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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
1094	October 18–20, 2013	St. Louis, MO	EXPIRED	Vol 34, No. 4
1095	November 2–3, 2013	Riverside, CA	EXPIRED	Vol 34, No. 4
1096	January 15–18, 2014	Baltimore, MD	EXPIRED	Vol 35, No. 1
1097	March 21–23, 2014	Knoxville, TN	January 28	Vol 35, No. 2
1098	March 29–30, 2014	Baltimore, MD	January 28	Vol 35, No. 2
1099	April 5–6, 2014	Albuquerque, NM	February 11	Vol 35, No. 2
1100	April 11–13, 2014	Lubbock, TX	February 10	Vol 35, No. 2
1101	June 16–19, 2014	Tel Aviv, Israel	TBA	N/A
1102	September 20–21, 2014	Eau Claire, WI	July 29	Vol 35, No. 3
1103	October 18–19, 2014	Halifax, Canada	August 19	Vol 35, No. 3
1104	October 25–26, 2014	San Francisco, CA	September 3	Vol 35, No. 4
1105	November 8–9, 2014	Greensboro, NC	September 16	Vol 35, No. 4
1106	January 10–13, 2015	San Antonio, TX	TBA	Vol 36, No. 1

LOUISVILLE, KY, October 5–6, 2013

Abstracts of the 1092nd Meeting.

00 ► General

1092-00-14 **Ming Fang*** (mfang@nsu.edu), Department of Mathematics, Norfolk State University, Norfolk, VA 23504, and **Cherng-Tiao Perng**. *re-indexing problem of Leveraged ETFs.*

Leveraged/inverse exchange-traded funds (ETFs) seek to deliver the multiples/opposite of the performance of the index or benchmark they track. Leveraged and inverse ETFs typically are designed to achieve their stated performance objectives on a daily basis. Many real-life and hypothetical examples have been given to show that performance of these ETFs over a period longer than one day can differ significantly from their stated daily performance objectives. In this paper, we are attempting to establish a mathematical framework for this highly sophisticated financial engineering product and give mathematically rigorous treatments of some well-known observations. (Received May 14, 2013)

1092-00-17 **Delaram Kahrobaei*** (dkahrobaei@gc.cuny.edu), **David Garber** and **Ha T Lam**. *Polycyclic group-based cryptosystems (using conjugacy search problem) are secure against Length Based attacks.*

After the Anshel-Anshel-Goldfeld (AAG) key-exchange protocol came out in 1999, it was studied with braid groups and then with Thompson's group as the underlying platform. The length-based attack, first originated by Hughes and Tannenbaum, has been used to extensively study AAG with the braid group platform. Meanwhile, a new platform, using polycyclic groups, was proposed by Eick and Kahrobaei. In this talk, we show the result of our study of the resistance of AAG with polycyclic group platform under the length-based attack. In particular polycyclic groups could provide a secure platform for any cryptosystem based on conjugacy search problem. (Received June 11, 2013)

1092-00-315 **Christine A Kelley*** (ckelley2@math.unl.edu) and **Kathryn A Haymaker** (s-khaymak1@math.unl.edu). *Design and Implementation of LDPC codes for flash memory.*

In this talk we will discuss coding design constraints imposed by the nature of flash memory channels, and how to effectively implement binary LDPC codes in this setting. We will also discuss nonbinary LDPC codes and their decoding for this application. (Received August 12, 2013)

1092-00-364 **Benito Chen-Charpentier** (bmchen@uta.edu) and **Maria C.A. Leite*** (maria.leite@utoledo.edu). *A model for coupling wildfire and insect outbreak in forests.*

Wildfire and insect infestations are two major natural disturbances of forest lands in the United States. The potential interaction between insect outbreak and wildfire is rarely explored in a model framework and it is a challenging task. The association between insect and fire dynamics is complex, particularly when evaluated over time and at large scale, and no consensus exist in the published literature about its consequences on forest dynamics. In this talk we discuss mathematical models incorporating the effect of insect outbreaks either as a single disturbance in the forest population dynamics or coupled with wildfire disturbances. We will show that 1) the beetle-tree system parametrized model exhibits the well known temporal dynamics of beetle-tree interaction described by the dual equilibria theory. 2) The beetle-tree-fire model reveals the existence of positive feedback between wildfire and insect outbreak disturbances in certain region of fire strength, which agrees with one of the several current theories in the field. (Received August 13, 2013)

01 ► History and biography

1092-01-40 **Daniel J. Curtin*** (curtin@nku.edu), Department of Mathematics and Statistics, Northern Kentucky University, Highland Heights, KY 41099. *Jan De Witt (1625–72) and the Beginnings of Modern Analytic Geometry.*

Jan De Witt's two-volume *Elementa curvarum linearum* (Elements of Curves) appeared as part of Frans van Schooten's famous Latin edition of Descartes' *Geometrie*. The second volume was the first systematic treatment of lines and conic sections to start with first- and second-degree equations and then derive the known curve represented by each equation. This was a major step in moving towards the modern approach of starting with equations. Previously the usual starting point had been a geometric or mechanical definition of the curve, as in Descartes. De Witt's examples are accessible to students with a pre-calculus background, being similar to what they already know. However, students will be challenged to think a bit more deeply about their knowledge of these basic curves. (Received July 13, 2013)

1092-01-41 **Donald A. Sokol*** (vsokol@sbcglobal.net), 11S047 Palisades Rd., Burr Ridge, IL 60527. *Plimpton 322: Triangular numbers in base 60 and N squared.*

Since George Plimpton purchased in 1922 and donated what is now identified as Plimpton 322 to Columbia University in the mid 1930's; a lengthy dialogue has continued for almost a century. Early contributors included Neugebauer and Sachs. More recent participants have been A. Abdulaziz from Univ. of Balamand and E. Robson of All Souls College in Oxford, UK.

Earlier forensic work and mathematical analysis identified its contents as containing integer triples (a,b,c) associated with what is now known as the Pythagorean Theorem. The later work focused on what mathematical techniques were used by the Babylonians to construct these integer triples. Most of the early work suggested they knew Euclid's formulas before Euclid was able to formulate them. Newer work suggests variations in that theme, including reciprocal pairs. This presentation; however, suggests something quite different, i.e. using triangular numbers as multiples of base 60, n squared and 2 (n squared) in their calculations of a, b, and c. (Received July 14, 2013)

1092-01-49 **Nicholas A Scoville*** (nscoville@ursinus.edu), Ursinus College, 601 E. Main Street, Dept. of Math and CS, Collegeville, PA 19426. *Topology and its history are connected under the classroom topology.* Preliminary report.

A first course in point-set topology tends to not only be divorced from history, but also divorced from any other branch of mathematics in the minds of many students. This makes continued motivation of new topological concepts difficult. In contrast, the historical development of certain concepts provides automatic motivation and places the concept in its larger mathematical context. In this talk, we will outline a preliminary list of topics which trace the evolution of connectedness. Beginning with Cantor and a problem of Fourier series, we investigate the contributions of Jordan and Schoenflies, culminating in the current definition first given by Lennes. We share pedagogical suggestions to connect the thought of these mathematicians to build a coherent narrative which teaches some of the main properties of connectedness through part of its historical development. (Received July 17, 2013)

1092-01-60 **Chris Christensen*** (christensen@nku.edu). *Facing New Problems.* Preliminary report.

