\partial_r\Gamma - \partial_t\Gamma = 0, \text{ Div } b = 0.$$

We then obtain a weighted estimate which, in turn, provides a Gaussian upper bound on solutions. There is still a question as to if a lower bound can be obtained. The standard Nash Inequality will not suffice due to a necessary vanishing condition on smooth solutions, but perhaps a similar argument with a different weight will be fruitful. (Received September 15, 2009)

1054-35-304 **Igor Kukavica*** (kukavica@usc.edu), **Amjad Tuffaha** and **Mohammed Ziane**. *Local well-posedness for a structure-fluid interaction model.*

In the talk we address a structure-interaction model introduced by Lions. The system describes the fluid, modeled by the Navier-Stokes equations, and an elastic body, modeled by an elasticity equation. On the common boundary, which is variable but held fixed, the velocities and stresses are matched. We discuss available results on local well-posedness and prove a new local well posedness when the velocity u belongs to H^1 and the elastic displacement w belongs to $H^{1/2+}$ with w_t in $H^{3/2+}$. (Received September 15, 2009)

1054-35-309 **Alexis F. Vasseur*** (vasseur@math.utexas.edu) and **Cristina Caputo**. *Global regularity of solutions to a class of systems of reaction-diffusion.*

In this talk, we present the study of the regularity of solutions to some systems of reaction–diffusion equations, with reaction terms having a subquadratic growth. We show the global boundedness and regularity of solutions, without smallness assumptions, in any dimension N. The proof is based on blow-up techniques. The natural entropy of the system plays a crucial role in the analysis. It allows us to use of De Giorgi type methods introduced for elliptic regularity with rough coefficients. Even if those systems are entropy supercritical, it is possible to control the hypothetical blow-ups, in the critical scaling, via a very weak norm. (Received September 16, 2009)

37 ► Dynamical systems and ergodic theory

1054-37-12 **Mrinal Kanti Roychowdhury*** (roychowdhurymk@utpa.edu), Dept of Mathematics, UTPA, 1201 West University Drive, Edinburg, TX 78539. *Quantization dimension function and ergodic measure with bounded distortion.tex.*

The term "quantization" in the title originates in the theory or signal processing. It was used by electrical engineers starting in the late 40's. As a mathematical topic quantization for probability distributions concerns the best approximation of a d-dimensional probability distribution P by a discrete probability with a given number of n-supporting points or in other words, the best approximation of a d-dimensional random vector X with distribution P by a random vector Y with at most n values in its image. The random vector Y which gives the error minimum is called the optimal quantizer of the random vector X and the corresponding error is called the optimal error. The image set of the optimal quantizer is called the optimal set. One of the main goal of quantization theory is to estimate the rate called **Quantization dimension** at which the specified measure of the error goes to zero as n increases.

In this talk the quantization dimension function for the image measure on a self-conformal set of an ergodic measure with bounded distortion and its relationship with the temperature function of the thermodynamic formalism will be shown. (Received June 13, 2009)

1054-37-15 **Jiu Ding*** (jiudin@gmail.com), Department of Mathematics, University of Southern Mississippi, 118 College Dr., Box 5045, Hattiesburg, MS 39406, and **Yifa Tang**, State Key Laboratory of Scientific and Engine, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, 100190, Peoples Rep of China. *Non-convexity of the Dimension Function for Sierpiński Pedal Triangles,.*

We disprove a recent conjecture on the Schur-convexity of the dimension function for the family of Sierpiński pedal triangles. We also show that this function is not convex and the related area-ratio function is not concave in their respective domain. (Received June 29, 2009)

1054-37-49 **Slobodan N. Simić*** (simic@math.sjsu.edu), Department of Mathematics, San Jose State University, San Jose, CA 95192-0103. *Oseledets regularity functions for Anosov flows.*

Oseledets regularity functions quantify the deviation between the growth associated with a dynamical system along its Lyapunov bundles and the corresponding uniform exponential growth. Precise degree of regularity of these functions is unknown. We show that for every invariant Lyapunov bundle of a volume preserving Anosov flow on a closed smooth Riemannian manifold, the corresponding Oseledets regularity functions are in $L^p(m)$, for some $p > 0$, where m is the probability measure defined by the volume form. We prove an analogous result for essentially bounded cocycles over volume preserving Anosov flows. (Received August 28, 2009)

1054-37-52 **M Field*** (mikefield@gmail.com), Department of Mathematics, University of Houston, Houston, TX 77204-3008. *Exponential mixing for hyperbolic flows.* Preliminary report.

We describe recent work on (stable) exponential mixing for a large class of hyperbolic flows as well as an intriguing conjecture about the typicality of exponential mixing that arises from this work. (Received August 30, 2009)

1054-37-64 **Annalisa Crannell*** (annalisa.crannell@fandm.edu), Department of Mathematics, Box 3003, Franklin & Marshall College, Lancaster, PA 17604-3003. *Shifts of Finite Type and Fibonacci Harps.*

We make an explicit connection between the Fibonacci Harp (or Fibonacci String) and two well-known dynamical systems: subshifts of finite type and the baker's map on the unit interval. In particular, we show that the boundary of the Fibonacci Harp is an embedding of a commonly studied shift of finite type in the unit interval. Moreover, every shift of finite type embeds as the boundary of a lattice harp. (Received September 01, 2009)

1054-37-89 **Peter H. Baxendale*** (baxendal@math.usc.edu), Department of Mathematics, University of Southern California, 3620 South Vermont Avenue, KAP 108, Los Angeles, CA 90089-2352. *A Spectral Analysis of the Stochastic Integrate-and-Fire Oscillator.*

The integrate and fire oscillator is a widely used model for the evolution of the membrane potential in a nerve cell. One important problem is to determine the effect of periodic modulation of the input current or the firing threshold function on the sequence of firing times. For a noise-free system the sequence of firing phases (modulo the period of the modulation) is a deterministic dynamical system on the circle, and its bifurcation scenario has been studied by many authors. When white noise is added to the membrane potential, the sequence of firing phases becomes a uniformly ergodic Markov chain on the circle and the bifurcation behavior is smoothed out. However numerical computations with small noise intensity suggest that some of the deterministic behavior shows up in the eigenvalues of the Markov transition operator. This talk will describe recent theoretical results, obtained jointly with John Mayberry (Cornell University), on small noise asymptotics of the spectrum of this Markov transition operator. (Received September 07, 2009)

1054-37-93 **Sheldon E. Newhouse*** (newhouse@math.msu.edu). *Verified Computation of Invariant Manifolds for Planar Diffeomorphisms.* Preliminary report.

We describe accurate and efficient methods for obtaining rigorous enclosures of long pieces of stable and unstable manifolds for hyperbolic periodic points in planar diffeomorphisms. This allows accurate computation of homoclinic points and their images. The methods involve the application of verified computation using differential algebraic techniques and associated computer software. In some cases such as those occuring in the standard Henon map $H(x, y) = (1 + y - 1.4 * x^2, 0.3 * x)$ disjoint tubular neighborhoods of width smaller than $1e - 4$ can be obtained for hundreds of pieces of stable curves, each of arclength at least 0.5.

Applications to the estimation of topological entropy for Henon maps will also be described.

This is joint work with A. Wittig, J. Grote, M. Berz, and K. Makino. (Received September 07, 2009)

1054-37-106 **Matthew Nicol*** (nicol@math.uh.edy), Mathematics Department, University of Houston, Cullen Boulevard, Houston, TX 77204-3008, and **Chinmaya Gupta** (ccgupta@math.uh.edu) and **William Ott** (ott@math.uh.edu). *A Borel-Cantelli lemma for nonuniformly expanding dynamical systems.* Preliminary report.

Let $(A_n)_{n=1}^{\infty}$ be a sequence of sets in a probability space $(X, \mathcal{B}, \mu)$ such that $\sum_{n=1}^{\infty} \mu(A_n) = \infty$. The classical Borel-Cantelli lemma states that if the sets A_n are independent, then $\mu(\{x \in X : x \in A_n \text{ for infinitely many values of } n\}) = 1$. We present analogous dynamical Borel-Cantelli lemmas for certain sequences of sets (A_n) in X (including nested balls) for a class of deterministic dynamical systems $T : X \to X$ that admit invariant probability measures. Our results apply to a class of Gibbs-Markov maps and one-dimensional nonuniformly expanding systems modeled by Young towers. We discuss some applications of our results to the extreme value theory of deterministic dynamical systems. (Received September 09, 2009)

1054-37-107 **Qiudong Wang*** (dwang@math.arizona.edu), Department of Mathematics, University of Arizona, Tucson, AZ 85721. *Dynamics of Periodically Perturbed Homoclinic Solutions.*

We study the dynamics of homoclinic tangles in periodically perturbed second order equations. Let μ be the size of the perturbation and Λ_μ be the homoclinic tangles. We prove that (i) for infinitely many μ, Λ_μ contain *nothing else* but a horseshoe of infinitely many branches; (ii) for infinitely many μ, Λ_μ contain *nothing else* but one sink and one horseshoe of infinitely many branches; and (iii) there are positive measure set of μ so that Λ_μ admits strange attractors with Sinai-Ruelle-Bowen measure. (Received September 09, 2009)

1054-37-145 **Robert J Sacker** (rsacker@usc.edu), University of Southern California, 3620 South Vermont Ave., KAP 108, Los Angeles, CA 90089-2532, and **Hubertus F von Bremen*** (hfvonbremen@csupomona.edu), California State Polytechnic University Pomon, 3801West Temple Ave, Pomona, CA 91768. *Conjecture on the stability of periodic solutions to Ricker's equations with periodic parameters.*

In this work we propose a conjecture about the stability of periodic solutions to Ricker's equation with periodic parameters. Analytically we show that the conjecture is true for systems with period-two parameters, and we obtain a stability region in parameter space that is larger than the one in the cited literature. Numerically we investigate the period-three case, and again as stated in the conjecture, the results suggest the stability region is larger than that proved in the literature. (Received September 11, 2009)

1054-37-154 **Andrew Török*** (torok@math.uh.edu), Department of Mathematics, University of Houston, Houston, TX 77204-3008, and **Ian Melbourne** and **Viorel Nitica**. *Transitivity of Euclidean-type extensions of hyperbolic systems.*

Let $f : X \to X$ be the restriction to a hyperbolic basic set of a smooth diffeomorphism. We show that in the class of $C^r, r > 0$, cocycles with fiber special Euclidean group $SE(n)$ those that are transitive form a residual set (countable intersection of open dense sets). This result is new for $n \geq 3$ odd.

More generally, we consider Euclidean-type groups $G \ltimes \mathbb{R}^n$ where G is a compact connected Lie group acting linearly on $\mathbb{R}^n$. When $\operatorname{Fix} G = \{0\}$, it is again the case that the transitive cocycles are residual. When $\operatorname{Fix} G \neq \{0\}$, the same result holds on restriction to the subset of cocycles that avoid an obvious and explicit obstruction to transitivity.

This is joint work with Ian Melbourne and Viorel Niţică.
(Received September 12, 2009)

1054-37-155 **Amanda J. Potts*** (apotts@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208-2730. *Multiple ergodic averages for flows and configurations in sets of positive density in* $\mathbb{R}$.

We show the L^2-convergence of continuous time ergodic averages of a product of functions evaluated at return times along polynomials. These averages are the continuous time version of the averages appearing in Furstenberg's proof of Szemerédi's Theorem. For each average we show that it is sufficient to prove convergence on special factors, the Host-Kra factors, which have the structure of a nilmanifold. We also give a description of the limit. In particular, if the polynomials are independent over the real numbers then the limit is the product of the integrals. We further show that if the collection of polynomials has "low complexity", then for every set E of real numbers with positive density and for every $\delta > 0$, the set of polynomial return times for the "δ-thickened" set E_δ has bounded gaps. (Received September 12, 2009)

1054-37-162 **Ami E Radunskaya*** (aer04747@pomona.edu), Math Department, Pomona College, 610 N.College Ave., Claremont, CA 91711. *The Effect of Parametric Noise on Carrying Capacity.*

Dynamical systems arising from models of self-regulating growth often contain a stochastic component representing noise in the environment, or "parametric" noise. What is the effect of this noise on the long-term behavior of the system? How does this answer depend on the distribution of the random variable? In order that the question make sense, the system must have a well-defined long-term average, i.e. it must be ergodic. In this talk we prove ergodicity for a class of systems, and show that the randomness is beneficial to the system in the sense that the long-term average is increased by the presence of noise.

This work was done in collaboration with undergraduates Leigh Fisher (Pomona College, '05) and Hannah Albert (Scripps College, '09). (Received September 13, 2009)

1054-37-163 **Nathaniel D Emerson*** (nemerson@usc.edu), University of Southern California, 3620 South Vermont Ave., KAP 108, Los Angeles, CA 90089-2532. *On Yoccoz Return Functions.*

The key to understanding the dynamics of a complex polynomial is to understand the dynamics of its critical points. The Yoccoz τ-function codes the dynamics of a critical point with bounded orbit of some polynomials. We introduce a generalization of this function, the Yoccoz return function, which codes the dynamics of a critical point with bounded orbit of any complex polynomial with a disconnected Julia set. We give a complete description of Yoccoz return functions for an important class of polynomials. We derive necessary conditions on Yoccoz return functions, which allow for the recursive definition of an abstract tau-function. These conditions are also sufficient for polynomials that have a disconnected Julia set and exactly one critical point with bounded orbit. (Received September 13, 2009)

1054-37-200 **Ning Ju*** (ningju@math.okstate.edu), 401 Mathematical Sciences, OSU, Stillwater, OK 74078. *Dimension estimates for the global attactor of the solutions to the 2D Boussinesq equations with fractional dissipation.*

It was recently obtained, by the author, existence of the global attractor for the solutions of the Boussinesq equations with fractional dissipation in 2D periodic domain, assuming that the dissipation power is greater than $\frac{1}{2}$ and the time-independent external resources are sufficiently smooth, especially it is proved that the global attractor for vorticity and temperature exists in $H^s \times H^s$ for any $s \geqslant 0$. In this discussion, we present estimates of fractal and Hausdorff dimensions of the global attactor, utilizing the standard framework of Lyapunov exponent in infinite dimensional function spaces which was originally estabilished by the works of Constantin, Foias and Temam in dealing with Navier-Stokes equations. (Received September 14, 2009)

1054-37-217 **Michel L. Lapidus** (lapidus@math.ucr.edu), 900 Big Springs Rd, Surge Bldg, Dept of Mathmatics, Riverside, CA 92521, and **Robert G. Niemeyer*** (niemeyer@math.ucr.edu), 900 Big Springs Rd., Surge Bldg, Dept of Mathematics, Riverside, CA 92521. *Towards Periodic Orbits of the Koch Snowflake Billiard.* Preliminary report.