As World War II loomed, changes were occurring in the cipher bureaus of the likely combatants. One of the changes was that cipher bureaus were beginning to recruit mathematicians to serve as codebreakers. The

recruitment of mathematicians was prompted by the advent of the use of cipher machines. In their preparation for war, the US Navy searched college campuses to find people with "cipher brains." The academic mathematicians who were recruited by the Navy were given little training in cryptology. Two of the mathematicians who were recruited to serve in OP-20-GM, the research section of Naval Communications, were Andrew Gleason and Marshall Hall, Jr. This presentation will consider some of the problems that were faced by Gleason and Hall and the other US Navy cryptologic mathematicians as they attacked the ciphers of the Imperial Japanese Navy and how their being mathematicians directed their attacks. (Received July 24, 2013)

1092-01-106 **Colin B. P. McKinney*** (mckinnec@wabash.edu), 301 W Wabash Ave, Crawfordsville, IN 47933. *The tradition of diagrams in manuscripts of Eutocius.*

Eutocius of Ascalon flourished circa 500 C.E. He compiled a new edition of Apollonius' Conics and also wrote a commentary on it, which gives us a glimpse of the different source versions he used. In this talk, I will show several examples of diagrams from the extant manuscripts that exhibit the interplay (or lack thereof) between a manuscript's text and its diagrams. (Received August 02, 2013)

1092-01-116 **Adam E. Parker*** (aparker@wittenberg.edu), Department of Math and Computer Science, Wittenberg University, P.O. Box 720, Springfield, OH 45501. *"New" techniques from primary sources in ordinary differential equations.*

The pedagogical value of using primary sources in teaching is well documented, especially for calculus courses. Extending this idea to an ordinary differential equations course is a natural next step. This talk will discuss how student projects centered around primary sources can lead to rediscovering lost techniques that are certainly novel for the students and probably the instructor as well. We will illustrate this with three examples: 1) How Bernoulli solved the "Bernoulli differential equation" in a surprising way not taught often anymore, 2) what Cauchy contributed in order to get his name attached to "Cauchy-Euler equations", and 3) how D'Alembert solved systems of differential equations about 100 years before modern matrix techniques were available. (Received August 05, 2013)

1092-01-143 **Alejandro R. Garciadiego*** (gardan@unam.mx), Departamento de Matematicas, 016, Facultad de Ciencias, Ciudad Universitaria, Universidad Nacional Autonoma de Mexico, 03700 Mexico, D. F., Mexico. *Mathemorphosis, a new approach to the teaching of mathematics.*

On a previous conference (Joint Meeting, San Diego 2013), we discussed the methodological and thematic boundaries of a new pedagogical magazine entitled Mathemorphosis (see: Abstracts of Papers Presented to the American Mathematical Society 34 (1) (winter 2013) 529). The publication is addressed to an illiterate audience; to those who have had difficulties for a long period of time and feel completely hopeless towards the discipline. Some of the basic editorial premises are, among others: to forbid the usage of abstract definitions, without the introduction of several examples found in a daily routine; to exclude the usage of axioms, without a previous detailed explanation of their meaning and applications; to avoid, as much as possible, a presupposed familiarity with a symbolic language; and, most important, to reject an unavoidable examination of the material presented. The essays, that might run from a quarter of folio to fifteen pages, should include activities to improve, in general, reading and writing techniques. On this occasion, we will provide specific examples on how to achieve our goal of transmitting mathematics, essentially from the humanities, in a subliminal way. (Received August 06, 2013)

1092-01-192 **Jeffrey A Oaks*** (oaks@uindy.edu), Dept. of Mathematics and Computer Science, University of Indianapolis, 1400 E. Hanna Ave., Indianapolis, IN 46227. *Medieval arithmetical problem solving: algebra, false position etc.*

There were several problem solving techniques in force in medieval Arabic, Latin, and Italian mathematics, including single and double false position, algebra, working backwards, "analysis", and others. Often a single enunciation was solved by several methods, and often different solutions by algebra were obtained through different assignments of the unknown. I will present translations of problems from different Arabic and Italian books that illustrate the variety of techniques. (Received August 09, 2013)

1092-01-227 **Kathleen M Clark*** (kclark@fsu.edu), School of Teacher Education, 1114 West Call Street, Tallahassee, FL 32303. *The contributions of a history and philosophy of mathematics course on undergraduate students' mathematical thinking.* Preliminary report.

This talk presents initial findings from a research study conducted in 2012 in which the contributions of a history and philosophy of mathematics course on the mathematical knowledge of undergraduate students were investigated. The primary research question was: In what ways does the study of the history and philosophy of

mathematics change undergraduate students' mathematical thinking about "essential" mathematics concepts? Although research exists that describes how history of mathematics contributes to the development of mathematical knowledge for teaching, it is also of interest to examine the potential impact of a history of mathematics course on the more general undergraduate population. The present study employed mathematical task interviews with four participants (two mathematics majors, two non-mathematics majors), both pre- and post-instruction, on the topics of the complex number system, the concept of infinity, and the axiomatic structure of mathematics. Initial analyses indicate positive impacts on the students' mathematical knowledge and that comparisons among different undergraduate majors may reveal opportunities for future research. (Received August 10, 2013)

1092-01-294 **Richard Pulskamp*** (pulskamp@xavier.edu), Dept. of Mathematics & Computer Science, Cincinnati, OH 45207-4441, and **Daniel E. Otero** (otero@xavier.edu), Dept. of Mathematics & Computer Science, Cincinnati, OH 45207-4441. *The* Ludus Regularis *of Wibold.*

In around the year 965, Wibold, archdeacon of Noyon, created a dice game known as the *Ludus Regularis* for the benefit of the clerics under his control. Players acquired "virtues" based on the rolls of dice, and may have moved around a game board — as in modern-day *Monopoly*. The rules, in the words of Wibold himself, appear in the *Chronicle of Arras and Cambrai*. This game is mathematically interesting for its combinatorial aspects and for the construction of the dice themselves. Wibold's text ends with a puzzle that hides the author's name. (Received August 12, 2013)

03 ► Mathematical logic and foundations

1092-03-13 **Jaykov Foukzon*** (jaykovfoukzon@list.ru). *Strong Reflection Principles and Large Cardinal Axioms.*

In this article we proved so-called strong reflection principles corresponding to formal theories Th which has omega-models. An posible generalization of the Lob's theorem is considered. Main result is let k be an inaccessible cardinal and H is a set of all sets having hereditary size less then k, then ¬ Con(ZFC + V=H}.

arXiv:1301.5340v6. (Received May 04, 2013)

1092-03-88 **Justin Tatch Moore***, Department of Mathematics, Malott Hall, Cornell University, Ithaca, NY 14853-4201. *Baumgartner's isomorphism problem for $\aleph_2$-dense sets of reals.*

In 1973, Baumgartner proved that it is relatively consistent with ZFC that every two $\aleph_1$-dense subsets of $\mathbb{R}$ are isomorphic. At the time, he asked whether a similar result can be obtained for $\aleph_2$-dense subsets of $\mathbb{R}$. In this talk, I will discuss some progress which has been made on this problem, indicating what is required of a model of set theory in which the continuum is at least $\aleph_2$ and all $\aleph_2$-dense sets of reals are isomorphic. (Received July 31, 2013)

1092-03-107 **Nam D Trang*** (namtrang35@gmail.com), Pittsburgh, PA. *Determinacy in $L(\mathbb{R}, \mu)$.*

Working in $\mathsf{ZF} + \mathsf{DC}$. We say that ω_1 is X-supercompact if there is a normal fine measure on $\mathcal{P}_{\omega_1}(X)$. We let Θ be the supremum of α such that there is a surjection from $\mathbb{R}$ onto α. We briefly sketch the proof of the following theorem:

$\mathsf{ZFC} \vdash \mathrm{Con}(\mathsf{ZF} + \mathsf{DC} + \Theta > \omega_2 + \omega_1 \text{ is } \mathbb{R}\text{-supercompact}) \Leftrightarrow \mathrm{Con}(\mathsf{ZF} + \mathsf{DC} + \mathsf{AD} + \omega_1 \text{ is } \mathbb{R}\text{-supercompact})$.

Canonical models of the above theories are of the form $L(\mathbb{R}, \mu)$ for some normal fine filter μ on $\mathcal{P}_{\omega_1}(\mathbb{R})$. We also discuss some applications of the structure theory of such models and some related open problems. (Received August 03, 2013)

1092-03-163 **Jeremy F Alm*** (alm.academic@gmail.com), Department of Mathematics, 1101 W. College Ave., Jacksonville, IL 62650, and **Robin Hirsch** and **Jacob Manske**. *Finite Monk algebras and equational bases defining RRA over wRRA.*

A finite Monk algebra is a symmetric integral relation algebra whose only forbidden "triangles" (cycles of diversity atoms) are the monochromatic triangles (1-cycles). In this talk we briefly present three new results:

(i) n-color Monk algebras are representable for all $n \leq 300$ (except possibly for $n = 8, 13, 292$);

(ii) RRA is not definable over wRRA by equations using only finitely many variables, which is proven using algebras derived from Monk algebras by splitting atoms; and

(iii) the smallest known weakly representable but not representable relation algebra has five atoms.

This is joint work with Jacob Manske (on (i)) and Robin Hirsch (on (ii) and (iii)). (Received August 07, 2013)

1092-03-213 **Simon Thomas** and **Jay Williams*** (jaywill@caltech.edu), Mathematics 253-37, Caltech, Pasadena, CA 91125. *Cone measures and isomorphism of Kazhdan groups.*

It is a result of Martin that for every Borel Turing-invariant set $X \subseteq 2^{\mathbb{N}}$, either X or its complement contains a Turing cone, i.e. a set consisting of every Turing degree above a specific degree. We show there is no analog of Martin's theorem in the context of embeddability of finitely generated groups. Along the way we prove some results on groups which are bi-embeddable with Kazhdan groups. We also show that isomorphism of Kazhdan groups is weakly universal. (Received August 09, 2013)

1092-03-221 **Sean D Cox***, Dept of Mathematics and Applied Mathematics, Virginia Commonwealth University, 1015 Floyd Ave, Richmond, VA 23284. *Presaturation and bounding by canonical functions on $NS \restriction S^2_1$.*

If $\mathcal{I}$ is a normal ideal on an uncountable regular cardinal κ, we say that $\mathcal{I}$ is **presaturated** iff the boolean algebra $\wp(\kappa)/\mathcal{I}$ preserves κ^+ and yields wellfounded generic ultrapowers; this is weaker than **saturation**, which requires that $\wp(\kappa)/\mathcal{I}$ has the κ^+ chain condition. I will discuss some joint work with Martin Zeman, where we show that GCH is consistent with presaturation of $NS \restriction S^2_1$, where $S^2_1 := \omega_2 \cap \mathrm{cof}(\omega_1)$. This model also satisfies that every $f : \omega_2 \to \omega_2$ is bounded on an ω_1-club by a canonical function. (Received August 10, 2013)

1092-03-230 **John Krueger*** (jkrueger@unt.edu), Department of Mathematics, University of North Texas, 1155 Union Circle #311430, Denton, TX 76203. *Coherent Adequate Sets.*

Adequate sets provide a framework for forcing with models as side conditions. We describe coherent adequate sets, which are adequate sets together with a requirement of isomorphisms between certain models in a side condition. We give several applications of the method, including a forcing poset for adding a square sequence with finite conditions. (Received August 10, 2013)

1092-03-253 **Dima Sinapova*** (sinapova@math.uic.edu), Chicago, IL. *Scales, squares, and SCH.*

Scales and squares are combinatorial principles that are central to singular cardinal arithmetic. We will discuss the relationship between SCH, very good scales and the weak square principle. We will also present some old and new Prikry type forcings and their impact on scales, squares, and not SCH. (Received August 11, 2013)

1092-03-255 **Trevor M. Wilson*** (twilson@math.uci.edu). *Absolutely complementing trees and generic absoluteness.*

We introduce a method for building an absolute complement for a given tree, assuming many failures of covering with respect to constructibility from the tree. As an application, we derive connections between universal Baireness and generic absoluteness appearing around the level of $(\Sigma^2_1)^{\mathrm{Hom}_\infty}$ sets of reals analogous to those established by Feng–Magidor–Woodin around the level of Σ^1_2 sets of reals. (Received August 11, 2013)

1092-03-268 **Clinton T. Conley*** (clintonc@math.cornell.edu) and **Benjamin D. Miller**. *Applications of projective rigidity to the Borel reducibility among non-measure-hyperfinite equivalence relations.*

We define projective rigidity and discuss its use in introducing complexity low in the Borel reducibility hierarchy. In particular, we discuss antidichotomy results for the class of non-measure-hyperfinite countable Borel equivalence relations and local versions of the Adams-Kechris embedding of suitably definable partial orders into Borel reducibility. (Received August 12, 2013)

1092-03-270 **E. Todd Eisworth*** (eisworth@ohio.edu), Athens, OH 45701. *On the cov vs. pp problem.*

We will provide an overview of the "cov vs. pp problem" in pcf theory, and then demonstrate that one of the pieces of this multi-faceted problem is settled by a very weak pcf assumption. (Received August 12, 2013)

1092-03-289 **Scott S Cramer***, scramer@math.berkeley.edu. *Inverse limit reflection and generalized descriptive set theory.*

The structure $L(V_{\lambda+1})$ was first studied by Woodin to prove the consistency of $AD^{L(R)}$ from large cardinals. He later showed that many of the same structural properties of $L(R)$ under determinacy hold for $L(V_{\lambda+1})$ under large cardinals. Laver first introduced the tool of inverse limits in this context to tackle the problem of reflecting large cardinals at this level. In this talk we will extend Laver's results on inverse limit reflection, and then use this technique to analyze further the structure of $L(V_{\lambda+1})$ and its relationship to models of determinacy. (Received August 12, 2013)

1092-03-320 **Andreas Blass*** (ablass@umich.edu), Mathematics Department, University of Michigan, 530 Church Street, Ann Arbor, MI 48109, **Natasha Dobrinen** (natasha.dobrinen@du.edu), Department of Mathematics, University of Denver, 2360 Gaylord St., Denver, CO 80208, and **Dilip Raghavan** (raghavan@math.nus.edu.sg), Department of Mathematics, National University of Singapore, Singapore, 119076, Singapore. *The next best thing to a P-point.*

I'll describe properties of the ultrafilters on ω^2 that are produced by forcing with the quotient of $\mathcal{P}(\omega^2)$ by the Fubini square of the cofinite filter on ω. These generic ultrafilters are weak P-points but not P-points, and they satisfy the strongest square-bracket partition relations that are consistent with not being a P-point. Like P-points, they are not at the top of the Tukey ordering, but, unlike previously known examples of this sort, they are not basically generated. (Received August 12, 2013)

1092-03-341 **Farmer Schlutzenberg***, schlutf@muohio.edu. $\mathrm{HOD}^{L(\mathbb{R})}$ *order of measurability of* $L(\mathbb{R})$ *regular cardinals.* Preliminary report.

The analysis of $\mathrm{HOD}^{L(\mathbb{R})}$ as a core model, under AD, provides a detailed picture of that model, including its large cardinal properties. A direct consequence is that for every ordinal μ, if $\omega < \mu < \Theta$ and μ is regular in $L(\mathbb{R})$, then μ is measurable in $\mathrm{HOD}^{L(\mathbb{R})}$. We will discuss an strengthening of this, showing that in $\mathrm{HOD}^{L(\mathbb{R})}$, the order of measurability of μ is reasonably high. (Received August 13, 2013)

1092-03-346 **Anush Tserunyan*** (anush.tserunyan@gmail.com). *Finite index pairs of countable Borel equivalence relations.*

Motivated by the question of whether finite index extensions of countable treeable equivalence relations are themselves treeable, we investigate finite index pairs (E, F) of nested countable Borel equivalence relations in general and give a characterization of the case when E is normal in F (in the measurable setting). Then we focus on the case when E is treeable and derive a converse to a theorem of Jackson-Kechris-Louveau stating that the orbit equivalence relations induced by free Borel actions of virtually free groups are treeable. Finally, we present a natural example of a universal treeable-by-n equivalence relation, which one could hope to show is not treeable, thus giving a negative answer to the above question. (Received August 13, 2013)

1092-03-356 **Andrew Marks*** (marks@caltech.edu). *Uniformly universal countable Borel equivalence relations.* Preliminary report.

We investigate uniform universality–a strengthened form of a countable Borel equivalence relation being universal–which we conjecture is equivalent to the usual notion. Assuming this conjecture we can resolve several open questions concerning how countable groups, probability measures, the subset relation, and increasing unions interact with universality. For many natural classes of countable Borel equivalence relations we can also classify exactly which are uniformly universal. (Received August 13, 2013)

05 ► Combinatorics

1092-05-31 **John L Goldwasser*** (jgoldwas@math.wvu.edu). *Maximum density of exact copies of a subgraph of the d-cube in the n-cube.* Preliminary report.

Let H be a subgraph of the d-cube, where d is fixed. If J is a subgraph of a large n-cube, what is the maximum density of d-cube subgraphs of the n-cube whose intersection with J is precisely H, with the same embedding in the d-cube? We answer this question when H is a perfect matching of parallel edges. We discuss the difficulties when H is a single edge. We show the maximum density is 15/16 when H is a single edge in the 2-cube, with host graph a large Hamming ball of radius 3, rather than the n-cube. We also consider these problems when H is a set of vertices embedded in the d-cube. (Received July 09, 2013)

1092-05-35 **David Galvin*** (dgalvin1@nd.edu), University of Notre Dame, Notre Dame, IN. *Stirling numbers of graphs, and the normal ordering problem.*

The Stirling number of the second kind $\left\{ {n \atop k} \right\}$ counts the number of partitions of a set of size n into k non-empty sets. A graph theoretic interpretation of this quantity — the number of partitions of the empty graph of order n into k non-empty independent sets — admits an obvious generalization to arbitrary graphs. A more analytic interpretation — the coefficient of x^k in the polynomial $p(x)$ defined by $\left(x\frac{d}{dx}\right)^n e^x = p(x)e^x$ — also admits a natural generalization, with $\left(x\frac{d}{dx}\right)^n$ replaced by an arbitrary word in the alphabet $\{x, d/dx\}$. This latter generalization is the *Weyl algebra normal ordering problem*.