In this talk, we shall demonstrate significant analytical and experimental evidence suggesting the existence of periodic orbits of the Koch snowflake billiard. In addition, we outline exactly how we propose to demonstrate the existence of periodic orbits and give a major consequence in the form of an analogue to the Veech Dichotomy for Rational Billiards. (Received September 14, 2009)

1054-37-294 **Huyi Hu*** (hu@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Sandro Vaienti** (vaienti@cpt.univ-mrs.fr), Centre de Physique Theorique, Luminy Case 907, F-13288 Marseille, Cedex 9, France. *Decay of correlations for some nonuniformly expanding maps.* Preliminary report.

We study decay of correlations for some nonuniformly expanding maps that do not have a Markov partition. We apply the results of Sarig and Guoezel, and obtain that if Losota-Yorke inequality is satisfied for reduced systems, then under some general conditions on the systems, one can get polynomial decay of correlations. The results can be applied to one dimensional maps with an indifferent fixed point. (Received September 15, 2009)

1054-37-301 **Nicolai T Haydn*** (nhaydn@usc.edu), University of Southern California, Los Angeles, CA 90089, and **Sandro Vaienti** (vaienti@cpt.univ-mrs.fr), Centre de Physique Théorique, CNRS, 13288 Marseille, France. *The Rényi Entropy Function and the Large Deviation of Short Return Times.*

We obtain existence and regularity properties of the Rényi entropy function for the very wide class of weakly ψ-mixing systems. We then uses these properties to obtain the decay rate for the large deviation of the return

time to cylinder sets. The decay rate turns out to be exponential with a rate given by the Rényi entropy function. We also obtain bounds for the free energy. (Received September 15, 2009)

41 ► Approximations and expansions

1054-41-70 **Machiel van Frankenhuijsen*** (vanframa@uvu.edu), Utah Valley University, Department of Mathematics, 800 West University Parkway, Orem, UT 84058-5999. *Complex dimensions of nonlattice self-similar strings.*

By the work of the presenter and Michel Lapidus, nonlattice fractal strings have complex dimensions in an almost periodic pattern. In this talk, we will give very precise information about the distribution of the complex dimensions inside the critical strip. We will give examples of fractal strings where the set of real parts has a gap, and of strings close to the point of transition in this phenomenon. (Received September 02, 2009)

42 ► Fourier analysis

1054-42-34 **Joe Adams*** (jdfadams@gmail.com), 7399 Magnolia Ave. #2, Riverside, CA 92504. *Finite Fourier Analysis and Polynomial Multiplication.* Preliminary report.

We begin with a discussion of characters and a development of Fourier analysis on a finite abelian group. Then using Z/nZ as a special case, we introduce the discrete Fourier transform (DFT) and associated identities. The circular convolution and the circular convolution property provide an efficient means of polynomial multiplication. We conclude with some applications of finite Fourier analysis. (Received August 13, 2009)

1054-42-181 **Izabella Laba*** (ilaba@math.ubc.ca), Department of Mathematics, UBC, Vancouver, B.C. V6T1Z2, Canada. *Maximal operators and differentiation theorems in sparse sets.*

We study maximal averages associated with singular measures on $\mathbf{R}$. Our main result is a construction of singular Cantor-type measures in one dimension for which the corresponding maximal operator are bounded on L^p for all $p > 1$. As a consequence, we answer a question of Aversa and Preiss on density and differentiation theorems in one dimension. Our proof combines probabilistic techniques with the methods developed in multidimensional harmonic analysis. (Joint work with Malabika Pramanik.) (Received September 13, 2009)

45 ► Integral equations

1054-45-85 **Rod Freed*** (raf12@cox.net), 25832 Empresa, Mission Viejo, CA 92691. *Solving Nonlinear Integral Equations.*

In many applications we must solve an integral equation when we do not know the precise form of the integrand. In cases of this sort we can obtain a solution in the following way. First, we find the differential equation which corresponds to the integral equation. Second, we note that the function that satisfies the differential equation (and thus satisfies the differential equation) is also the conditional expectation of a diffusion process. Third, we use the properties of diffusion processes in conjunction with nonparametric kernel regression to approximate the solution to our integral equation as accurately as we wish. (Received September 06, 2009)

46 ► Functional analysis

1054-46-30 **Valentin Deaconu**, **S. Kaliszewski** and **John Quigg*** (quigg@asu.edu). *Skew products of topological graphs and noncommutative duality.* Preliminary report.

For (discrete) directed graphs (and subsequently for higher-rank graphs), Raeburn et al developed a satisfying theory of coverings and fundamental groups. The coverings were closely related to skew products, and the associated C*-algebras turned out to be crossed products by coactions. In joint work with Valentin Deaconu and Steve Kaliszewski, we are (in the process of) developing a version of this theory for the topological graphs of Katsura. The noncommutative duality seems to carry over, but since the groups are no longer discrete the coverings become something else. (Received August 07, 2009)

1054-46-46 **Palle E. T. Jorgensen*** (jorgen@math.uiowa.edu), Dept of Math, University of Iowa, Iowa City, IA. *Harmonic analysis of selfsimilar measures.*

In the talk we outline some recent results covering the use of harmonic analysis and representation theory in the study of selfsimilar measures. A number of subclasses will be covered, as will joint work with Dutkay, Kornelson, Pearse, Pedersen, and Shuman. (Received August 26, 2009)

1054-46-76 **Ionut Chifan*** (ionut.chifan@vanderbilt.edu), 1326 Stevenson Center, Nashville, TN 37240, and **Adrian Ioana** (adiioana@math.ucla.edu), Los Angeles, CA 90095. *On relative property (T) and Haagerup's property.*

For a given countable group Γ we consider the following three properties:

(1) Γ has an infinite subgroup with relative property (T).

(2) The group von Neumann algebra $L(\Gamma)$ has a diffuse von Neumann subalgebra with relative property (T).

(3) Γ does not have Haagerup's property.

It is clear that (1)⇒(2)⇒(3). We prove that both of the converses are false. This is joint work with Adrian Ioana. (Received September 04, 2009)

1054-46-83 **Alexander Kumjian*** (alex@unr.edu), Department of Mathematics, MS 084, University of Nevada, Reno, NV 89557, and **Astrid an Huef** and **Aidan Sims**. *Diagonals in Fell algebras,.* Preliminary report.

We say that a C^*-algebra A is Fell (or type I_0) if it is generated by abelian elements. In this case A is almost a continuous trace algebra but $\widehat{A}$ need not be Hausdorff. Such algebras arise naturally in the study of certain dynamical systems. We prove:

- An abelian C^*-subalgebra B of a type I_0 algebra A is a diagonal iff it satisfies the extension property. (i.e. pure states of B extends uniquely).
- Up to Rieffel-Morita equivalence (RME) each such A contains a diagonal.
- The twists arising from RME algebras of type I_0 containing diagonals are equivalent in a natural sense.

This opens the door for a classification of such algebras up to RME. (Received September 05, 2009)

1054-46-105 **George A. Elliott*** (elliott@math.toronto.edu), Department of Mathematics, University of Toronto, Toronto, Ontario M6P 4B1. *Villadsen algebras.*

A brief survey of what is known concerning simple C*-algebra inductive limits of matrix algebras over compact metric spaces of unbounded dimension is given. The first such examples, which could not be obtained using bounded dimension, were given by Jesper Villadsen in his Ph.D. thesis. The question of extending the known classification result in the case of bounded dimension (due to Gong, Li, and the speaker) to the case of unbounded dimension is considered. It has been shown by Andrew Toms that the Cuntz semigroup is needed (in addition to the more usual invariants) to distinguish algebras in this class. It is not clear what other invariants will be needed. (Received September 09, 2009)

1054-46-108 **Paul S. Muhly*** (pmuhly@math.uiowa.edu), Department of Mathematics, University of Iowa, Iowa City, IA 52242, and **Baruch Solel** (mabaruch@techunix.technion.ac.il), Department of Mathematics, Technion, 32000 Haifa, Israel. *Morita Transforms of Operator Tensor Algebras.* Preliminary report.

Suppose that E_i is a C^*-correspondence over the C^*-algebra A_i, $i = 1, 2$. A (strong) *Morita equivalence* between (A_1, E_1) and (A_2, E_2) is an invertible C^*-correspondence X from A_1 to A_2 such that $E_1 \otimes_{A_1} X \simeq X \otimes_{A_2} E_2$. In *Proc. London Math. Soc.* **81** (2000), 113–168, we showed that a Morita equivalence between (A_1, E_1) and (A_2, E_2) induces a strong Morita equivalence between the corresponding tensor algebras $\mathcal{T}_+(E_1)$ and $\mathcal{T}_+(E_2)$ in the sense of Blecher, Muhly and Paulsen in the *Memoirs of the AMS* **143** (2000), no. 681. In this talk we will make precise the sense in which a strong Morita equivalence between (A_1, E_1) and (A_2, E_2) induces an isometry between the space of completely contractive representations of $\mathcal{T}_+(E_1)$ and the completely contractive representations of $\mathcal{T}_+(E_2)$ and discuss other features of the representation theory of tensor algebras that are preserved under this notion of Morita equivalence. (Received September 09, 2009)

1054-46-111 **N Christopher Phillips***, Department of Mathematics, University of Oregon, Eugene, OR 97403-1222. *Crossed products by free minimal actions of $\mathbb{Z}^d$ on finite dimensional compact metric spaces.* Preliminary report.

Let X be a finite dimensional compact metric space, and let $h\colon \mathbb{Z}^d \times X \to X$ be a free minimal action. We describe initial work towards understanding the structure of the transformation group C*-algebra $C^*(\mathbb{Z}^d, X, h)$. (Received September 09, 2009)

1054-46-148 **Marius V Ionescu*** (ionescu@math.uconn.edu), Department of Mathematics, 196 Auditorium Road, Unit 3009, University of Connecticut, Storrs, CT 06269-3009. *Powers of the Laplacian on PCF Fractals.* Preliminary report.

Kigami provided an analytic construction of the Laplacian on PCF self-similar fractals based on the energy and a measure on the fractal. A fractafold is the equivalent of a manifold in the fractal world. Strichartz showed how one could extend the construction of the Laplacian to fractafolds. He provides a complete description of the spectrum of the Laplacian for a compact fractafold. The spectrum of the Laplacian on infinite blowups of the Sierpinski gasket has been studied by Teplyaev.

Let K be such a PCF fractal and assume that X is a fractafold without boundary based on K. In this talk we introduce complex powers $(1-\Delta)^\alpha$, of the Laplacian on X. We show that these operators form a group which extends the natural powers of the Laplacian. We describe other key properties that these complex powers have. In particular, we show that the operators $(1-\Delta)^\alpha$, defined originally on a dense subset of L^2, extend to L^p-bounded operators when the real part of α is non-positive. We also provide a description of the kernels of these operators and study the "singular integral" behavior of them. The key ingredients in our proofs are the heat kernel estimates due to Barlow and Perkins and the Green's function constructed by Kigami. (Received September 11, 2009)

1054-46-167 **Ilan Hirshberg***, Department of Mathematics, Ben Gurion University, P.O.B. 653, Be'er Sheva, Israel, and **Daniel W. Markiewicz**, Department of Mathematics, Ben Gurion University, P.O.B. 653, Be'er Sheva, Israel. *Perturbations of E_0-semigroups.*

An E_0-semigroup is a one-parameter semigroup of endomorphisms of $B(H)$. We consider families of E_0-semigroups parametrized by a compact Hausdorff space X, with the appropriate continuity requirement. We provide a classification of such perturbed families in terms of an invariant given by vector bundles over the space X, in the case in which all E_0-semigroups in the family are of type I_n for a given n. (Received September 13, 2009)

1054-46-173 **Leonel Robert*** (leonel.robert@gmail.com) and **Aaron Tikuisis**. *Fields of Hilbert spaces over a topological space.*

A field of Hilbert spaces may be expressed as a supremum of locally trivial vector bundles defined on open subsets of the base space. This point of view may be exploited to transplant results from the theory of vector bundles to the setting of fields of Hilbert spaces. For example, one can always embed a field of Hilbert spaces inside another one with sufficiently larger dimension (depending on the covering dimension of the base space). One can use clutching functions to construct new fields of Hilbert spaces from old ones. If the base space has dimension at most 3, all the isomorphism classes of fields of Hilbert spaces may be described in terms of cohomological data. I will talk about these and other results obtained recently in collaboration with Aaron Tikuisis. (Received September 13, 2009)

1054-46-196 **Stephen Bigelow**, **Scott Morrison** and **Emily Peters*** (eep@euclid.unh.edu), Department of Math and Stats, University of New Hampshire, Durham, NH 03824, and **Noah Snyder**. *The extended Haagerup planar algebra.*

The extended Haagerup subfactor was the last unknown item on Haagerup's 1993 list of possible small-index subfactors. We construct this subfactor by constructing its associated planar algebra. This finishes the classification of subfactors with index up to $3+\sqrt{2}$. Our construction works by identifying a planar subalgebra of the graph planar algebra of the desired principal graph. The challenge is to demonstrate that this planar subalgebra is small enough to be a subfactor planar algebra, which we accomplish by viewing some of the relations on the subalgebra as substitutes for a braiding relation. (Received September 14, 2009)

1054-46-204 **Hans Wenzl***, Dept of Math, UCSD, La Jolla, CA 92093. *Another q-Brauer algebra and subfactors.* Preliminary report.