I'll show how these two generalizations are closely related, and give a simple graph theoretic answer to the normal ordering problem. In part joint work with J. Engbers and J. Hilyard. (Received August 01, 2013)

1092-05-36 **Pavle Blagojević** and **Boris Bukh***, Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213, and **Roman Karasev**. *Turán numbers for $K_{s,t}$-free graphs: topological obstructions and algebraic constructions.*

How many edges can an n-vertex graph have without containing G as a subgraph. If G is not bipartite, then asymptotics is known, but for only a few bipartite graphs the humankind knows the answer. In all the instances when the answer is known the construction is algebraic. It turns out that no real algebraic construction of extremal $K_{4,4}$-free graphs is possible. In this talk, I will explain what that means, and sketch a new construction of extremal $K_{s,t}$-free graphs for t much larger than s. (Received July 12, 2013)

1092-05-37 **Richard P Anstee** and **Linyuan Lu*** (lu@math.sc.edu), Columbia, SC 29208. *Repeated columns and an old chestnut.*

Let $t \geq 1$ be a given integer. Let $\mathcal{F}$ be a family of subsets of $[m] = \{1, 2, \ldots, m\}$. Assume that for every pair of disjoint sets $S, T \subset [m]$ with $|S| = |T| = k$, there do not exist $2t$ sets in $\mathcal{F}$ where t subsets of $\mathcal{F}$ contain S and are disjoint from T and t subsets of $\mathcal{F}$ contain T and are disjoint from S. We show that $|\mathcal{F}|$ is $O(m^k)$.

Our main new ingredient is allowing, during the inductive proof, multisets of subsets of $[m]$ where the multiplicity of a given set is bounded by $t-1$. We use a strong stability result of Anstee and Keevash. This is further evidence for a conjecture of Anstee and Sali. These problems can be stated in the language of matrices Let $t \cdot M$ denote t copies of the matrix M concatenated together. We have established the conjecture for those configurations $t \cdot F$ for any $k \times 2$ (0,1)-matrix F. (Received July 12, 2013)

1092-05-44 **Jozsef Balogh** and **Hong Liu*** (hliu36@illinois.edu). *On the number of K_4-saturating edges.*

Let G be a K_4-free graph, an edge in its complement is a K_4-*saturating* edge if the addition of this edge to G creates a copy of K_4. Erdős and Tuza conjectured that for any n-vertex K_4-free graph G with $\lfloor n^2/4 \rfloor + 1$ edges, one can find at least $(1+o(1))\frac{n^2}{16}$ K_4-saturating edges. We construct a graph with only $\frac{2n^2}{33}$ K_4-saturating edges. Furthermore, we prove that it is best possible, i.e., one can always find at least $(1+o(1))\frac{2n^2}{33}$ K_4-saturating edges in an n-vertex K_4-free graph with $\lfloor n^2/4 \rfloor + 1$ edges. (Received July 15, 2013)

1092-05-46 **Andrzej Dudek*** (andrzej.dudek@wmich.edu), Kalamazoo, MI 49008. *On generalized Ramsey numbers of Erdős and Rogers.*

In a graph G, a set $S \subseteq V(G)$ is called *s-independent* if the subgraph of G induced by S does not contain K_s. Let the *s-independence number* of G, denoted by $\alpha_s(G)$, be the size of the largest s-independent set in G. (Hence, in particular, $\alpha_2(G)$ is the ordinary independence number.) The classical *Ramsey number* $R(t,u)$ can be defined in this language as the smallest integer n such that $\alpha_2(G) \geq u$ for every K_t-free graph G of order n. A more general problem results by replacing the ordinary independence number by the s-independence number. Following this approach, in 1962 Erdős and Rogers introduced the function

$$f_{s,t}(n) = \min\{\alpha_s(G) : G \text{ is a } K_t\text{-free graph of order } n\}.$$

In this talk, we present some old and recent developments concerning this function. In particular, we partially confirm an old conjecture of Erdős by showing that $\lim_{n\to\infty} \frac{f_{s+1,s+2}(n)}{f_{s,s+2}(n)} = \infty$ for any $s \geq 4$ (joint work with John Retter and Vojta Rödl). Furthermore, we discuss some extensions for hypergraphs (joint work with Dhruv Mubayi). (Received July 16, 2013)

1092-05-67 **John Lenz*** (lenz@math.uic.edu). *Perfect Packings in Quasirandom Hypergraphs.*

The Hajnal-Szemerédi theorem states that if $|V(G)| = n$ and $\delta(G) \geq (1-1/r)n$, then G contains a perfect K_r packing, a collection of disjoint copies of K_r which cover all the vertices of G. The constant $1-1/r$ is sharp, and similar sharp minimum degree bounds are known for graphs besides K_r and for various k-uniform hypergraphs. Nevertheless, Komlós-Sárközy-Szemerédi showed that for graphs the lower bound on the minimum degree can be weakened if the graph is assumed to be quasirandom. In this talk, I will discuss recent results (joint with Dhruv Mubayi) on perfect packings in weak/linear quasirandom hypergraphs. Both existence of packings and quasirandom constructions which avoid packings will be discussed. This is joint work with Dhruv Mubayi (Received July 26, 2013)

1092-05-73 **Laszlo A. Szekely*** (szekely@math.sc.edu) and **Hua Wang** (hwang@georgiasouthern.edu). *Extremal values of ratios: distance problems vs. subtree problems in trees.* Preliminary report.

The authors pointed out a dual behaviour of two tree indices, the Wiener index and the number of subtrees [*Discrete Appl. Math.* **155**2006, 374–385; *Adv. Appl. Math.* **34**(2005), 138–155]. Wagner [*SIAM J. Disc. Math.* **21**(2007), 33–46] found a large negative correlation between these quantities. Barefoot, Entringer and Székely [*Discrete Appl. Math.* **80**(1997), 37–56] determined extremal values of $\sigma_T(w)/\sigma_T(u)$, $\sigma_T(w)/\sigma_T(v)$, $\sigma(T)/\sigma_T(v)$, and $\sigma(T)/\sigma_T(w)$, where T is a tree on n vertices, v is in the centroid of the tree T, and u, w are leaves in T, and $\sigma_T(x)$ is the sum of distances from x to all other vertices of the tree. Now we test how far the negative correlation between distances and subtrees go if we look for the extremal values of $F_T(w)/F_T(u)$, $F_T(w)/F_T(v)$, $F(T)/F_T(v)$, and $F(T)/F_T(w)$, where T is a tree on n vertices, v is in the subtree core of the tree T, and u, w are leaves in T, $F(T)$ is number of subtrees of T and $F_T(x)$ is number of those containing the vertex x—the complete analogue, changing distances to the number of subtrees. The conclusion is that analogous phenomena hold for these ratios. (Received July 28, 2013)

1092-05-124 **Arthur H Busch*** (art.busch@udayton.edu), University of Dayton, Department of Mathematics, Dayton, OH 45469-2316, and **Atif Abueida** and **R. Sritharan**. *Hamiltonian Spider Intersection Graphs are Cycle Extendable.*

A cycle C of length k is extendable if there is a cycle C' of length $k+1$ with $V(C) \subset V(C')$. A graph $G = (V, E)$ of order n is cycle extendable when every cycle C of length $k < n$ is extendable. A chordal graph is a spider intersection graph if it admits an intersection representation which consists of subtrees of a sub-divided star (or spider). In 1990, Hendry conjectured that all hamiltonian chordal graphs are cycle extendible, and this conjecture was recently disproven. We show that all hamiltonian spider intersection graphs are cycle extendable, generalizing known results on cycle extendability in interval graphs and split graphs, and we consider the tree structure of the known counter-examples. (Received August 05, 2013)

1092-05-138 **Jonathan Cutler** and **A. J. Radcliffe*** (aradcliffe1@math.unl.edu). *Graphs with given maximum degree containing the most complete subgraphs.*

I will talk about a number of extremal problems concerning *enumerative graph parameters*—those counting structures associated with a graph. Examples include the number of independent sets in a graph or the number of proper k-colorings. I will focus on a recent result on the graph with given maximum degree having the most complete subgraphs. (Received August 06, 2013)