We study another q-deformation of Brauer's centralizer algebra. It contains the Hecke algebras of type A as a subalgebra, where the embedding is determined by certain commuting square conditions. This is motivated by

the problem of finding a rigorous construction of subfactors in connection with twisted loop groups. We also give formulas for indices and relative commutants of such subfactors. (Received September 14, 2009)

1054-46-218 **Cyril Houdayer** and **Dimitri Shlyakhtenko*** (shlyakht@math.ucla.edu), Department of Mathematics, UCLA, Los Angeles, CA 90095. *II_1 factors with an exotic MASA.*

Using an extension of techniques of Ozawa and Popa, we give an example of a non-amenable strongly solid II_1 factor M containing an "exotic" maximal abelian subalgebra A: as an A, A-bimodule, $L^2(M)$ is neither coarse nor discrete. Thus we show that there exist II_1 factors with such property but without Cartan subalgebras. It also follows from Voiculescu's free entropy results that M is not an interpolated free group factor, yet it is strongly solid and has both the Haagerup property and the complete metric approximation property. (Received September 14, 2009)

1054-46-259 **Hafedh Herichi*** (herichi@math.ucr.edu), 1805 Meridian Ave # 6, South Pasadena, CA 91030. *Generalized L-Fractal strings.*

Generalized L-fractal strings are considered as a subclass of generalized fractal strings which, viewed as continued or discrete measures, are associated measures to ordinary fractal strings. During this talk, we will define ordinary fractal strings, the Cantor string is an example of such strings, their Minkowsky measurability, and tubuluar neighborhood. Next , we will introduce Generalized Fractal strings, provide examples and discuss some of their properties.The notion of "fractality" of such objects will be determined using tools of the "Theory of complex dimensions", which will be discussed in details, we will end up our talk showing that Minkowsky measurability of these sets could itself, when certain conditions are provided, be interpreted in terms of complex dimensions. (Received September 15, 2009)

1054-46-263 **Childress P Scot*** (10goto10@math.ucr.edu), University of California at Riverside, Riverside, CA 92507. *Fractal Strings, Complex Dimensions, and Adelic Structures.*

We present a generalization of the notion of a Fractal Membrane as introduced by Michel Lapidus in his study of fractal strings and complex dimensions (See "In Search of the Riemann Zeros," AMS, 2008). Fractal Membranes are a versatile tool for (among other things) attaching a notion of 'prime' and 'arithmetic' to the lengths of a fractal string. In this talk, we will outline the necessary background for, and sketch the construction of, what we refer to as "adelic structures." We will show how these structures allow us to attach a similar notion of prime and sense of arithmetic to not just the lengths of a fractal string, but also to its frequencies and complex dimensions. (Received September 15, 2009)

1054-46-284 **Jason Asher*** (asherj@math.ucla.edu). *Free Diffusions and von Neumann Algebras.*

We establish technical properties of von Neumann algebras that are generated by the sationary laws of certain free stochastic differential equations. In particular, we consider the free diffusion equation $dX_t = dS_t - \frac{1}{2}DV(X_t)dt$ for a suitably locally convex self-adjoint multivariate polynomial V. We will make use of results of Guionnet and Shlyakhtenko that give existence and uniqueness of, and asymptotic norm convergence to, stationary solutions of such SDE. (Received September 15, 2009)

1054-46-310 **Jesse Peterson*** (jesse.d.peterson@vanderbilt.edu), Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240. *Cocycle Superrigidity for Gaussian Actions.*

I will present a general setting to prove U_{fin}-cocycle superrigidity for Gaussian actions in terms of closable derivations on von Neumann algebras. In this setting I will provide new examples of this phenomenon, extending results of S. Popa. I will also use a result of K. Schmidt to give a necessary cohomological condition on a group representation in order for the resulting Gaussian action to be U_{fin}-cocycle superrigid. This is joint work with Thomas Sinclair. (Received September 16, 2009)

47 ► Operator theory

1054-47-29 **Yun-Su Kim*** (Yun-Su.Kim@utoledo.edu), 1712 Secor road, A.P.T. D, Toledo, OH 43607. *Algebraic Elements and Invariant Subspaces.*

We show that if a completely non-unitary contraction T in $L(H)$ has a non-trivial algebraic element h, then T has a non-trivial invariant subspace. (Received August 06, 2009)

1054-47-123 **Luis Santiago*** (santiago@math.toronto.edu), Toronto, Ontario M2M3W1, Canada. *Classification of *-homomorphisms using the Cuntz semigroup functor.*

We will show how the homomorphisms from the C*-algebra of continuous function on a tree to a C*-algebra of stable rank one can be classified by means of the Cuntz functor. In the special case when the tree consists of a single edge we describe a class of codomain C*-algebras–not necessarily of stable rank one–for which this classification holds. We will also discuss how in certain cases the classification fails. These results are obtained in a joint work with Alin Ciuperca and George Elliott and in a joint work with Leonel Robert. (Received September 10, 2009)

1054-47-258 **Audrey N. Moore*** (amoore@desu.edu), 30133 Armory Road, Dagsboro, DE 19939. *The problem of a nilpotent linear operator with two invariant subspaces.* Preliminary report.

In this talk we will investigate the problem of a nilpotent linear operator with two invariant subspaces. In particular, nilpotency index four yields a border line case which is tame infinite, between smaller nilpotency indices which give rise to finite categories and larger indices which give rise to wild categories. This talk will focus on aspects of the tame infinite category obtained in this set up. (Received September 15, 2009)

49 ► Calculus of variations and optimal control; optimization

1054-49-18 **Mostafa Ghandehari*** (ghandeha@uta.edu), Civil Engineering, Box 19308, Univ. of Texas at Arlington, Arlington, TX 76019, and **Khosrow Behbehani**. *An Optimal Control Problem in Pharmacokinetics.*

A system of ordinary differential equations for compartmental model of pharmacokinetics is used as an optimal control problem were the dosage is a control parameter. Pontryagin's maximum principle is applied to find optimal values of the dosage. Examples of compartmental medications are given. (Received July 09, 2009)

51 ► Geometry

1054-51-24 **Michelle Previte*** (MichellePrevite@psu.edu), Penn State Erie, School of Science, Erie, PA 16563, **Joseph P Previte** (jpp4@psu,edu), Penn State Erie, School of Science, Erie, PA 16563, and **Mary Vanderschoot** (Mary.Vanderschoot@wheaton.edu), Department of Mathematics & Computer Science, Wheaton College, Wheaton, IL 60187. *Growth Degree of Limits of Vertex Replacement Rules.*

We give necessary and sufficient conditions that determine when a vertex replacement rule given by exactly one replacement graph generates an infinite graph with exponential growth and when it generates an infinite graph with polynomial growth. We also compute the formula for the growth degree of infinite graphs with polynomial growth that are generated by vertex replacement rules given by exactly one replacement graph and show that it coincides with the Hausdorff dimension of the fractal generated by the same rule. (Received July 23, 2009)

1054-51-32 **John Sarli*** (jsarli@csusb.edu), Department of Mathematics, California State University, 5500 University Parkway, San Bernardino, CA 92407. *The Intrinsic Conics of the Hyperbolic Plane.*

We explore Jacob Steiner's definition of a projective conic by taking it as the definition of an intrinsic conic for any planar incidence geometry. It is well known, for example, that in the real affine plane this definition produces all conics with their affine types distinguished by the invariants of the generating affine transformation; in particular, if the collineation is (anti)conformal the conic is either a circle or a rectangular hyperbola. In the hyperbolic plane the situation is more intricate: There is a considerable variety of intrinsic conics even though all collineations are (anti)conformal. We classify these conics and provide metric characterizations for each congruence class. Further, we show there is a natural duality among congruence classes manifested by inversion in certain equidistant curves. (Received August 10, 2009)

1054-51-169 **Hung Lu*** (hlu@hpu.edu), 1188 Fort Street Mall, Suite 430, Honolulu, HI 96813, and **Michel L. Lapidus**. *p-adic fractal strings and their complex dimensions.*

We develop a geometric theory of p-adic fractal strings and their complex dimensions. We obtain an explicit volume formula for the tubular neighborhood of a p-adic fractal string $\mathcal{L}_p$, expressed in terms of the underlying complex dimensions. We also prove that the abscissa of convergence of the geometric zeta function associated to

a self-similar string $\mathcal{S}_p$ coincides with the Minskowski dimension of $\mathcal{S}_p$. The general theory is illustrated by some simple examples, the nonarchimedean Cantor, Euler, and Fibonacci strings. (Received September 13, 2009)

1054-51-190 **Steffen Winter***, Institut für Algebra und Geometrie, Universität Karlsruhe, Kaiserstr. 89, 76133 Karlsruhe, Germany, and **Jan Rataj**, Charles University, Prague, Czech Rep. *On volume and surface area of parallel sets.*

We show that if A is a bounded subset of $\mathbb{R}^d$ and $r > 0$ then the set of all points with distance r from A is $(d-1)$-rectifiable. This observation allows to improve some known results on volume and boundary surface area of the r-parallel sets. We also study the asymptotic behaviour of both measures as $r \to 0$ and show that there is a close relation between the Minkowski content and the corresponding rescaled limit of the boundary surface area. This also suggest a characterization of Minkowski measurability in higher dimensions extending results of Lapidus and Pomerance on the real line. Some applications to random sets, in particular the Wiener sausage, and to self-similar fractal sets are discussed. (Received September 14, 2009)

52 ► Convex and discrete geometry

1054-52-152 **Erin P. J. Pearse*** (erin-pearse@uiowa.edu), 25L MacLean Hall, Iowa City, IA 52242, and **Michel L. Lapidus** and **Steffen Winter**. *Tube formulas and self-similar tilings.*

Let A be a bounded open subset of d-dimensional Euclidean space. A tube formula for A is a function of ϵ that gives the volume of the region lying outside of A but within ϵ of A. Tube formulas are useful for studying curvature and other geometric properties of sets, and have been studied classically by Steiner, Federer, and Weyl.

A type of self-similar tiling is naturally associated to iterated function systems which satisfy a strengthened version of the open set condition. I will describe the conditions under which this tiling allows one to compute the tube formula for the corresponding self-similar set. The resulting formula is an extension of both the Steiner formula of convex geometry and the tube formulas for fractal subsets of the real line from the theory of fractal strings and complex dimensions as developed by Lapidus and van Frankenhuijsen. This is a joint work with Steffen Winter and Michel Lapidus. (Received September 12, 2009)

53 ► Differential geometry

1054-53-13 **Pak Tung Ho*** (pho@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *The long time existence and convergence of the CR Yamabe flow.*

The main theme of the talk is about CR Yamabe flow on the the compact strictly pseudoconvex CR manifold. I will show that the flow always converges when the CR invariant is positive. Partial result on the convergence of the flow will be discussed. I will also discuss the monotonicity of the eigenvalues of some geometric operators under the CR Yamabe flow. (Received June 15, 2009)

1054-53-25 **Jacob Bernstein***, Mathematics Department, Bldg. 380, Stanford, CA 94305. *Conformal and Asymptotic Properties of Embedded Genus-g Minimal Surfaces with One End.*

Using the tools developed by Colding and Minicozzi in their study of the structure of embedded minimal surfaces in $\mathbb{R}^3$, we investigate the conformal and asymptotic properties of complete, embedded minimal surfaces of finite genus and one end. Indeed, we show that any such surface is conformal to a once-punctured compact Riemann surface. This completes the classification of the conformal type of embedded finite topology minimal surfaces in $\mathbb{R}^3$. Moreover, we deduce that such surfaces are asymptotic to a helicoid – and so call them genus-g helicoids. (Received July 27, 2009)

1054-53-27 **Owen Dearricott*** (owend@ucr.edu), 900 University Avenue, Surge 228, Riverside, CA 92521. *Positive curvature on a 3-Sasakian 7-manifold.*

We discuss a construction of a positively curved metric on a 3-Sasakian manifold obtained as a connection metric over a conformal self-dual Einstein orbifold. The method amounts to using a trick of Thorpe to test the positivity of the sectional curvature of a related curvature operator. (Received August 04, 2009)

1054-53-28 **Valentino Tosatti*** (tosatti@math.harvard.edu), Columbia University, Department of Mathematics, 2990 Broadway, New York, NY 11027. *Degenerations of Calabi-Yau metrics.*

We are interested in the behaviour of families of Ricci-flat Kahler metrics on a compact Calabi-Yau manifold, with Kahler classes approaching the boundary of the Kahler cone. We will give an overview of some examples and

results concerning this quesion, and explain the connections to the theory of degenerate complex Monge-Ampere equations and to birational geometry. (Received August 04, 2009)

1054-53-35 **Valentino Tosatti** and **Ben Weinkove*** (weinkove@math.ucsd.edu), Mathematics Department, UCSD, 9500 Gilman Drive #0112, La Jolla, CA 92093. *The Calabi-Yau equation on the Kodaira-Thurston manifold.*

We prove that the Calabi-Yau equation can be solved on the Kodaira-Thurston manifold for all given T^2-invariant volume forms. This provides support for Donaldson's conjecture that Yau's theorem has an extension to symplectic four-manifolds with compatible but non-integrable almost complex structures. This is a joint work with Valentino Tosatti. (Received August 14, 2009)

1054-53-37 **Ye-Lin Ou*** (yelin_ou@tamu-commerce.edu), Department of Mathematics, Texas A & M University-Commerce, P. O. Box 3011, Commerce, TX 75429. *Some constructions of biharmonic maps.*

Biharmonic maps are critical points of the bi-energy functional. Harmonic maps are automatically biharmonic and we call those non-harmonic biharmonic maps proper biharmonic maps. Examples of proper biharmonic maps are difficult to find. In this talk, we will first review some fundamental problems in the study of biharmonic maps, some known examples of proper biharmonic maps, and we will then present several methods that can be used to construct many new examples of proper biharmonic maps including biharmonic flat tori of any dimension in spheres, a family of biharmonic conformal immersions of cylinder into Euclidean 3-space, a foliation of proper biharmonic hypersurface in a conformally flat space, and some biharmonic maps between surfaces. (Received August 17, 2009)

1054-53-112 **Jeffrey S Case*** (casej@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *On the non-existence of quasi-Einstein metrics.*

We study complete Riemannian manifolds satisfying the equation $\mathrm{Ric} + \nabla^2 f - \frac{1}{m} df \otimes df = 0$ by studying the associated PDE $\Delta_f f + \mu e^{-2f/m} = 0$ for $\mu \leq 0$. By developing a gradient estimate for f, we show there are no nonconstant solutions. We then apply this result to show that there are no Ricci flat warped product metrics with Einstein fibers with scalar curvature. We also show that one can "take the limit" $m \to \infty$ and get that for nontrivial steady Ricci solitons, $R + |\nabla f|^2$ is a positive constant. (Received September 09, 2009)

1054-53-120 **Chenxu He*** (hech@math.upenn.edu), 209 South 33rd Street, Philadelphia, PA 19104. *Non-negatively curved cohomogeneity one manifolds.*

Non-negatively or positively curved manifolds play an important role in global Riemannian geometry. Though there are many examples of non-negative curved manifold, the construction methods are few. Recently Grove-Ziller discovered many new examples in cohomogeneity one manifolds, i.e., it admits an isometric action by a compact Lie group with one dimensional orbit. However not every cohomogeneity one manifold supports non-negatively curved invariant metric. The first examples were discovered by Grove-Wilking-Verdiani-Ziller.