1092-05-142 **Lucas Kramer** and **Ryan R. Martin*** (rymartin@iastate.edu), Department of Mathematics, 396 Carver Hall, Iowa State University, Ames, IA 50010, and **Michael Young**. *Diamond-free families in the Boolean lattice.*

For a family of subsets of $\{1, \ldots, n\}$, ordered by inclusion, and a partially-ordered set P, we say that the family is P-free if it does not contain a subposet isomorphic to P. We want to compute $\mathrm{La}(n, P)$, the largest size of a P-free family of subsets of $\{1, \ldots, n\}$. It is conjectured that, for any fixed P, this quantity is $(k + o(1))\binom{n}{\lfloor n/2 \rfloor}$ for some fixed integer k, depending only on P. The conjecture has been verified for a number of small posets P as well as posets of a "tree shape." The smallest poset for which this conjecture is open is Q_2, the Boolean lattice on two elements, also called a "diamond." We will discuss improved bounds on the size of a Q_2-free family, utilizing Razborov's flag algebra method. (Received August 06, 2013)

1092-05-145 **Gexin Yu*** (gyu@wm.edu), Department of Mathematics, College of William and Mary, Williambsurg, VA 23185. *Strong edge-colorings for k-degenerate graphs.* Preliminary report.

We prove that the strong chromatic index for each k-degenerate graph with maximum degree Δ is at most $(4k-2)\Delta - k(2k-1) + 1$. This confirms a conjecture of Chang and Narayanan. (Received August 06, 2013)

1092-05-153 **Jimmy Shan***, 1409 W Green, Urbana, IL 61801. *G-parking functions and minimal free resolutions of powers of linear forms.*

For a graph G, Postnikov-Shapiro [**?**] construct two ideals I_G and J_G. I_G is a monomial ideal and J_G is generated by powers of linear forms. They proved the equality of the Hilbert series and conjectured that the graded Betti numbers are equal. When $G = K_{n+1}^{l,k}$ is the complete graph on the vertices $[n+1] := \{0, 1, \cdots, n\}$ with the edges $e_{i,j}$, $i, j \neq 0$, of multiplicity k and the edges $e_{0,i}$ of multiplicity l, for two non-negative integers k and l, they gave an explicit formula for the graded Betti numbers of I_G, which are conjecturally the same for J_G. We prove this conjecture. (Received August 07, 2013)

1092-05-165 **Andrzej Czygrinow** and **Theodore Molla*** (tmolla@asu.edu). *Tight co-degree condition for the existence of loose Hamilton cycles in* 3*-uniform hypergraphs.*

Recently many results analogous to Dirac's Theorem have been proved for hypergraphs. A (k,l)*-cycle* is a hypergraph in which the vertices can be arranged in a cycle so that every edge contains k consecutive vertices and every pair of consecutive edges intersect in exactly l vertices. Call a $(k,k-1)$-cycle a *tight cycle* and a $(k,1)$-cycle a *loose cycle*.

Let H be a 3-uniform hypergraph on n vertices with minimum co-degree $\delta(H)$. Rödl, Ruciński and Szemerédi proved that $\delta(H) \geq (1/2+o(1))n$ implies that H contains a tight Hamilton cycle and Kühn and Osthus showed that $\delta(H) \geq (1/4+o(1))n$ is sufficient for H to contain a loose Hamilton cycle. Both results are from 2006. In 2011 Rödl, Ruciński and Szemerédi improved their previous result by showing that, for sufficiently large n, $\delta(H) \geq \lfloor n/2 \rfloor$ implies the existence of a tight Hamilton cycle. We will sketch a proof of an analogous result for loose cycles, that is we will show that every sufficiently large 3-uniform hypergraph on $n \in 2\mathbb{Z}$ vertices with minimum co-degree at least $n/4$ contains a loose Hamilton cycle. This result is best possible and uses the probabilistic absorbing technique. (Received August 07, 2013)

1092-05-176 **Éva Czabarka***, czabarka@math.sc.edu, and **Aaron Dutle**, **Péter L. Erdős** and **István Miklós**. *On realizations of a joint degree matrix.*

The joint degree matrix of a graph gives the number of edges between vertices of degree i and degree j for every pair (i,j). Similar to the swap operations in the Havel-Hakimi algorithm, one can perform restricted swap operations to transform a graph into another with the same joint degree matrix. We prove that the space of all realizations of a given joint degree matrix over a fixed vertex set is connected via these restricted swap operations. We also give a new simple proof of the necessary and sufficient conditions for a matrix to be a joint degree matrix of a graph. (Received August 08, 2013)

1092-05-177 **Andrew P. Dove*** (doveap@mailbox.sc.edu) and **Jerrold R. Griggs** (griggs@math.sc.edu). *Packing posets in a family of subsets.* Preliminary report.

We are interested in maximizing the number of pairwise unrelated embeddings of a poset P in the family of all subsets of $[n]$. For instance, Sperner showed that when P is one element, $\binom{n}{\lfloor n/2 \rfloor}$ is the maximum number of embeddings of P. Griggs, Stahl, and Trotter have shown that when P is a chain on k elements, $\frac{1}{2^{k-1}}\binom{n}{\lfloor n/2 \rfloor}$ is asymptotically the maximum number of copies of P. We prove that for any P the maximum number of unrelated copies of P is asymptotic to a constant times $\binom{n}{\lfloor n/2 \rfloor}$. Moreover, the constant has the form $1/c(P)$, where $c(P)$ is an integer related to representing P by subsets. (Received August 08, 2013)

1092-05-187 **William T. Trotter** and **Ruidong Wang*** (rwang49@math.gatech.edu), School of Mathematics, 686 Cherry Street, Atlanta, GA 30332. *Incidence Posets and Cover Graphs.*

We prove two theorems concerning incidence posets of graphs, cover graphs of posets and a related graph parameter. First, answering a question of Haxell, we show that the chromatic number of a graph is not bounded in terms of the dimension of its incidence poset, provided the dimension is at least four. Second, answering a question of Kříž and Nešetřil, we show that there are graphs with large girth and large chromatic number among the class of graphs having eye parameter at most two. (Received August 08, 2013)

1092-05-189 **Éva Czabarka** and **Aaron Dutle*** (dutle@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208, and **Travis Johnston** and **László Székely**. *Constructing Diamond-free Posets with Markov Chains and Groups.*

The *Diamond conjecture* of Griggs and Lu asserts that the largest induced subposet of the boolean lattice that contains no *diamond* (i.e., four elements with $A < B_1, B_2 < C$) is no larger than size of the middle two levels. If the conjecture is true, it is obviously tight by taking the middle two levels as a subposet. In this talk, we present a technique for constructing diamond-free families using a Markov chain on a different poset, derived from an abelian group, which produces examples of diamond-free families on three or more levels. Many of these are asymptotically tight to the conjectured bound, giving reason for why the conjecture has been so difficult. (Received August 08, 2013)

1092-05-219 **Ervin Gyori*** (gyori.ervin@renyi.mta.hu). *Hypergraph generalizations of extremal graph theorems on paths and cycles.*

We present several recently proved theorems about hypergraphs not containing cycles of given length. (Joint works with Bollobas, Lemons.) Beyond that we deal with various hypergraph generalizations of Erdos-Gallai extremal theorem on paths. (Joint work with Katona and Lemons.) In case of paths, a systematic discussion of

hypergraph versions will be presented. Many theorems are proved but some conjectures are still open. Especially, the constant factor in the theorems is not determined precisely either. (Received August 10, 2013)

1092-05-225 **J Balogh** and **J Butterfield***, butter@umn.edu, and **P Hu** and **J Lenz**. *Mantel's Theorem for Random Hypergraphs.*

A cornerstone result in extremal graph theory is Mantel's Theorem, which states that every maximum triangle-free subgraph of K_n is bipartite. A sparse version of Mantel's Theorem is that, for sufficiently large p, every maximum triangle-free subgraph of $G(n,p)$ is with high probability (w.h.p.) bipartite. Recently, DeMarco and Kahn proved this for $p > K\sqrt{\log n/n}$ for some constant K, and apart from the value of the constant this bound is best possible. We study an extremal problem of this type in random hypergraphs. Denote by F_5 the 3-uniform hypergraph with vertex set $\{a,b,c,d,e\}$ and edge set $\{abc, ade, bde\}$. Frankl and Füredi proved that the maximum 3-uniform hypergraph on n vertices containing no copy of F_5 is tripartite for $n > 3000$. It is natural to ask for what p is every maximum F_5-free subhypergraph of $G^3(n,p)$ w.h.p. tripartite. We show this holds for $p > K \log n/n$ for some constant K and does not hold if $p = 0.1\sqrt{\log n}/n$. (Received August 10, 2013)

1092-05-240 **Ronald Graham**, **Linus Hamilton**, **Ariel Levavi** and **Po-Shen Loh*** (ploh@cmu.edu), Department of Mathematical Sciences, Wean Hall 6113, Carnegie Mellon University, Pittsburgh, PA 15213. *Anarchy is free in network creation.*

The Internet has emerged as the most important network in modern computing, but miraculously, it was created through the individual actions of a multitude of agents rather than by a central authority. This motivates the game theoretic study of network formation, and we consider one of the best-studied models, due to Fabrikant et al. In it, each of n agents is a vertex, which creates edges to other vertices at a cost of α each. Every edge can be freely used by every agent, regardless of who paid the creation cost. To reflect the desire to be close to other vertices, each agent's cost function is further augmented by the sum of its (graph theoretic) distances to all other vertices.