I will present more examples of obstructions to negatively curved metric in cohomogeneity one manifold which generalize the earlier results. I will also show some new manifolds with cohomogeneity one action which have a small family of invariant metrics. (Received September 09, 2009)

1054-53-121 **Zhiqin Lu*** (zhiqinlu@gmail.com), Department of Mathematics, UCI, Irvine, CA 92697. *Incompleteness of the Weil-Petersson metric.*

We shall discuss the incompleteness of the Weil-Petersson metric on moduli space of Calabi-Yau manifolds. The essential part of the talk will be a generalization of C-L Wang's result from one-dimensional space to high dimensional space. The result is partially joint with C-L Wang. (Received September 10, 2009)

1054-53-175 **Xiaofeng Sun*** (xis205@lehigh.edu), 14 E. Packer Ave., Department of Mathematics, Lehigh University, Bethlehem, PA 02138. *Teichmuller Space of Polarized Calabi-Yau Manifolds.*

In this talk we will discuss the Teichmuller space of polarized Calabi-Yau Manifolds, its properties and the corresponding period maps. In particular we will study the injectivity of the period maps, namely the Torelli problem. We will discuss the invariance of the polarized CY symplectic form. We will also give simple proofs of the Torelli theorem for the Teichmuller space of polarized algebraic Hyper-Kahler manifolds. (Received September 13, 2009)

1054-53-189 **Konrad Waldorf*** (waldorf@math.berkeley.edu), University of California, Berkeley, Department of Mathematics, 970 Evans Hall, Berkeley, CA 94720-3840. *String Connections and Supersymmetric Sigma Models.*

I describe a smooth and finite-dimensional approach to string structures and string connections on spin bundles. It is based on trivializations of a certain Chern-Simons 2-gerbe, and turns out to be equivalent to homotopy-theoretical notions of Stolz and Teichner. I will report on several new results about string connections. Finally I will try to illuminate the relation between string connections and the supersymmetric sigma model. (Received September 14, 2009)

1054-53-219 **Gregory R. Kallo*** (kallo@math.ucla.edu). *Local Isometric Embedding in Low Codimensions.* Preliminary report.

Explicit intrinsic necessary and generically sufficient conditions will be given and proved for the existence of low-codimension local isometric embeddings of Riemannian manifolds into Euclidean spaces. These conditions have the form of equations, inequalities, and inequations on the components of the Riemann curvature tensor at each point. These results extend classical results of T.Y.Thomas and C. Allendoerfer for codimension 1. (Received September 14, 2009)

1054-53-239 **Chad S Sprouse*** (chad.sprouse@csun.edu), CSU Dept. of Mathematics, 18111 Nordhoff St., Northridge, CA 91330. *Eigenvalue pinching with lower curvature bounds.*

We discuss pinching theorems based on the lower eigenvalues of the Laplacian, for functions and differential forms, on manifolds with a fixed lower curvature bound. (Received September 15, 2009)

1054-53-266 **William Wylie*** (wylie@math.upenn.edu), Department of Mathematics, David Rittenhouse Lab, 209 South 33rd Street, Philadelphia, PA 19104-6395. *On the classification of m-Quasi-Einstein metrics.*

We say an n-dimensional Riemannian manifold is m-Quasi-Einstein if it is the base of an n+m-dimensional warped product Einstein manifold. Quasi-Einstein manifolds are a natural generalization of Einstein manifolds from the perspective of curvature dimension inequalities and are also related to gradient Ricci solitons. I will discuss conditions on symmetry and curvature under which we can classify Quasi-Einstein metrics. This is joint work with Chenxu He of UPenn and Peter Petersen of UCLA. (Received September 15, 2009)

54 ► General topology

1054-54-156 **Logan Godkin*** (lgod@student.ucr.edu), University of California at Riverside, Mathematics Department, Surge 272, 900 University Avenue, Riverside, CA 92521, and **Mohamed Ait Nouh** (maitnouh@math.ucr.edu), University of California at Riverside, Mathematics Department, Surge 272, 900 University Avenue, Riverside, CA 92521. *Twisting of torus knots.* Preliminary report.

A twisted knot is a knot obtained from the *unknot* by locally twisting a handfull of strands (see Figure 1). More specifically, twisting can be defined in the Dehn surgery context, which reveals an important connection between twisting operations and 3- and 4-dimensional topology and geometry. Recall that a (p, q)-torus knot is a knot that wraps around the standard solid torus in the longitudinal direction p times and the meridional direction q times. Note that p and q are coprime (see Figure 2). A torus knot $T(p, q)$ $(0 < p < q)$ is *exceptional* if $q \equiv \pm 1 \pmod{p}$. In this talk, we will study Ait Nouh-Yasuhara old conjecture that states that all non-exceptional torus knots are non-twisted. In this talk, we prove that this conjecture holds for the infinite family of $(p, p + 6)$-torus knots, for any $p \geq 5$. (Received September 12, 2009)

1054-54-157 **Mayura Patankar*** (mpata001@student.ucr.edu), University of California at Riverside, Department of Mathematics, Surge 272, 900 University Avenue, Riverside, CA 92521, and **Mohamed Ait Nouh** (maitnouh@math.ucr.edu), University of California at Riverside, Department of Mathematics, Surge 272, 900 University Avenue, Riverside, CA 92521. *When DNA meets Knot Theory.* Preliminary report.

It is known that the DNA is represented by a 4-plat or a composite of 4-plats. Some problems of DNA such that modeling topoisomerase action, turns out to be equivalent to solving "tangle equations"

$$N(U + \frac{f_1}{g_1}) = K_1 \text{ and } N(U + \frac{f_2}{g_2}) = K_2$$

$\frac{f_2}{g_2}$ is the unknown rational tangle, that has to be found as a function of the given rational tangles U, $\frac{f_1}{g_1}$ and the 4-plats knots K_1 and K_2.

We are interested in the case where K_1 and K_2 are smooth slice knots. We proved, for example, that the second homology class $(2,3) \in CP^2 \# CP^2$ can not be represented by a smooth sphere, answering a question raised by Terry Lawson in his papar "The minimal genus problem", Expo. Math. 15 (1997), $385-431$. This surprising application to dimension four encouraged us to look backward. We are investigating application of dimension four to some DNA problems such as topoisomerase and Recombinases and Mu transposome, which are known to be related to cancer and the human immunodeficiency virus (HIV). (Received September 12, 2009)

1054-54-172 **Anthony Barsha*** (abars001@student.ucr.edu), University of California at Riverside, Department of Mathematics, Surge 272, 900 University Avenue, Riverside, CA 92521, and **Mohamed Ait Nouh** (maitnouh@math.ucr.edu), University of California at Riverside, Department of Mathematics, Surge 272, 900 University Avenue, Riverside, CA 92521.
Twisting of Knots with less than ten crossings. Preliminary report.

A twisted knot K_n is a knot obtained from the unknot by performing a $(-\frac{1}{n})$-Dehn surgery along a trivial knot C, for instance, Figure 1 shows that K_{+1} is the twist knot. In this talk, we will classify twisting of knots with crossing number less or equal to ten, and give, for the first time, the smallest non-twisted knot in this family. (Received September 13, 2009)

1054-54-174 **Lisa Hernandez*** (lihernandez@calbaptist.edu), 8432 Magnolia Ave., Riverside, CA 92508. *Girth: Discussions, Comments, and Corrections.* Preliminary report.

A knot diagram can be divided by a circle into two parts, such that each part can be coded by a planar tree with integer weights on its edges. A half of the number of intersection points of this circle with the knot diagram is called the girth. The girth of a knot is the minimal girth of all diagrams of this knot. The girth of a knot minus 1 is an upper bound of the Heegaard genus of the 2-fold branched covering of that knot. We discuss this invariant along with addressing errors in previous work. (Received September 13, 2009)

55 ► Algebraic topology

1054-55-100 **Laura Scull*** (scull_l@fortlewis.edu), Department of Mathematics, Fort Lewis College, 1000 Rim Drive, Durango, CO 81301, and **Dorette Pronk**. *Orbifolds and Equivariant Homotopy Theory.*

An orbifold is called representable if it can be presented as the orbit space of a manifold by the action of a compact Lie group. A large class of orbifolds is known to be representable. In this talk we will discuss generalizing results of equivariant homotopy theory to obtain orbifold homotopy invariants for representable orbifolds. .

Orbifolds can be represented by smooth étale groupoids where two such groupoids represent the same orbifold if and only if they are Morita equivalent. An orbifold is representable precisely when it can be represented by a smooth translation groupoid. This means that any generalization of constructions for G-spaces need to be invariant under Morita equivalence.

We have examined the notion of Morita equivalence in the context of translation groupoids, and used our results to give a more concrete method for deciding when equivariant results apply in the orbifold setting. We will discuss these results and their applications. (Received September 08, 2009)

1054-55-101 **Maia Averett*** (maverett@mills.edu), MCS Department, Mills College, 5000 MacArthur Blvd, Oakland, CA 94613. *Real Johnson-Wilson Theories.*

This talk will summarize some recent work on a new family of cohomology theories made accessible by Kitchloo and Wilson, the so-called Johnson-Wilson theories $ER(n)$. We will relate the theories $ER(n)$ to homotopy fixed points of the Morava E-theories E_n under an action of a certain subgroup of the Morava stabilizer group. In doing so, we obtain a calculation of the coefficients of the homotopy fixed points of E_n for this subgroup and also see that, after completion, the $ER(n)$ are commutative S-algebras. If time permits, we will also discuss the $ER(n)$ cohomology of $BO(k)$ and $ER(n)$-orientations. (Received September 08, 2009)

1054-55-142 **Soren Galatius*** (galatius@stanford.edu), Dept. of Math, Stanford University, Stanford, CA 94305. *Monoids of moduli spaces of manifolds.*

This talk will present joint work with Oscar Randal-Willams, arXiv:0905.2855. The cobordism category C_d is a topological category whose objects are closed $(d-1)$-manifolds and whose morphisms are compact d-dimensional cobordisms. The homotopy type of the classifying space BC_d was previously determined by Galatius-Madsen-Tillmann-Weiss. The goal of this work is to find subcategories $D \subset C_d$ such that map $BD \to BC_d$, induced by

the inclusion, is a homotopy equivalence. The smaller such D, the better. For $d = 2$ we prove that in most cases of interest, one can pick such a D with just one object, and furthermore D can be chosen homotopy commutative (as a topological monoid). My talk will explain this result and its applications. (Received September 11, 2009)

1054-55-178 **Anssi S. Lahtinen*** (aslahtin@stanford.edu). *The Atiyah–Segal completion theorem in twisted K-theory.*

According to the Atiyah–Segal completion theorem, the K-theory of the Borel construction of a finite G-CW complex X is the completion of the G-equivariant K-theory of X with respect to the augmentation ideal of the representation ring of G. I will discuss a generalization of this theorem to twisted K-theory and explain how the generalized theorem fits into a picture connecting the Verlinde algebra of G to the String Topology of BG. (Received September 13, 2009)

1054-55-202 **Chad D Giusti*** (cgiusti@uoregon.edu), Department of Mathematics, University of Oregon, Eugene, OR 97403. *Unstable Vassiliev Theory.*

We begin by constructing the spaces of plumbers' knots, which are piecewise linear with all pipes parallel to the axes. These knots are closely related to lattice knots and provide a new version of finite complexity knot theory which, in the limit, gives rise to classical knot theory. The rigid geometry of these spaces induces a combinatorial cellular structure. We exploit this to construct an algorithm for distinguishing the unstable isotopy class of a plumbers' knot. This algorithm has demonstrated that, for example, there are seven components of the space of plumbers' knots with five moves, though only three classical knot types are present.

We next describe the notion of the Vassiliev derivative for a singular plumbers' knot, extending the definition to include singularities other than collections of isolated double-points. This allows us to import Vassiliev's original techniques to our finite-complexity setting, where we can exploit the cell structure to explicitly compute Vassiliev derivatives while retaining geometric information. This result opens the door to constructing new Vassiliev-style knot invariants and/or seeing the strength of finite-type invariants once we understand the behavior of Vassiliev derivatives under stabilization (subdivision of pipes). (Received September 14, 2009)

1054-55-210 **Gabriel C. Drummond-Cole*** (gabriel.c.drummond.cole@gmail.com), Mathematics Department, 365 Fifth Avenue, Room 4208, New York, NY 10016-4309. *Homotopy BV and Deligne-Mumford space.* Preliminary report.

There is a construction (due to Barannikov-Kontsevich-Manin) which begins with a differential BV algebra A satisfying a $d-\bar{d}$ lemma and produces a hypercommutative algebra structure (that is, an action of the homology of the genus zero Deligne-Mumford moduli space) on the homology of A. Building on a formality theorem of Terilla, we generalize this construction to a chain level version, and explain how the $d - \bar{d}$ lemma hypothesis is unnecessary if a version of noncommutative Hodge-to-de Rham degeneration is assumed. The tools used include the theory of homotopy operads; these tools put the relationship between dBV algebras and actions of the Deligne-Mumford operads space into perspective, and are related to a topological picture underlying the algebra. (Received September 15, 2009)

1054-55-221 **Eric J Malm*** (emalm@math.stanford.edu), 450 Serra Mall, Building 380, Stanford, CA 94301. *String Topology and the Based Loop Space.*

The Chas-Sullivan product, a multiplication operation on the homology of the free loop space of a manifold, is one of the fundamental features of string topology. Geometrically, this product arises from the intersection product of the manifold and the Pontryagin product on its based loop space. Continuing an extensive series of relations between free loop spaces and Hochschild homology and cohomology, we use Poincare duality with local coefficients to show that the homology of the free loop space is isomorphic to the Hochschild cohomology of the algebra of singular chains of the based loop space. This isomorphism takes the Chas-Sullivan product to the Hochschild cup product and induces a Batalin-Vilkovisky structure on Hochschild cohomology compatible with the standard Gerstenhaber bracket. (Received September 14, 2009)

1054-55-226 **Brad S Shelton***, Brad Shelton, Department of Mathematics, University of Oregon, Eugene, OR 97403, and **Hal Sadofsky**, Eugene, OR 97403. *The Koszul property as a homeomorphism invariant and a measure of singularities.*

Let X be a topological space which admits a regular CW structure $C(X)$. Let K be a field. We make some minor technical assumptions about X. We associate to the CW structure $C(X)$ a quadratic K-algebra $A(C(X))$. The relationship between the Koszul property of $A(C(X))$ and the combinatorial structure of $C(X)$ was established earlier in the work of Cassidy, Phan and Shelton. In this talk we announce that the Koszul property for $A(C(X))$ is a homeomorphism invariant of X and furthermore that the Koszul property implies that X has no singularities of a specific type. (Received September 14, 2009)

1054-55-245 **Jonathan W Lee*** (jlee@math.stanford.edu), Stanford University Mathematics Department, Building 380, 450 Serra Mall, Stanford, CA 94305-2125. *Homotopy colimits and the space of square-zero upper-triangular matrices.* Preliminary report.