Previous research proved that in many regimes of the (α, n) parameter space, every Nash equilibrium has total social cost (sum of all agents' costs) within a constant factor of the optimal social cost. In algorithmic game theory, this approximation ratio is called the price of anarchy. We significantly sharpen some of those results, proving that for all constant non-integral $\alpha > 2$, the price of anarchy is not only bounded by a constant, but tends to 1 as $n \to \infty$. For constant integral $\alpha \geq 2$, we show that the price of anarchy is bounded away from 1. (Received August 11, 2013)

1092-05-242 **Tao Jiang**, **Kevin G Milans*** (milans@math.wvu.edu) and **Douglas B West**. *Multicolor degree-Ramsey numbers of cycles.*

We write $H \xrightarrow{s} G$ if every s-edge-coloring of the *host graph* H contains a monochromatic copy of the *target graph* G. A typical problem in Ramsey theory fixes a target graph and asks for a host graph which is extremal with respect to some graph property; we are interested in host graphs with small maximum degree. The *multicolor degree-Ramsey number* of a graph G, denoted $R_\Delta(G;s)$ is $\min\{\Delta(H)\colon H \xrightarrow{s} G\}$.

We study $R_\Delta(C_n;s)$. First, consider the case that n is fixed and s grows. It is easy to show that if n is odd, then $R_\Delta(C_n;s)$ is at least exponential in s, but if n is even, then $R_\Delta(C_n;s) \leq f(n)s^2$ for some function f. From below, we show that $R_\Delta(C_4;s) \geq s^{14/9}$. Perhaps surprisingly, $R_\Delta(C_n;s)$ is bounded above by a function that depends only on s. For even cycles, show that $R_\Delta(C_{2n};s) \leq 16s^6$. This is joint work with Tao Jiang and Douglas B. West. (Received August 11, 2013)

1092-05-246 **Stephen G Hartke** and **Derrick Stolee*** (dstolee@iastate.edu). *A Linear Programming Approach to the Manickam-Miklós-Singhi Conjecture.*

The Manickam-Miklós-Singhi Conjecture states that when $n \geq 4k$, every multiset of n real numbers with nonnegative total sum has at least $\binom{n-1}{k-1}$ k-subsets with nonnegative sum. Using a poset on the k-subsets of $[n]$, we develop a branching strategy and a linear programming formulation to show that verifying the conjecture for fixed values of k is a finite problem. To improve our search, we develop a zero-error randomized propagation algorithm. Using implementations of these algorithms, we verify a stronger form of the conjecture for all $k \leq 7$. (Received August 11, 2013)

1092-05-248 **Guantao Chen*** (gchen@gsu.edu), Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30303, **Hikoe Enomoto**, Graduate School of Economics, Waseda University, Tokyo, 169-8050, Japan, **Kenta Ozeki**, National Institute of Informatics, Tokyo, 101-8430, Japan, and **Shoichi Tsuchiya**, Department of Mathematical Information Scienc, Tokyo University of Science, Tokyo, 162-8601, Japan. *Triangulations on the plane without spanning Halin subgraphs.*

A *Halin graph*, defined by Halin, is a plane graph $H = T \cup C$ such that T is a spanning tree of H with no vertices of degree 2 where $|T| \geq 4$ and C is a cycle whose vertex set is the set of leaves of T. Halin graphs are edge-minimal 3-connected graphs with many useful properties. In 1975, Lovász and Plummer conjectured that "every 4-connected plane triangulation has a spanning Halin subgraph". In this talk, we show that there is an infinite family of 5-connected plane triangulations which have no spanning Halin subgraph. Consequently, the Lovász and Plummer Conjecture does not hold. (Received August 11, 2013)

1092-05-249 **S K Mason*** (masonsk@wfu.edu), Winston Salem, NC 27109, and **R J Parsley**. *A geometric interpretation of the weighted games poset.* Preliminary report.

A weighted game is a situation in which each player carries a certain amount of weight, and a coalition can pass a motion once their combined weight meets or exceeds a certain quota. We introduce a polytope associated to the partially ordered set of weighted games and show that vertical lines in the polytope correspond to saturated chains in the partially ordered set. We use properties of the poset to prove results (such as facet enumerations) about the polytope. (Received August 11, 2013)

1092-05-280 **Jessica McDonald*** (mcdonald@auburn.edu). *Immersion Structure.*

Immersion is a containment relation between graphs (or digraphs) which is defined similarly to the more familiar notion of minors, but is incomparable to it. Given graphs (or digraphs) G and H, when does G contain H as an immersion? In this talk we discuss several structural results related to this question. (Received August 12, 2013)

1092-05-281 **Steve Butler*** (butler@iastate.edu). *Variations on Erdős-Ko-Rado.* Preliminary report.

The Erdős-Ko-Rado Theorem looks at maximizing the size of the largest family of sets which pairwise intersect. The idea of finding maximally intersecting families can be extended to other combinatorial objects which have a notion of intersection. We will survey some of these results and present some other variations. (Received August 12, 2013)

1092-05-283 **Xiaoyu Liu*** (xiaoyu.liu@wright.edu), 3640 Colonel Glenn Highway, Beavercreek, OH 45435. *A family of* $[2^{2t}, 3t+1, 2^{2t-1} - 2^{t-1}]$ *binary codes.*

We study a family of $[2^{2t}, 3t+1, 2^{2t-1} - 2^{t-1}]$ binary codes, which are obtained from the first order Reed Muller code RM$[1, 2t]$, together with some of its bent function cosets. (Received August 12, 2013)

1092-05-285 **Zdenek Dvorak** and **Bernard Lidicky** (lidicky@illinois.edu). *3-coloring triangle-free planar graphs with a precolored 8-cycle.*

Let G be a planar triangle-free graph and let C be a cycle in G of length at most 8. We characterize all situations where a 3-coloring of C does not extend to a proper 3-coloring of the whole graph. (Received August 12, 2013)

1092-05-291 **James M Carraher*** (s-jcarrah1@math.unl.edu), **Stephen G Hartke** and **Paul Horn**. *Edge-disjoint rainbow spanning trees.*

Let G be a properly edge-colored copy of the complete graph K_n. A rainbow spanning tree of G is a spanning tree where each edge has a different color. Brualdi and Hollingsworth and Kaneko, Kano, and Suzuki conjecture that every properly edge-colored complete graph K_n ($n \geq 5$) has $\lfloor n/2 \rfloor$ edge-disjoint rainbow spanning trees. We show that for every properly edge-colored K_n ($n \geq 1,000,000$) contains at least $\lfloor n/(1000 \log n) \rfloor$ edge-disjoint rainbow spanning trees. (Received August 12, 2013)

1092-05-327 **Tao Jiang*** (jiangt@miamioh.edu), Department of Mathematics, Miami University, Oxford, OH 45056. *Two results on the Turan problem of graphs and hypergraphs.* Preliminary report.

A hypergraph is *linear* if any two edges intersect in at most one vertex. Given n and a linear r-graph H, the linear Turan number $ex_L(n, H)$ is the largest number of edges in a linear r-graph on n vertices that does not contain H as a subgraph. We show that $ex_L(n, C^r_{2m}) = O(n^{1+\frac{1}{m}})$, where C^r_{2m} is the r-uniform linear cycle of length $2m$. This generalizes the Bondy-Simonovits theorem for 2-uniform cycles. We conjecture that a similar bound holds for odd cycles when $r \geq 3$. This is joint work with C. Collier-Cartaino.

Next, we consider the following question. For a positive integer t and a positive real d, let $\mathcal{F}_{d,t}$ denote the family of graphs with average degree at least d and number of vertices at most t. A simple random argument yields $ex(n, \mathcal{F}_{d,t}) = \Omega(n^{2-2/d+\epsilon_1(t)})$, where $\epsilon_1(t) \to 0$ as t grows. J. Verstraëte asked if a similar upper bound holds, namely $ex(n, \mathcal{F}_{d,t}) = O(n^{2-2/d+\epsilon_2(t)})$, where $\epsilon_2(t) \to 0$ as t grows. We answer the question affirmatively for all positive integers d and some rational numbers d. Along the way, we establish a Turan result on cube-like graphs. This is joint work with A. Newman. (Received August 13, 2013)

1092-05-331 **Paul Balister***, Dept. of Math Sciences, University of Memphis, Memphis, TN 38152, and **Bela Bollobas** and **Svante Janson**. *Random vertex orderings of graphs.*

Fix some hereditary graph property P. We consider which probability distributions on random vertex orderings can be assigned to graphs in P so that these distributions are preserved under isomorphisms and on taking induced subgraphs. One example is the uniform distribution which gives equal probability to all $n!$ orderings on any graph on n vertices. For many graph properties we show that this is the only example, but there also many properties for which non-uniform distributions exist. Often the distinction between these two cases depends quite subtly on P. (Received August 13, 2013)

1092-05-369 **Zoltan Furedi*** (z-furedi@illinois.edu), Budapest, Hungary, and **David S. Gunderson**, , Canada. *Extremal numbers for odd cycles.*

We describe the C_{2k+1}-free graphs on n vertices with maximum number of edges. The extremal graphs are unique for $n \notin \{3k-1, 3k, 4k-2, 4k-1\}$. The value of $\mathrm{ex}(n, C_{2k+1})$ can be read out from the works of Bondy (1971), Woodall 1972, and Bollobás (1979), but here we give a new streamlined proof. The complete determination of the extremal graphs is also new.

We obtain that the bound for $n_0(C_{2k+1})$ is $4k$ in the classical theorem of Simonovits, from which the unique extremal graph is the bipartite Turán graph. (Received August 13, 2013)

1092-05-386 **Jaehoon Kim*** (kim805@illinois.edu), 1409 W. Green Street, Urbana, IL 61801, and **Alexandr V Kostochka** and **Xuding Zhu**. *(0,1)-improper coloring of sparse graph.*

A graph G is a $(0,1)$-colorable if $V(G)$ can be partitioned into two sets V_0 and V_1 so that $G[V_0]$ is an independent set and $G[V_1]$ has maximum degree at most 1. The problem of verifying whether a graph is $(0,1)$-colorable is NP-complete even in the class of planar graphs of girth 9.

Maximum average degree, $Mad(G) = \max_{H \subset G}\{\frac{2|E(H)|}{|V(H)|}\}$, is a graph parameter measuring how sparse the graph G is. Borodin and Kostochka showed that every graph G with $Mad(G) \leq \frac{12}{5}$ is $(0,1)$-colorable, thus every planar graph with girth at least 12 also is $(0,1)$-colorable.

The aim of this talk is to prove that every triangle-free graph G with $Mad(G) \leq \frac{22}{9}$ is $(0,1)$-colorable. We prove the slightly stronger statement that every triangle-free graph G with $|E(H)| < \frac{11|V(H)|+5}{9}$ for every subgraph H is $(0,1)$-colorable and show that there are infinitely many not $(0,1)$-colorable graphs G with $|E(G)| = \frac{11|V(G)|+5}{9}$. (Received August 14, 2013)

06 ► Order, lattices, ordered algebraic structures

1092-06-59 **Melvin F. Janowitz*** (nekj@dimavs.rutger.edu), DIMACS, Ruthers Univeristy, 96 Frelinghuysen Road, Picataway, NJ 08854. *Generalized Oligarchies.* Preliminary report.

In cases of a medical, terrorist, or natural emergency there often is a need to simultaneously reach multiple but possibly related decisions dealing with public safety. A recent newsworthy event involves the explosions at the Boston Marathon. This leads to a study of the direct product of oligarchies involving the same collection of agents, but analyzing different but possibly related issues. The paper will relate conditions that normally involve social networks with conditions that have arisen in developing the fundamentals of the structure of finite lattices. The need for a simultaneous analysis of related issues is that a solution to one problem may adversely affect the solution to some of the other related problems. (Received July 24, 2013)

1092-06-62 **William T Trotter*** (trotter@math.gatech.edu), School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332, and **Ruidong Wang**. *Upper and Lower Cover Dimension.* Preliminary report.

In previous work on incidence posets and cover graphs, we proved the following elementary fact: If P is a poset, G is a the cover graph of P and Q is the incidence poset of G, then the dimension of Q is at most twice the dimension of P. We conjecture that this inequality is best possible, i.e., we believe that for each positive integer

d, there is a d-dimensional poset P so that if G is the cover graph of P and Q is the incidence poset of G, then the dimension of Q is $2d$. This conjecture is true for $d = 1$ and $d = 2$ but is open for $d \geq 3$.

Motivated by efforts to resolve this conjecture, we will present new concepts of dimension which are monotonic on suborders determined by subgraphs of the order diagram, considered as an oriented graph. These new concepts lead naturally to ramsey-theoretic conjectures—most of which have corresponding density analogues. (Received July 25, 2013)

1092-06-94 **George Gratzer*** (gratzer@me.com). *The order of principal congruences of a bounded lattice.*

We characterize the order of principal congruences of a bounded lattice as a bounded ordered set. We also state a number of open problems in this new field. (Received August 01, 2013)

1092-06-108 **Yuri Movsisyan*** (yurimovsisyan@yahoo.com), 0025 Yerevan, Armenia. *Super-Boolean Functions and Free Boolean Quasilattices.*

A Boolean quasilattice is an algebra with hyperidentities of the variety of Boolean algebras. In this talk we give a functional representation of the free n-generated Boolean quasilattice with two binary, one unary and two nullary operations. Namely, we define the concept of super-Boolean function and prove that the free Boolean quasilattice with two binary, one unary and two nullary operations on n free generators is isomorphic to the Boolean quasilattice of super-Boolean functions of n variables. (Received August 03, 2013)

1092-06-137 **Erika D. Foreman*** (erika.foreman@louisville.edu). *Order Automorphisms of Function Lattices.*

The residuated maps on complete lattices (simply the join homomorphisms) form their own lattice, which we denote Res(L). In this talk, we explore the order automorphisms on the lattice Res(L) where L is a finite non-distributive lattice. It's known that left-and-right composition of f in Res(L) with automorphisms of L yields an order automorphism of Res(L). It begs the question, then, if all order automorphisms of Res(L) can be classified as such. We explore this question with some specific examples. (Received August 06, 2013)

1092-06-158 **Ryan Therkelsen*** (rtherkelsen@bellarmine.edu). *Poset Properties for Generalized Partitions.* Preliminary report.

Given a positive integer n, a partition is usually described as a sequence of (positive) integers that sum to n, recorded in non-increasing order. Relaxing the non-increasing convention (in a specific way) leads to new objects we've called "generalized partitions". The partially ordered set consisting of these generalized partitions, under dominance order, is quite different than the poset of the "traditional" partitions under dominance order, though some important properties are preserved. I will examine a few of the differences between these posets as well as an important structural similarity. Additionally, a description of how the generalized partitions naturally arise in the study of a certain decomposition of the set of $n \times n$ matrices will be given, along with questions for future consideration. (Received August 07, 2013)

1092-06-205 **Nasir Sohail*** (snasir@ut.ee), Department of Pure Mathematics, Faculty of Mathematics, 200 University Ave. West, Waterloo, ON N2L 3G1, Canada. *Epimorphisms in certain varieties of partially ordered semigroups.*