Given an irreducible component X of the variety of square-zero upper-triangular matrices, a combinatorial formula developed by Rothbach gives a stratification of X into orbits of the Borel group. Specializing to the complex numbers and imposing a rank condition motivated by the Halperin-Carlsson conjecture on the free ranks of products of spheres, we consider a coarser stratification into orbits of the parabolic group, which facilitates a homotopy-theoretic description of X as the homotopy colimit of simpler spaces more amenable to cohomology calculations. (Received September 15, 2009)

1054-55-272 **Kevin Walker*** (kw_ams@canyon23.net), Microsoft Station Q, CNSI Building, UCSB, Santa Barbara, CA 93106. *Blob Homology 2.*

As the title suggests, this is a continuation of Scott Morrison's talk "Blob Homology 1".

Proving that the blob complex has various nice formal properties requires precise definitions of both TQFTs and weak n-categories with strong duality. The definitions we use are novel and very closely related. So closely related, in fact, that proving a Baez-Dolan type result relating TQFTs to n-categories becomes essentially tautological. It is somewhat harder to show that our definitions are (more or less) equivalent to more traditional definitions of TQFTs and n-categories. (Received September 15, 2009)

1054-55-273 **Robin Koytcheff*** (robink@math.stanford.edu), Department of Mathematics, Bldg. 380, 450 Serra Mall, Stanford, CA 94305-2125. *A homotopy-theoretic view of Bott–Taubes integrals and knot spaces.*

Bott and Taubes found knot invariants by considering a bundle over the space of knots and integrating differential forms along its fiber. This integration was used to construct Vassiliev (finite-type) invariants and subsequently real cohomology classes in the space of knots in $\mathbb{R}^n$, $n > 3$. The Pontrjagin–Thom construction allows us to perform "integration along the fiber" without using differential forms and thus construct cohomology classes with arbitrary coefficients. Motivated by Budney and F. Cohen's calculation of the homology of the space of knots in terms of the homology of the space of prime knots, we prove a product formula for our classes with respect to connect-sum. (Received September 15, 2009)

1054-55-287 **Aaron Leeman*** (aleeman34@gmail.com), 31828 Yucaipa Boulevard, Yucaipa, CA 92399. *Generating spaces for $S(n)$-acyclics.* Preliminary report.

In *Cellular Spaces, Null Spaces and Homotopy Localization*, Dror Farjoun proves that rationally acyclic, simply connected spaces are built out of a wedge of mod-p Moore spaces. He also proves that simply connected spaces which are acyclic with respect to mod-p K-theory have suspensions that are built out of $V(1)$, the cofiber of the Adams' map $v_1 : M^{q+3}(p) \to M^3(p)$, p an odd prime. This notion of one space being "built out of" another can be made precise but should be thought of as analogous to connected CW-complexes being built out of S^1.

I'll discuss a generalization of this result, mentioned by Dror Farjoun in the above book, where sufficiently connected spaces which are acyclic with respect to a homology theory called $S(n)$ have suspensions that are built out of a space we call $W(n)$, where $W(n)$ is an appropriately chosen type $n+1$, finite space. If the telescope conjecture is true, $S(n)$ can be taken to be the Johnson-Wilson theory $E(n)$. If it fails, $S(n)$ is a replacement for the theory $E(n)$ which has the same finite acyclic spectra. (Received September 15, 2009)

1054-55-292 **Weiwei Pan*** (wp1@stmarys-ca.edu), CA. *Group Actions on Categorified Bundles.*

Categoriﬁcation, coined by Louis Crane, refers to the process of ﬁnding analogues of set-theorectic objects in the setting of categories, and, more recently, to the process of finding higher-category analogues of ideas deﬁned in category theory. The results of categoriﬁcation are often richer versions of familiar mathematical structures that admit more powerful applications. In this talk we will discuss two particular examples of categorification in algebra and topology - 2-linear representations and 2-vector bundles, as our primarily motivation is to introduce geometrically defined equivariant categorified K-theories. Towards this end, we will define a notion of equivariant 2-bundles, and demonstrate their relation to categorified representations of groups. (Received September 15, 2009)

1054-55-297 **Daniel Dugger*** (ddugger@uoregon.edu), University of Oregon, Eugene, OR 97405, and **Daniel C. Isaksen**, Wayne State University, Detroit, MI 12345. *Relations amongst motivic Hopf elements.*

This talk will survey our present knowledge about motivic stable homotopy groups of spheres over an arbitrary field. These are a bigraded family of groups which in various ways generalize the classical stable homotopy

groups of spheres. The talk will focus particularly on motivic analogs of the classical Hopf elements, and on what we know about relations between these. (Received September 15, 2009)

1054-55-308 **Marcy Robertson*** (mrober5@uic.edu). *Derived Morita Theory for Enriched Symmetric Multicategories.*

We briefly discuss the construction of a model category structure on the category of "nicely enriched" symmetric multicategories, and use this to give a complete description of the derived category for an operadic or multicategorical algebra. Time permitting, we will introduce some applications of this theory to combinatorial representation theory. (Received September 16, 2009)

57 ► Manifolds and cell complexes

1054-57-38 **Hao Wu***, Department of Mathematics, GWU, Monroe Hall, Room 240, 2115 G Street, NW, Washington, DC 20902. *A colored $\mathfrak{sl}(N)$-homology for links in S^3.*

I will introduce a generalization of the Khovanov-Rozansky $\mathfrak{sl}(N)$-homology to colored links. I believe that it decategorifies to the quantum $\mathfrak{sl}(N)$-polynomial of links colored by exterior powers of the defining representation. (Received August 17, 2009)

1054-57-39 **Joel Hass*** (hass@math.ucdavis.edu), Department of Mathematics, 1 Shields Ave, University of California, Davis, CA 95616, **J Hyam Rubinstein** (rubin@ms.unimelb.edu.au), Department of Mathematics and Statistics, University of Melbourne, Parkville, Victoria, 3010, Australia, and **Abigail Thompson** (thompson@math.ucdavis.edu), Department of Mathematics, 1 Shields Ave, University of California, Davis, Davis, CA 95616. *The k-width of a knot.*

We define and investigate the notions of k-bridge number and k-width for a knot or link in R^3, where k is an integer between 1 and 4. These provide increasingly detailed information, as k grows, on the intersections of a curve with flat planes and round spheres in R^3. We examine properties of curves that minimize k-bridge number or k-width within their isotopy class.

There are two main motivations. The first is a search for geometric interpretations of some of the new knot and 3-manifold invariants that have been introduced in recent years. The second is to investigate how knotting affects the motion of a physical knot through a liquid or gel. The effect of knotting on the motion of loops of DNA through a gel depends on the knot type of the loop, as in gel electrophoresis. (Received August 17, 2009)

1054-57-42 **Joseph E Borzellino*** (jborzell@calpoly.edu), Department of Mathematics, California Polytechnic State University, 1 Grand Avenue, San Luis Obispo, CA 93407, and **Victor Brunsden** (vwb2@psu.edu), Department of Mathematics and Statistics, Penn State Altoona, 3000 Ivyside Park, Altoona, CA 16601. *Spaces of Smooth Orbifold Mappings.*

A well-known result in the theory of differentiable dynamical systems states that the set of smooth maps between a compact manifold M and a manifold N has the structure of a smooth infinite-dimensional manifold. By considering only diffeomorphisms, one sees that $\mathrm{Diff}(M)$ is an infinite-dimensional group with a local smooth manifold structure. In this talk, I will discuss generalizations of this result to the group of orbifold diffeomorphisms. Time permitting, I will discuss some recent work on analogous results for other classes of smooth orbifold maps. Part of the talk will review orbifolds and the mappings between them. (Received August 24, 2009)

1054-57-44 **Seiichi Kamada*** (kamada@math.sci.hiroshima-u.ac.jp), Department of Mathematics, Hiroshima University, Higashi-Hiroshima, Hiroshima 739-8526, Japan. *Knot symmetric quandles and their presentations.*

A symmetric quandle is a quandle with a good involution. For a knot in R^3, a knotted surface in R^4 or an n-manifold in R^{n+2}, the knot symmetric quandle is defined. We introduce the notion of a presentation of a symmetric quandle, and show how to get a presentation of a knot symmetric quandle from a knot diagram. (Received August 25, 2009)

1054-57-63 **Louis H. Kauffman*** (kauffman@uic.edu), Department of Mathemtics, University of Illinois at Chicago, 851 South Morgan Street, Chicago, IL 60607-7045. *Khovanov Homology and the Potts Model.*

We will discuss relationships between the Potts model in statistical mechanics and Khovanov homology. The talk is based on <arXiv:0907.3178>. (Received September 01, 2009)

1054-57-65 **Thomas W Mattman*** (TMattman@CSUChico.edu), Department of Mathematics, California State University, Chico, Chico, CA 95926, and **Pablo Solis** (pablo@math.berkeley.edu), Department of Mathematics, University of California, Berkeley, CA. *A proof of the Kauffman–Harary Conjecture.*

We prove the Kauffman–Harary Conjecture, posed in 1999: given a reduced, alternating diagram P of a knot with prime determinant p, every non-trivial Fox p-coloring of P will assign different colors to different arcs. (Received September 01, 2009)

1054-57-86 **Carmen L Caprau*** (ccaprau@csufresno.edu), Department of Mathematics, 5245 North Backer Avenue, M/S PB 108, Fresno, CA 93740. *The universal sl(2) foam cohomology for links via extended TQFTs.* Preliminary report.

The universal sl(2) foam cohomology is a cohomology theory for tangles (thus also for knots and links) that uses webs and foams (seamed cobordisms) modulo local relations, and which contains as particular cases isomorphic versions of the Khovanov, Lee and Bar-Natan homology theories. One of the main features of this invariant is that it satisfies the functoriality property with no sign ambiguity. In this talk we show how to obtain the universal sl(2) foam theory for links via a certain extended 2-dimensional topological quantum field theory (TQFT) defined on foams. (Received September 06, 2009)

1054-57-88 **Scott Carter J*** (carter@jaguar1.usouthal.edu), Department of Mathematics and Statistics, ILB 325, Mobile, AL 36688. *Non-orientable surface knots in thickened 3-manifolds that have an arbitrarily large number of triple points in their projections.*

This is based on joint work with Kanako Oshiro and Masahico Saito.

Let a positive integer N be given. A non-orientable connected surface is given that embeds in an interval thickened 3-manifold. Any isotopic embedding will have at least N triple points in its projection to the 3-manifold. Thus the triple point number for non-orientable surface knots (in this context) can be made as large as possible.

The result is proven by computing the symmetric 3rd homology of the octahedral quandle and observing that it has a non-torsion summand. (Received September 07, 2009)

1054-57-96 **J. Scott Carter** and **Masahico Saito*** (saito@math.usf.edu). *Quandle Cohomology and Cocycle Knot Invariants with Inner Automorphism Actions.* Preliminary report.

Quandle operations induce quandle automorphisms that form the inner-automorphism group of a quandle. Quandle homology theories are defined using coefficients that are modules over the inner-automorphism group. Invariants of knots and knotted surfaces are defined using 2- and 3-cocycles. A similar situation for categorical self-distributive maps in Hopf algebras is discussed. Relations to other quandle homology theories and invariants defined earlier are studied. (Received September 08, 2009)

1054-57-98 **Mohamed Ait Nouh*** (maitnouh@math.ucr.edu), University of California at Riverside, Department of Mathematics, Surge 272, 900 University Avenue, Riverside, CA 92521. *Genera and degrees of Knots in CP^2.*

The CP^2-genus of a knot K is the minimal genus over all isotopy classes of smooth, compact, connected and oriented surfaces properly embedded in $CP^2 - B^4$ with boundary K. We compute the CP^2-genus and realizable degrees of $(-2, q)$-torus knots for $3 \leq q \leq 11$ and $(2, q)$-torus knots for $3 \leq q \leq 17$. The proofs use gauge theory and twisting operations on knots. (Received September 14, 2009)

1054-57-131 **Igor Belegradek** (ib@math.gatech.edu), Department of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, **Slawomir Kwasik** (kwasik@math.tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118, and **Reinhard Schultz*** (schultz@math.ucr.edu), Department of Mathematics, University of California at Riverside, 900 Big Springs Road, Riverside, CA 92521. *Souls and moduli spaces of nonnegatively curved manifolds.*

The Cheeger-Gromoll Soul Theorem yields strong interrelationships between geometric topology and the structure of complete, noncompact manifolds with nonnegative sectional curvature by means of compact submanifolds which they call *souls*. New examples and results involving these relationships are obtained including (*i*) several families of new examples with nonunique souls of low dimension, (*ii*) finiteness and nonfiniteness results for possible diffeomorphism types of souls in a fixed manifold, (*iii*) metrics which have diffeomorphic souls but lie in different components of the moduli space of complete nonnegatively curved metrics on the underlying smooth manifold. Some results are obtained by means of surgery theory, and others are shown by global-geometric methods. (Received September 10, 2009)

1054-57-132 **Dave Auckly*** (auckly@msri.org), Dave Auckly, Mathematical Sciences Research Institute, Berkeley, CA 94720. *Gauge-string duality and the structure of large rank Chern-Simons invariants.* Preliminary report.

Gauge-string duality predicts that many gauge theories are equivalent to 'dual' string theories. For Chern-Simons theory, the best understood manifistation of this duality relates the Chern-Simons invariants of the three sphere to the Gromov-Witten of the resolved conifold, a the total space of a rank two complex vector over the projective line. This talk will review this duality and discuss what it might imply about the structure and unification of the theory. (Received September 10, 2009)

1054-57-159 **Francis Bonahon*** (fbonahon@math.usc.edu), Department of Mathematics, University of Southern California, Los Angeles, CA 90089-2532, and **Helen Wong**, Department of Mathematics, Carleton College, Northfield, MN 55057. *Skein relations and quantizations of representations of surfaces groups.* Preliminary report.

The space of representations of surface groups into the matrix group $\mathrm{SL}_2(\mathbb{C})$ occurs in many different contexts and can be seen in several ways. The algebraic geometry point of view sees this space as an algebraic variety, whose coordinate ring is generated by trace functions. The topologists and hyperbolic geometers tend to prefer explicit coordinates, such as shear coordinates or cusp length coordinates.

Quantizations of this representation space have been introduced in the past 15 years, using the Kauffman skein algebra (Przytycki-Sikora, Turaev) for the algebraic geometry framework, and quantum Teichmüller theory for the coordinate-based approach (Chekhov-Fock, Kashaev). Each point of view has its own advantages, and its own deficiencies. It was conjectured that these two quantizations were essentially equivalent, but a proof has remained elusive.

We establish a bridge between the two points of view. (Received September 13, 2009)

1054-57-160 **Toshio Saito*** (tsaito@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106. *Meridionally destabilizing number of knots.*

From the viewpoint of Heegaard theory, we have two types of natural positions of knots in closed orientable 3-manifolds: a bridge position with respect to a Heegaard surface, and a core position of a handlebody bounding a Heegaard surface. The latter has a close connection to tunnel number of knots.

A concept of meridionally destabilizing number, which is defined by considering such two positions, will be introduced in this talk. We could say this together with tunnel number gives a binary complexity of knots. We will then discuss its behavior for composite knots. (Received September 13, 2009)

1054-57-177 **Danny Calegari*** (dannyc@its.caltech.edu), California Institute of Technology, Pasadena, CA 91125. *Knots with small rational genus.*

(joint work with Cameron Gordon)

If K is a knot in a 3-manifold M, and $[K]$ has finite order in homology, there is some Seifert surface which wraps n times around the knot K for some n. Define the rational genus of K to be the infimum of $-\chi(S)/2n$ over all surfaces S and all n.

We classify knots in 3-manifolds with sufficiently small rational genus. In fact, there is a positive constant C so that if K is a knot with rational genus at most C, then K is "geometric" in M. For example, if M is hyperbolic, then K is isotopic to the core of a Margulis tube. If M is a Seifert fibered space, then K is isotopic to a fiber; and so on. (Received September 13, 2009)

1054-57-185 **Ayumu Inoue*** (ayumu7@is.titech.ac.jp). *Quandle and hyperbolic volume.*

We will show that hyperbolic volume can be viewed as a quandle cocycle. It gives us a criterion for determining invertibility and positive/negative amphicheirality of hyperbolic knots. The talk is based on arXiv:0812.0425. (Received September 14, 2009)

1054-57-187 **Kanako Oshiro*** (d085317@hiroshima-u.ac.jp), Department of Mathematics, 1-3-1 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8526, Japan. *Relationship between quandle cocycle invariants and symmetric quandle cocycle invariants for oriented links.*

Quandle cocycle invariants, introduced by Carter et. al., are defined for oriented (classical or surface) links. On the other hand, symmetric quandle cocycle invariants, introduced by Kamada, are defined for all (classical or surface) links which are not necessarily orientable. By the structure of these invariants, we have the following question: For oriented links, which is stronger? In this talk, we give the answer. (Received September 14, 2009)

1054-57-188 **Arnaud Deruelle**, **Katura Miyazaki** and **Kimihiko Motegi*** (motegi@math.chs.nihon-u.ac.jp), 3-25-40 Sakurajosui, Setagaya-Ku, Tokyo, 156-8550, Japan. *Networking Seifert surgeries on knots.*

How do Seifert fiber spaces arise after Dehn surgeries on hyperbolic knots? We approach this question in introducing "seiferters" and constructing the Seifert Surgery Network, a 1-dimensional complex whose vertices correspond to Seifert surgeries. A seiferter for a Seifert surgery is a trivial knot in the 3-sphere that becomes a fiber in the resulting Seifert fiber space. Twisting a Seifert surgery along its seiferter yields another Seifert surgery. Edges of the network correspond to such twistings. A path from a given Seifert surgery to that on a torus knot in the network explains how the surgery arises from one of the most basic Seifert surgeries. Studying Seifert surgeries through the network is as if we do not only diagnose an illness, but also detect its source of infection. In this talk, we look at some particular examples to illustrate our idea and give some fundamental results on the combinatorial structure of the Seifert Surgery Network. (Received September 14, 2009)

1054-57-193 **Slava Krushkal*** (krushkal@virginia.edu), University of Virginia, Department of Mathematics, Charlottesville, VA 22904-4137. *The Jacobi identity and the A-B slice problem.*

This talk will show that the relations in the graded Lie algebra associated to the lower central series of a link group play an important role in the A-B slice problem. This work is motivated by the 4-dimensional topological surgery conjecture. (Received September 14, 2009)

1054-57-224 **Rob Kirby*** (kirby@math.berkeley.edu), Mathematics Department, University of California, Berkeley, CA 94720-3840, and **David T. Gay**. *Broken fibrations on 4-manifolds.*

Broken fibrations will be defined and motivated, and their existence and uniqueness will be discussed. (Received September 14, 2009)

1054-57-234 **Ronald A Fintushel**, Department of Mathematics, Michigan State University, East Lansing, MI 48824, and **Ronald J Stern***, Department of Mathematics, UC Irvine, Irvine, CA 92617. *If smooth 4-manifolds are puzzling, what are the pieces?* Preliminary report.

We describe how starting with a decomposition of a manifold M that is a connect sum of blow-ups of complex projective planes into a union of 4-balls, there are null-homologous tori upon which surgeries result, in the case when SW invariants are defined, in an infinite number of smooth structures on M. (Received September 14, 2009)

1054-57-236 **Emille Davie*** (davie@math.ucsb.edu). *Detecting right-veering homeomorphisms of the once-punctured torus.*

We will define the Burau representation of the braid group, B_n, and discuss how to calculate Burau matrices. Viewing B_n as a group of isotopy classes of self-homeomorphisms of an n-times punctured disk D_n, I will give a simple way of determining the action of any braid on the generators of the fundamental group of D_n given its Burau matrix for $n = 3$. This action tells us if the braid is right-veering, left-veering, or neither. (Received September 15, 2009)

1054-57-243 **Daniel Matignon*** (matignon@latp.univ-mrs.fr), CMI, 39, rue Joliot Curie, 13013 Marseille, France. *On the knot complement problem for non-hyperbolic knots.*

The talk concerns Dehn surgery on knots in closed 3-manifolds. We will see two exhaustive and infinite families of pairs (M, k), where M is a lens space and k is a non-hyperbolic knot in M , which produces a manifold homeomorphic to M , by a non-trivial Dehn surgery. Then, we observe the uniqueness of such knot in lens spaces, the uniqueness of the slope, and that there is no preserving homeomorphism between the initial and the final lens spaces. We obtain further that Seifert fibered knots but the axes, and satellite knots are determined by their complements in lens spaces. An easy application shows that satellite knots are determined by their complement in closed, atoroidal and irreducible 3-manifolds. (Received September 15, 2009)

1054-57-281 **Michael John Williams*** (mikew@math.ucsb.edu), Department of Mathematics, South Hall, University of California, Santa Barbara, CA 93106. *Handle number one links and generalized property R.*

An n–component link L in the three sphere has Generalized Property R provided that if L admits a 0–framed Dehn surgery yielding $\#_n(S^1 \times S^2)$, then L is handleslide-equivalent to the 0–framed unlink (of n–components). We show that if the exterior of a 2-component link L in the three sphere admits a genus 2 Heegaard splitting, then L has Generalized Property R. (Received September 15, 2009)

1054-57-293 **Jeffrey T Boerner*** (jboerner@math.uiowa.edu), 14 MacLean Hall, Iowa City, IA 52245, and **Paul Drube**, 14 MacLean Hall, Iowa City, IA 52245. *Generalized skein modules of surfaces.*

Asaeda and Frohman examined the Bar-Natan skein module of surfaces embedded in a 3-manifold. This particular skein module comes from the TQFT associated to Khovanov homology. This TQFT is a particular example of a more general TQFT examined by Khovanov, among others. The general TQFT gives rise to a general skein module of surfaces, where the Bar-Natan skein module is a particular instance.

We will explore this general skein module of surfaces. Our exploration leads us to results relating the topology of the 3-manifold to independence of particular sets of surfaces in the skein module. We also examine certain families of the general skein module that yield interesting results. (Received September 15, 2009)

1054-57-306 **Michael Freedman*** (michaelf@microsoft.com), CNSI Bldg., Office 2245, University of California, Santa Barbara, CA 93106. *K-theory in condensed matter physics.*

I will review recent developments due to Kane, Kitaev, Ludwig, and others on the central role K-theory (ordinary, twisted, and controlled) in the understanding exotic phenomena associated with novel classes of insulators such as HgTe. (Received September 16, 2009)

58 ► Global analysis, analysis on manifolds

1054-58-45 **Gilles Halbout** (halbout@@math.univ-montp2.fr), CC5149, Place Eugène Bataillon, Montpellier, France, and **Xiang Tang*** (xtang@math.wustl.edu), 1 brookings drive, St. Louis, MO 63130. *Dunkl operator and quantization of $\mathbb{Z}_2$-singularity.* Preliminary report.

Let (X, ω) be a symplectic orbifold which is locally like the quotient of a $\mathbb{Z}_2$ action on $\mathbb{R}^n$. Let $A_X^{((\hbar))}$ be a deformation quantization of X constructed via the standard Fedosov method with characteristic class being ω. In this paper, we construct a universal deformation of the algebra $A_X^{((\hbar))}$ parametrized by codimension 2 components of the associated inertia orbifold $\widetilde{X}$. This partially confirms a conjecture of Dolgushev and Etingof in the case of $\mathbb{Z}_2$ orbifolds. To do so, we generalize the interpretation of Moyal star-product as a composition of symbol of pseudodifferential operators in the case where partial derivatives are replaced with Dunkl operators. The star-products we obtain can be seen as globalizations of symplectic reflection algebras. (Received August 26, 2009)

1054-58-50 **Markus J. Pflaum*** (markus.pflaum@colorado.edu), University of Colorado UCB 395, Boulder, CO 80305, 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 August 28, 2009)

1054-58-67 **Matilde Marcolli*** (matilde@caltech.edu), 1200 E. California Blvd, Pasadena, CA 91125, and **Elena Pierpaoli**. *Early universe models from Noncommutative Geometry.*

We analyze cosmological applications of particle physics models based on noncommutative geometry. The peculiar aspect of these models is a coupling of matter with gravity where the coefficients of the gravitational and cosmological terms in the Lagrangian depend upon the Yukawa couplings of the particle physics content of the model, and therefore run with the renormalization group flow. This provides a cosmological model of the early universe (between the unification and the electroweak epochs) with a running effective gravitational constant and a running effective cosmological constant. We analyze the effects on gravitational waves and on the evaporation law of primordial black holes, and resulting Linde type models of negative gravity in the early universe. We also discuss inflationary mechanisms related to a Higgs based slow-roll potential and to the running effective cosmological constant. (Received September 01, 2009)

1054-58-68 **Giuseppe Dito*** (giuseppe.dito@u-bourgogne.fr), Institut de Mathématiques de Bourgogne, Université de Bourgogne, B.P. 47870, 21078 Dijon, France. *Star-exponentials on a complex symplectic manifold.*

In this talk, I will present a construction of a sheave of deformation quantization algebras W on a the cotagent bundle of a complex manifold that contains the exponentials of micro-differential operators of order zero.

The algebra W is an analytic deformation extending the construction by M. Sato, M. Kashiwara, and T. Kawai of the sheaf of micro-local operators, and is obtained by imposing suitable growth conditions on the symbols.

This is a joint work with Pierre Schapira. (Received September 02, 2009)

1054-58-87 **John W Lott*** (lott@math.berkeley.edu), Department of Mathematics, University of California, 970 Evans Hall #3840, Berkeley, CA 94720. *Locally collapsed 3-manifolds.*

The endgame in Perelman's proof of the geometrization conjecture involves a purely Riemannian statement : A 3-manifold that is locally volume-collapsed, with respect to a lower curvature bound, is a graph manifold. I will present a proof of this statement. This is joint work with Bruce Kleiner. (Received September 07, 2009)

1054-58-125 **Michel L. Lapidus*** (lapidus@math.ucr.edu), Department of Mathematics, University of California, Riverside, CA 92521-0135. *Analysis on fractals, geodesic metric and noncommutative geometry.* Preliminary report.

We plan to discuss several problems related to aspects of analysis on fractals, mathematical physics and noncommutative geometry, eventually leading to what was coined by the author as 'noncommutative fractal geometry' (Topological Methods in Nonlin. Analys., vol. 4, 1994; Comtemp. Math., vol. 208, 1997). Chief among them is to find a suitable analogue of the Dirac operator (corresponding to an appropriate Laplacian), Riemannian volume and geodesic metric. We will discuss recent joint work (Advances in Math., vol. 217, 2008) with Erik Christensen and Cristina Ivan in which we answer all of these questions positively for a class of fractals (and of quantum graphs) including the classic Sierpinski gasket, equipped with its Euclidean metric and the associated Hausdorff measure. If time permits, we will also discuss joint work in progress with Jonathan Sarhad in which we address analogous problems for the Sierpinski gasket, but now in a context that is more directly suitable for standard analysis or probability on fractals. (Received September 10, 2009)

1054-58-249 **Arek Goetz*** (goetz@sfsu.edu), 1600 Holloway Ave, Department of Mathematics, San Francisco, CA 94132. *Symmetries can be broken when taking the first return map of a symmetric piecewise rotation.*

In this preliminary report, we illustrate fascinating examples of piecewise rotations T. The maps T are reversely symmetric. However, their first returns on smaller domain no longer possess this property. Piecewise rotations are collections of rotations defined on polygons. The results are obtained using symbolic computations. (Received September 15, 2009)

60 ► Probability theory and stochastic processes

1054-60-33 **Jun Kigami*** (kigami@i.kyoto-u.ac.jp), Graduate School of Informatics, Kyoto University, Kyoto, 606-8501, Japan. *Trace of a transient random walk on a tree on the Cantor set as the Martin boundary and associated heat kernel.*

It is well known that the Martin boundary M of a transient random walk (T, C) on a tree T is the Cantor set Σ. Let $(\mathcal{E}, \mathcal{F})$ be the Dirichlet form on the tree T associated with the random walk (T, C). Let $(\mathcal{E}_\Sigma, \mathcal{F}|_\Sigma)$ be the trace of $(\mathcal{E}, \mathcal{F})$ on the Martin boundary $M = \Sigma$. We study the structure of the Dirichlet form $(\mathcal{E}_\Sigma, \mathcal{F}|_\Sigma)$ on $L^2(\Sigma, \nu)$ in terms of effective resistances, where ν is the hitting distribution of the random walk on its Martin boudary $M = \Sigma$. Also we study the associated heat kernel, Levy density and the mean displacements. Moreover, we will show some relation with the noncommutative Riemannian geometry on the Cantor set. (Received August 12, 2009)

1054-60-36 **Amir AghaKouchak*** (amir@louisiana.edu), 915 S College Rd 220, Lafayette, LA 70503. *Simulation of multivariate random variables using a non-Gaussian copula.*

Environmental variables are known to be dependent in space and time. Detecting and modeling spatial and temporal dependencies of multivariate data are fundamental to many practical applications. Furthermore, simulation of multivariate random variables are commonly used in engineering applications such as uncertainty analysis, risk assessment, ensemble forecasting and decision making among others. In this paper a non-Gaussian copula derived by a non-monotonic transformations of the Gaussian copula is introduced for simulation of spatially dependent random variables. The non-monotonic transformation is performed using two parameters that express the anomaly from the Gaussianity. The asymmetry of dependence structures, if exists, can be described using the copula parameters. (Received August 15, 2009)

1054-60-115 **Alan Krinik*** (ackrinik@csupomona.edu), 3801 Temple Avenue, Department of Mathematics and Statistics, California St. Polytechnic University, Pomona, Pomona, CA 91768, and **Ken Shun**. *Markov Processes Having Transition Steps of Size One & Two.*

Conditions and Explicit formulae for the steady state distribution of Markov processes having transition steps of size one and two (in both, finite and countably infinite state spaces) are derived. The queueing performance measure for the average number of customers in the system are then determined. Formulae for the average waiting time in the queueing system are conjectured and confirmed via computer simulations. Examples and comparisons to the classical single server queueing system, M/M/1, are included. (Received September 10, 2009)

1054-60-117 **Jennifer M Switkes*** (jmswitkes@csupomona.edu), 3801 W. Temple Ave., Pomona, CA 91768. *Averaging Our Perceptions of Highway Speed.* Preliminary report.

We consider the effects of averaging drivers' perceptions of the average speed on a highway. This work builds on a previous model that considers a single driver's perception of the average speed on a highway, based on a continuous probability distribution of car speeds. (Received September 10, 2009)

1054-60-118 **Mike O'Neill*** (moneill@cmc.edu), Department of Mathematics, Claremont McKenna College, Claremont, CA 91711. *Stochastic methods and boundary behavior of harmonic functions.*

We will discuss some ideas from a stochastic proof of the McMillan twist point theorem on simply connected domains in the plane and explain how they lead to a generalization to non-tangentially accessible domains in two or more dimensions. The same techniques lead to a Fatou type convergence theorem along hyperbolic geodesics in nontangentially accessible domains. Extensions to uniform domains will be discussed if time permits. (Received September 09, 2009)

1054-60-119 **Mark L. Huber*** (mhuber@cmc.edu), Claremont McKenna College, 850 Columbia Avenue, Claremont, CA 91711. *Simulation reductions for the Ising model.*

Polynomial time reductions between problems have long been used to delineate problem classes. Simulation reductions also exist, where an oracle for simulation from a probability distribution is employed together with an oracle for Bernoulli draws to obtain a draw from a different distribution. An example is the Ising model, which has several different characterizations, including the random cluster view and the spins view. The well-known Swendsen-Wang algorithm gives simulation reductions from random clusters to spins, and from spins to random clusters. Here a third characterization of the Ising model called the subgraphs view is considered. In this work it is shown how to draw a subgraphs state given a random cluster state, and a random cluster state given a subgraphs state. This answers a long standing question of whether such a direct relationship between the subgraphs view and other versions of the Ising model existed. Moreover, these reductions result in the first method for perfect simulation from the subgraphs world and a new Swendsen-Wang style Markov chain for the Ising model. The method used is to write the desired distribution with set parameters as a mixture of distributions where the parameters are at their extreme values. (Received September 09, 2009)

1054-60-122 **Percy Brill*** (brill@uwindsor.ca), Department of Management Science, University of Windsor, 401 Sunset Avenue, Windsor, Ontario N9B3P4, Canada. *Alternative Solution of a Renewal Problem.*

We derive explicit analytical and asymptotic formulas for the expected number of renewals required to exceed a barrier. The method of analysis can be applied to determine the expected number of demands during an ordering cycle of an inventory system, and related quantities in queues and other stochastic models. (Received September 10, 2009)

1054-60-126 **Randall J Swift*** (rjswift@csupomona.edu), Department of Mathematics & Statistics, California State Polytechnic University, Pomona, CA 91768. *A Spectral Representation of a Class of Nonstationary Processes.* Preliminary report.

In this talk, an extension of the weakly harmonizable class of processes is considered. This class, termed almost periodic contractive harmonizable, is based upon the natural contractive operator associated with harmonizable processes. A spectral representation of these processes is obtained. A relation between the almost periodic contractive harmonizable and the oscillatory harmonizable classes is considered. This relationship yields a series representation for the almost periodic contractive harmonizable class. (Received September 10, 2009)

1054-60-147 **Amy R Ward*** (amyward@usc.edu), University of Southern California, Bridge Memorial Hall - BRI 401H, Los Angeles, CA 90089-0809, and **Mor Armony**. *Blind Fair Routing in Large-Scale Service Systems with Heterogeneous Customers and Servers.*

In a large-scale service system with heterogeneous customers and servers, there are two relevant controls: routing and scheduling. The routing decides which server should handle an arriving customer when more than one server is available. The scheduling decides which customer a server that has just become free should serve when there is more than one customer waiting. We propose a control policy for routing and scheduling that is both blind and fair. It is blind in the sense that it requires no information regarding system parameters. It is fair, to both customers and servers, in the sense that it equalizes the steady-state waiting time across different customer classes, and the steady-state idle time across different server pools (or, more generally, a weighted measure of customer wait time and server idle time). Finally, we analyze the performance of our proposed policy, and show that, in certain regions of the parameter space, its performance is very close to the performance of a policy that asymptotically minimizes customer waiting time subject to a constraint on equalizing server idle time. (Received September 11, 2009)

1054-60-225 **David German*** (dgerman@cmc.edu), 850 Columbia Ave, Claremont, CA 91711-6420. *Illiquid Markets and Demand-driven Prices.*

We study a financial model with a non-trivial price impact effect. In this model we consider the interaction of a large investor trading in an illiquid security, and a market maker who is quoting prices for this security. We assume that the market maker quotes the prices such that by taking the other side of the investor's demand, the market maker will arrive at maturity with maximal expected wealth. Within this model we concentrate on two major issues: evaluation of contingent claims, and hedging. (Received September 14, 2009)

1054-60-244 **Barry C. Arnold*** (barnold@ucr.edu), Department of Statistics, University of California, Riverside, Riverside, CA 92521. *Inequality and majorization: Robin Hood in unexpected places.*

The Lorenz order and its mathematical cousin majorization, best understood as natural consequences of accepting as axiomatic the belief that Robin Hood's activities in robbing the rich to give to the poor reduce inequality in the distribution of wealth, have proved to be useful tools in identifying and extending inequalities in a broad spectrum of settings in mathematics, statistics, economics, etc. A review of these concepts and a sampling of perhaps unexpected situations in which Robin Hood has an identifiable role will be presented. (Received September 15, 2009)

1054-60-246 **GERARDO RUBINO*** (rubino@irisa.fr), INRIA, Campus de Beaulieu, 35042 RENNES, France. *On the power of a queueing system.*

The power of a queuing system is a metric proposed by Leonard Kleinrock several years ago. The goal of that proposal was to combine two competing aspects of such a system when it is in equilibrium, its mean response time and its mean throughput, into a single number called power. Basically, the power is the ratio between its mean thoughput and its mean response time, both factors being appropriately scaled. Kleinrock proved some interesting properties of the power metric applied to single server nodes.

In this work, we discuss some other aspects of the power of queuing models. We look at what happens when there are more than one server or more than one node, for instance in case of Jackson networks. We also provide some results in case of a multiclass context. (Received September 15, 2009)

1054-60-248 **Jungwon (Chris) Mun*** (stat.chris@gmail.com), Department of Mathematics and Statistics, 3801 W. Temple Avenue, Pomona, CA 91768. *A Method to Detect Discordant Subjects in Linear Mixed-Effect Models.*

Many papers have proposed methods for detecting discordant subjects and observations for repeated measurements, which is often fitted by linear mixed-effect models. Most of these suggestions are deletion approaches and adapt existing methods, most likely Cook's distance, for regression data to repeated measurements. However, these straightforward modifications miss the unique and important features of repeated measurements and this causes inherent drawbacks in them per se. This article presents the limitations of simply modified Cooks distances with examples and suggests a new non-deletion method that detects discordant subjects and observations effectively and properly. The proposed method provides greater information on repeated measurements by utilizing (revised) residuals and cooperates well with linear mixed-effect models. In addition, this paper illustrates both the subject-wise and the observation-wise investigation with the new method. (Received September 16, 2009)

1054-60-262 **Mark Burgin**, Department of Mathematics, University of California, Los Angeles, Los Angeles, CA , and **Alan Krinik*** (ackrinik@csupomona.edu), Department of Mathematics and Statistics, California St. Polytechnic University, Pomona, Pomona, CA 91768. *Hyperprobabilities.* Preliminary report.

The extension of the real number line to hypernumbers has consequences for stochastic analysis. In particular, hyperprobabilities may be defined as equivalence classes of sequences having terms from the interval [0,1]. These sequences do not need to converge and thus extend the definition of the probability of an event to the hyperprobability of an event. Recasting many fundamental operations of probability theory in terms of hyperprobabilites leads to some interesting examples and applications. (Received September 15, 2009)

1054-60-299 **Daryl Daley*** (dndaley@gmail.com), Mathematical Sciences Institute, Australian National University, Canberra, ACT 0200, Australia. *Topics in Space-time Modelling.* Preliminary report.

This talk will survey recent work concerning space-time processes in the hope that it may shed light on problems and applications. For simplicity, homogeneity in space and stationarity in time are common assumptions, while when it is sensible, isotropy leads to reduction in dimensionality of the associated mathematical formulation. (Received September 15, 2009)

62 ► Statistics

1054-62-171 **Marc A Suchard*** (msuchard@ucla.edu), 695 Charles E. Young Dr., South, Los Angeles, CA 90095, and **Andrew Rambaut**. *Many-core statistical inference of stochastic processes: a bright computational future.*

Massive numerical integration plagues the statistical inference of partially observed stochastic processes. An important biological example entertains partially observed continuous-time Markov chains (CTMCs) to model molecular sequence evolution. Joint inference of phylogenetic trees and codon-based substitution models of sequence evolution remains computationally impractical. Parallelizing data likelihood calculations is an obvious strategy; however, across a cluster-computer, this scales with the total number of processing cores, incurring considerable cost to achieve reasonable run-time.

To solve this problem, we describe many-core computing algorithms that harness inexpensive graphics processing units (GPUs) for calculation of the likelihood under CTMC models of evolution. High-end GPUs containing hundreds of cores and are low-cost. Our novel algorithms are particularly efficient for large state-spaces, including codon models, and large data sets, such as full genome alignments where we demonstrate up to 150-fold speed-up. (Received September 13, 2009)

1054-62-211 **Hoon Kim*** (hoonkim@csupomona.edu), Department of Mathematics & Statistics, California State Polytechnic University, 3801 W. Temple Ave, Pomona, CA 91768, and **HeeJeong Lim** (heejeonglim@fullerton.edu), Department of Mathematics, California State University, Fullerton, CA 92831. *Population-adjusted conditional autoregressive model for estimating female breast cancer mortality.* Preliminary report.

We propose a population-adjusted conditional autoregressive (CAR) model to describe the structured spatial clustering. When borrowing information from the neighboring areas to estimate the mortality rates, the conventional CAR model share the information regardless of the population size. We conjecture that the amount of information borrowed should be weighed based on the neighbor's population sizes. Mortality rate of a certain area may be more affected by the neighboring densely-populated area(s) rather than by the less-populated area(s).

Posterior estimates are obtained via Markov chain Monte Carlo methods. For estimating female breast cancer mortality rates, we use the loglinear mixed model which includes the age effects, regional effects, and nonlinear temporal trends. Numerical results from the female breast cancer in the state of California during 2001-2006 show that the small areas near densely-populated areas have more shrinkage effects toward the overall means. (Received September 14, 2009)

1054-62-232 **Roger M. Hayne*** (roger.hayne@milliman.com), Milliman Inc., 70 South Lake Avenue, Suite 1100, Pasadena, CA 91101-4705. *A Stochastic Framework for Incremental Average Reserve Models.*

Much of casualty actuarial practice involves extrapolating future payments on books of insurance contracts given historical information of losses from similar contracts in the past. Very often the underlying loss generating process is unknown or poorly understood, so principles-based models, such as those available in many branches

of physical sciences are not available. Traditional methods have been heuristic at best and provided "estimates" without any assessment as to the uncertainty in those estimates. We have attempted to cast one of the more common of the traditional methods into a stochastic framework and use the power of maximum likelihood estimation (MLE) to provide not only estimates of future payments but also rough gauges of how uncertain those estimates are, including both process and parameter uncertainty. (Received September 14, 2009)

65 ► Numerical analysis

1054-65-16 **Jiu Ding***, Department of Mathematics, University of Southern Mississippi, 118 College Dr., Box 5045, Hattiesburg, MS 39406, and **Noah Rhee**, Department of Mathematics and Statistics, University of Missouri at Kansas City, Kansas City, MO 64110. *A Least squares Method for Computing a Stationary Density of the Frobenius-Perron Operator.*

We propose a piecewise linear least squares approximation method for computing stationary density functions of Frobenius-Perron operators associated with piecewise C^2 and stretching mappings of the unit interval. Using techniques from matrix analysis and difference equations, we prove the L^1-norm and the BV-norm convergence of the method. (Received June 29, 2009)

1054-65-208 **Blake A Hunter*** (blakehunter@math.ucdavis.edu), Mathematical Sciences Building, One Shields Ave., University of California, Davis, CA 95616, and **Thomas Strohmer**. *Compressed Diffusion Maps.*

Diffusion maps provide a technique to extract the underlying structure of a data set. They use good known local similarity information to reveal the hidden global structure. This local similarity structure, thought to be necessary, can be replaced by compressed sensing measurements. Compressed sensing provides a mathematically rigorous way to obtain dimensionality reduction. 1000×1000 grayscale images are examples of signals in $\mathbb{R}^{1,000,000}$ where the true underlying data may only have a few degrees of freedom or be sparse in some unknown basses. Standard learning techniques require an appropriate transformation to higher dimension where dimensionally reduction is done before clustering. We show that instead of requiring the local distances be made in the large ambient dimension, measurements can be made on the order of the dimension of the hidden underlying structure. Our theoretical guarantees are complemented with numerical results along with a number of examples of the unsupervised organization and clustering of image data. (Received September 14, 2009)

1054-65-295 **Vicente Alvarez*** (valvarez123@gmail.com), Department of Mathematics, San Bernardino Valley College, San Bernardino, CA 92410. *Numerical computation of the eigenfunctions of the Kusuoka Laplacian on the Sierpinski gasket.* Preliminary report.

We will present numerical and graphical results concerning the eigenfunctions and the eigenvalues of the Kusuoka Laplacian on the Sierpinski Laplacian. We will also briefly compare our results with those concerning the standard fractal Laplacian on the Sierpinski gasket. (Received September 15, 2009)

76 ► Fluid mechanics

1054-76-57 **Andrea Bertozzi*** (bertozzi@math.ucla.edu), 520 Portola Plaza, UCLA Department of Mathematics, Los Angeles, CA 90095, and **Thomas Laurent** (laurent@math.ucla.edu), 520 Portola Plaza, UCLA Department of Mathematics, Los Angeles, CA 90095. *Well-posedness of a multidimensional aggregation equation.*

We consider the 'active scalar' aggregation equation defined by the motion of a density by a vector field defined by the gradient of a scalar potential convolved with the density, $u_t - \nabla \cdot (u \nabla K * u) = 0$. When the potential is attractive this process results in aggregation of the density. We present new results on local and global well-posedness for this problem for bounded data, data in the L^p spaces, and for very weak measure solutions. Some of the results connect to classical well-posedness results for the inviscid Euler equations from fluid dynamics. The main difference is that the problem considered involves a gradient vector field rather than one that is divergence free. Some of the work is joint with Jose Carillo and Jesus Rosado from Barcelona. (Received August 31, 2009)

1054-76-58 **Xiaoming Wang*** (wxm@math.fsu.edu), 208 James J. Love Building, Florida State University, Tallahassee, FL 32306. *Approximating long time statistical properties.*

We present a few recent results as well well open problems on approximation of long time statistical behavior of certain type of dissipative fluid systems. (Received September 01, 2009)

1054-76-97 **Elizabeth Thoren*** (ethoren@math.ucsb.edu), Department of Mathematics, South Hall Rm 6607, University of California, Santa Barbara, CA 93106. *Linear Instability for Incompressible Inviscid Fluid Flows: Two Classes of Perturbations.* Preliminary report.

One approach to examining the stability of a fluid flow is to linearize the evolution equation at an equilibrium and determine (if possible) the stability of the resulting linear evolution equation. In this talk I will split the space of perturbations of an equilibrium flow into two classes and analyze the growth of the linear evolution operator acting on each class. This classification of perturbations is most naturally described in V.I. Arnold's geometric view of fluid dynamics. The first class of perturbations I will examine are those that preserve the topology of vortex lines and the second class is the factor space corresponding to the first class. I will establish lower bounds for the essential spectral radius of the linear evolution operator restricted to each class of perturbations, which leads to linear instability criteria for equilibrium flows subject to perturbations from each class. (Received September 08, 2009)

1054-76-165 **Hans Lindblad*** (lindblad@math.ucsd.edu), 9500 Gilman Drive, La Jolla, CA 92093, and **Steve Shkoller**. *Well posedness for the linearized motion of the free surface of a gas.* Preliminary report.

Well posedness for the linearized motion of the free surface of a gas. (Received September 13, 2009)

1054-76-207 **Irena Lasiecka** and **Amjad Tuffaha*** (tuffaha@usc.edu). *A Bolza Control problem arising in Linearized Fluid-Structure Interaction.*

We consider a Bolza boundary control problem involving a fluid-structure interaction model. We develop an optimal feedback control synthesis based on Riccati theory. The model considered consists of a linearized Navier-Stokes equation coupled on the interface with a dynamic wave equation. The model incorporates convective terms resulting from the linearization of the Navier Stokes equation around equilibrium. The existence of the optimal control and its feedback characterization via a solution to a Riccati equation is established. It is shown that this fluid-structure interaction system does satisfy a Singular Estimate (SE) condition crucial for the application of Riccati theory of optimal control. This is accomplished by showing that the maximal abstract parabolic regularity is transported via hidden hyperbolic regularity of the boundary traces on the interface. Thus, the established Singular Estimate allows for the application of the recently developed general theory which, in turn, implies well-posedness of the feedback synthesis and of the associated Riccati Equation. (Received September 14, 2009)

1054-76-209 **Elaine M. Cozzi*** (ecozzi@andrew.cmu.edu). *The axisymmetric Euler equations with initial vorticity in borderline spaces of Besov type.*

Vishik established the existence and uniqueness of solutions to the two-dimensional Euler equations in borderline spaces of Besov type. His result implies, among many things, the uniqueness of a solution to the two-dimensional Euler equations in the space bmo. We extend some of Vishik's results to the case of axisymmetric initial velocity in three dimensions. We also prove convergence in the limit of vanishing viscosity for these types of solutions. (Received September 14, 2009)

81 ► Quantum theory

1054-81-8 **Michael G Dombroski*** (dombroskistm11@verizon.net), Los Angeles City College, Los Angeles, CA 90029. *A Mathematical Quantization of Space-Time-Matter.* Preliminary report.

The universe appears to be very complicated when looked at in very tiny detail. But it appears there may be a simple key to unlock the quantum world. It could be a summation of *powers-of-three*: $\mathrm{W}_a := \sum_{j=0}^{a} 3^{6j}$. The four relations involving this depend upon only even integers (e), and odd integers (o).

The four combinations needed are:

$$\mathrm{X_o} := \left(3^3\mathrm{W}_{\frac{(\mathrm{o}-1)}{2}-1} + \mathrm{W}_{\frac{(\mathrm{o}-1)}{2}} + 3^{3(\mathrm{o})}\right) \qquad \mathrm{Z_e} := \left(3^3\mathrm{W}_{\frac{(\mathrm{e})}{2}-1} + \mathrm{W}_{\frac{(\mathrm{e})}{2}}\right)$$

$$\mathrm{Y_o} := \left(3^3\mathrm{W}_{\frac{(\mathrm{o}-1)}{2}-1} - \mathrm{W}_{\frac{(\mathrm{o}-1)}{2}} + 3^{3(\mathrm{o})}\right) \qquad \mathrm{T_e} := \left(3^3\mathrm{W}_{\frac{(\mathrm{e})}{2}-1} - \mathrm{W}_{\frac{(\mathrm{e})}{2}}\right)$$

These, when simplified, are:

$$\boxed{(\mathrm{X_o}, \mathrm{Y_o}, \mathrm{Z_e}, \mathrm{T_e})} = \left(\frac{+3^{3(\mathrm{o}+1)}-1}{26}, \frac{+3^{3(\mathrm{o}+1)}-1}{28}, \frac{+3^{3(\mathrm{e}+1)}-1}{26}, \frac{-3^{3(\mathrm{e}+1)}-1}{28}\right)$$

The signs of the $\pm 3^{(\cdot+1)}$ shows the $(+++-)$ nature of the signs. These $(\mathrm{X_o}, \mathrm{Y_o}, \mathrm{Z_e}, \mathrm{T_e})$ are four functions, called here the *Space-Time-Matter* (STM) functions, analogs of $(x, y, z, -t)$. For specific integers of (e) and (o), the functions evaluate to simply four integers. This is so, even though they may *appear* to be rational numbers.

How were the initial W forms of $(\mathrm{X_o}, \mathrm{Y_o}, \mathrm{Z_e}, \mathrm{T_e})$ found? That is the subject of this paper. See http://dombroskiSTM.org. (Received May 14, 2009)

1054-81-20 **Brant Jones** and **Anne Schilling*** (anne@math.ucdavis.edu), Department of Mathematics, University of California, One Shields Ave, Davis, CA 95616. *Affine crystals for type E.* Preliminary report.

Let $\mathfrak{g}$ be an affine Kac–Moody algebra and $U_q'(\mathfrak{g})$ be the associated quantized affine algebra. Kirillov–Reshetikhin modules are finite dimensional $U_q'(\mathfrak{g})$-modules labeled by a node r of the Dynkin diagram together with a nonnegative integer s. It was recently proven in collaboration with Masato Okado that all Kirillov–Reshetikhin modules for nonexceptional types have a crystal basis.

In this talk, we focus on type E, for which Chari has given the decomposition of Kirillov–Reshetikhin modules into classical highest-weight modules. We extend the classical crystals for most of these modules to give an explicit combinatorial realization of the Kirillov–Reshetikhin crystals. This realization is based on exploiting affine Dynkin diagram automorphisms.

This is joint work with Brant Jones. (Received July 14, 2009)

1054-81-69 **Justin D Thomas*** (justmas@gmail.com), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208. *A geometric proof of the generalized Deligne conjecture.* Preliminary report.

The d-dimensional version of the Swiss Cheese operad interpolates between the operads E_{d-1} and E_d. We show that the swiss cheese operad is up to homotopy generated in degrees 0 and 1. We show that this purely topological result implies that the Hochschild cochains of an E_{d-1} algebra form an algebra (up to homotopy) over E_d. This is the dimension d Deligne "conjecture". (Received September 02, 2009)

1054-81-78 **Mikhail Khovanov*** (khovanov@math.columbia.edu), Department of Mathematics, Columbia University, New York, NY 10027. *Adventures in categorification.* Preliminary report.

We'll discuss categorification via several examples and outline common structures present in them. (Received September 04, 2009)

1054-81-285 **Michael A Maroun*** (mmaro001@ucr.edu). *The Rigorous Feynman Path Integral, Analytic Continuation and Convolution as Generalized Evolution.*

I present a brief outline of the investigation of the mathematically rigorous Feynman Path Integral (FPI) and its applications to physical systems. The formalism is equivalent to the Schrodinger Unitary time evolution when certain generalized methods of integration are employed including but not limited to analytic continuation. However, the FPI formalism extends the unitary evolution to more general time evolutions through contraction semi-groups. The FPI also gives an explicit convolution form for the Feynman quantum propagator through the Trotter Product formula. The form of the potentials can be generalized to include measures and distributions. The mathematical forms and physical significances of the generalized potentials are summarized in the contexts of multi-particle systems. Their implications and possible applications to Quantum Field Theory are also discussed. (Received September 15, 2009)

90 ► Operations research, mathematical programming

1054-90-241 **Kourosh Modarresi*** (kouroshm@stanfordalumni.org), P O Box 19544, Stanford, CA 94309. *An Approximate Solution for Smart Grid's Optimization Problem.*

Smart grids are an important step in addressing the difficulties that utilities are to be facing in coming years. One major difficulty is the variability of both electricity production and the demand for the electricity. The major challenge is that given the variability, and by using an integrated database system, to find an optimal scheduling for both electricity production and demand.

The optimization problem requires the application of mathematical programming which, in this case, is a mixed-integer programming, where some of the optimization (decision) variables are constrained to be integers. The significant fact is that smart grids involve distributed energy production sources and thus the number of the electricity generating units is a large number. That leads to a large number of integer-valued decision variables.

As a consequence, the smart grid optimization problem is a NP hard problem. In this work, we consider an approximate approach for the solution of the resulting optimization problem. (Received September 15, 2009)

92 ► Biology and other natural sciences

1054-92-134 **John Fricks*** (fricks@stat.psu.edu), 325 Thomas Bldg, University Park, PA 16802, and **Matthew Kutys**, **John Hughes** and **William Hancock**. *The Role of Neck Linker Extension in Kinesin Stepping.*

Kinesin is a two headed molecular motor which processes along a microtubule by "hand over hand" steps. In recent experiments, the neck linker of these motors have been modified with the insertion of amino acids to increase the distance (and mechanics) between the heads which bind to the motor. These modifications can have profound effects on the velocity and number of steps taken by the motor. In this talk, we will compare three different stochastic models (Markov-modulated diffusion processes) which incorporate these modifications and discuss their relationship to the experimental results. In addition, we will discuss limit theorems that allow us to connect these microscopic phenomena to a more mesoscopic scale. This is joint work with John Hughes, Matt Kutys, and William Hancock. (Received September 10, 2009)

97 ► Mathematics education

1054-97-280 **Franque Michele Bains*** (fbain001@ucr.edu), 3680 Monroe Street, Apt 901, Riverside, CA 92504, and **Borislava Gutarts** (gutarts@exchange.calstatela.edu), California State University, Los Angeles, Depertment of Mathematics, 5151 State University Drive, Los Angeles, CA 90032. *The Effects of Mandatory Homework on Mathematics Performance in an Undergraduate Calculus Course.* Preliminary report.

US students' performance in mathematics courses has been problematic for many years. In the discussion on the possible ways of improving students' performance, invariably the issue of homework and its impact on students' achievement gets raised. In this talk the authors will provide a brief overview of the literature on possible benefits of mandatory homework. The authors will present their recent experiment on the alleged benefits of mandatory homework. This experiment comprised of five sections of an undergraduate calculus course, where students were divided into two groups. Group 1 was administered mandatory (collected and graded) homework while Group 2 was assigned the same homework (not for collection or grade) and was instead given weekly quizzes. The goal was to measure the difference in the performance of the two groups, and the hypothesis was that Group 1 would outperform Group 2. The results will be revealed that may surprise many. In addition to the experimental study, the authors administered student opinion surveys, discussion of which will also be provided. The role of homework to facilitate learning will be analyzed, and the authors will propose two components to be incorporated into a class structure to best promote mathematics learning in college students. (Received September 15, 2009)

2000 MATHEMATICS SUBJECT CLASSIFICATION

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83 Relativity and gravitational theory
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92 Biology and other natural sciences
93 Systems theory; control
94 Information and communication, circuits
97 Mathematics education

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ABSTRACTS

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