A partially ordered semigroup, briefly posemigroup, is a pair $(S, \leq)$ comprising a semigroup S and a partial order $\leq$ (on S) that is compatible with the binary operation, i.e. for all $s_1, s_2, t_1, t_2 \in S$, $(s_1 \leq t_1,\ s_2 \leq t_2)$ implies $s_1 s_2 \leq t_1 t_2$. A posemigroup homomorphism is a monotone semigroup homomorphism. A class of posemigroups is called a variety if it is closed under taking homomorphic images, direct products (endowed with componentwise order) and subposemigroups. Each variety of posemigroups gives rise to a category in natural way. A posemigroup homomorphism $f : (S, \leq_S) \longrightarrow (T, \leq_T)$ is called an epimorphism if it is right cancellative in the usual sense of category theory. Clearly f is an epimorphism in the category of all posemigroups if such is $f' : S \longrightarrow T$ in the category of all semigroups, where $f'(s) = f(s)$ for all $s \in S$. The aim of this article is to show that the converse of this statement, which may not be true in general, holds in the varieties of absolutely closed semigroups. (Received August 09, 2013)

1092-06-234 **Joshua N Cooper*** (cooper@math.sc.edu), Columbia, SC 29208. *When Is Linear Extension Counting Easy?*

A now-classic result of Brightwell and Winkler is that counting linear extensions for general posets is #P-hard. It is well-known that counting antichains is also #P-hard (Provan-Ball), but that this can be done in polynomial time for dimension 2 posets (Möhring). For which classes of posets is counting linear extensions easy in the aforementioned sense? We introduce a new class, bwisic (an acronym for "bounded width indecomposable

strong interval condition") posets, generalizing series-parallel posets, for which we provide a polynomial-time algorithm to count the number of linear extensions. (Received August 10, 2013)

1092-06-247 **Csaba Biro** (csaba.biro@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY, **Mitchel T. Keller*** (kellermt@wlu.edu), Department of Mathematics, Washington and Lee University, 204 W Washington St, Lexington, VA 24450, and **Stephen J. Young** (stephen.young@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY. *Posets with cover graph of pathwidth two have bounded dimension.*

Joret, Micek, Milans, Trotter, Walczak, and Wang recently asked if there exists a constant d such that if P is a poset with cover graph of P of pathwidth at most 2, then $\dim(P) \leq d$. We answer this question in the affirmative. We also show that if P is a poset containing the standard example S_5 as a subposet, then the cover graph of P has treewidth at least 3. (Received August 11, 2013)

1092-06-267 **Dwight Duffus*** (dwight@mathcs.emory.edu), Mathematics and Computer Science Department, Emory University, Atlanta, GA 30322, and **Kyle Thayer** (kyle.thayer@gmail.com), Boulder, CO. *Subgroups G of S_n such that quotients B_n/G are symmetric chain orders.*

We are interested in the following problem posed several years ago by R. Canfield and S. Mason: determine conditions on subgroups G of the symmetric group S_n under which the quotient B_n/G of the Boolean lattice B_n of all subsets of an n-element set, ordered by containment, is a symmetric chain order. This has its roots in a general problem of R. Stanley, a special case of which is to show that the initial segments of a product of two chains, ordered by containment, is an SCO. We present some results extending the families of subgroups G of S_n for which B_n/G is an SCO. This is related to work of the authors, K. K. Jordan, V. Dhand, and P. Hersh and A. Schilling. (Received August 12, 2013)

1092-06-295 **John W. Snow*** (john.snow@cune.edu) and **Kalle Kaarli**. *Reflexive Relations on Lattices.*

Any algebra $\mathbf{A}$ gives rise to an algebra $\mathbf{Ref}(\mathbf{A})$ of compatible reflexive relations under the operations of intersection, composition, and converse with the identity and universal relations as constants. In 2009, Snow characterized $\mathbf{Ref}(\mathbf{A})$ for finite $\mathbf{A}$ with a boolean lattice reduct. In 2012, Kaarli gave a characterization when $\mathbf{A}$ is finite with a lattice reduct. We will discuss these characterizations and present an extension to infinite $\mathbf{A}$ with a complete lattice reduct. (Received August 12, 2013)

1092-06-306 **Teena Carroll*** (ccarroll@ehc.edu), Emory & Henry College, Department of Mathematics, Emory, VA 24327. *Excluding Subposets in Boolean Set Systems.*

This talk will present bounds on the largest Boolean Set system which contains no induced V, i.e. the set system contains no three distinct sets A,B,C so that $C \subseteq A \cap B$ and $A \not\subset B$ (Joint work with Gyula Katona). The talk will include a history of similar extremal problems including Sperner's Lemma, considering them as questions of avoiding certain structures within a set system, and discuss the difficulties in avoiding induced substructures. (Received August 12, 2013)

1092-06-308 **William DeMeo*** (williamdemeo@gmail.com). *Finite group properties deducible from local subgroup lattice structure.*

We recently proposed classifying a group property according to whether or not we can deduce that a group has this property if its subgroup lattice contains an interval of a certain shape. More precisely, suppose $\mathcal{X}$ is a group property and suppose there exists a lattice L such that if G is a group and L is isomorphic to an interval $\{K : H \leq K \leq G\}$ in the subgroup lattice, with H a core-free subgroup of G, then G has property $\mathcal{X}$. We call such $\mathcal{X}$ a "core-free interval enforceable" property. In this talk we list some group properties that we have been able to classify as either core-free interval enforceable or not, and then we describe how the study of such properties might lead to an example of a finite lattice that is not the congruence lattice of a finite algebra. (Received August 12, 2013)

1092-06-330 **Peter Jipsen*** (jipsen@chapman.edu), Chapman University, School of Computational Sciences, One University Drive, Orange, CA 92866, and **Nathan Lawless** (lawle108@mail.chapman.edu). *An orderly algorithm to enumerate (semi)modular lattices.*

Heitzig and Reinhold [2002] developed an efficient algorithm to enumerate all finite lattices up to isomorphism and used it to count the number of lattices up to size 18. Here we present an improvement and adaptation of this algorithm which is used to construct all modular lattices up to size 23, all semimodular lattices up to

size 22 and all lattices up to size 19. We also use this approach to enumerate other types of lattices such as semidistributive, two-distributive and selfdual lattices. Additionally we prove that up to isomorphism there are at least 2^{n-3} modular lattices of size n. (Received August 13, 2013)

1092-06-358 **Andrew J Ylvisaker***, 700 E. Broadway, Monmouth, IL 61462. *Spectra in sub-signatures of* RA.

We present some early results from an investigation into the impact of removing certain operations from the signature of a relation algebra. This is joint work with Jeremy Alm. (Received August 13, 2013)

08 ► General algebraic systems

1092-08-3 **Ralph McKenzie***, Vanderbilt University, Department of Mathematics, Nashville, TN. *A perspective on fifty years of work, delight and discovery in general algebra.*

I conceive the talk to be like a ramble through general algebra and related fields of mathematics such as logic, model theory, graph theory and computational complexity. It will be in part a highly personal and biased offering of some of my reflections on personalities, good results and false starts collected over a long career in research. But also, I will strive to convey a convincing picture of a youthful field currently enjoying a vigorous state of healthy development. (Received March 18, 2012)

1092-08-42 **Alexander Wires*** (slawkenbergius@hotmail.com). *Finite Taylor algebras, Pointing Terms, and Cubed Elements.* Preliminary report.

Following the use of *pointed elements* and *pointing terms* in the proof of robust satisfiability for algebras of bounded width (ECCC Report No.163,2011), Barto and Kozik recently announced that pointed elements can in fact charactize such algebras. A property of an algebra is said to be *hereditary* if every subalgebra inherits that property. They claim that an idempotent finite algebra generates a congruence meet-semidistributive variety iff the existence of pointed elements is hereditary.

We extend the notion of a pointing term and define *cubed elements* for algebras. We show a finite idempotent algebra generates a Taylor variety iff the existence of cubed elements is hereditary. We discuss the connection with admissible relations and the constraint satisfaction problem. (Received July 15, 2013)

1092-08-77 **Jonah Horowitz*** (jonah.horowitz@gmail.com). *A Syntactic Approach to Linear Idempotent Mal'cev Conditions.*

Linear Idempotent Mal'cev conditions are key to the study of the complexity of constraint satisfaction problems. Naturally then, we wish to know how to distinguish those clones which satisfy a particular Mal'cev condition from those which do not. Building on the work of Freese and Valeriote (2009), we develop a class of Mal'cev conditions whose satisfaction can be reduced to a local question, when the clone under consideration is idempotent.

Initially we define the sort of Mal'cev condition we are examining and proceed to explain what properties a "local" version of that condition would have. We then prove, by inductive syntactic construction, that when enough such "local" versions are satisfied they produce a term which satisfies the original Mal'cev condition. We proceed to give examples of Mal'cev conditions already in use to which this result can be applied, in particular allowing us to determine whether or not a given finite idempotent algebra satisfies a particular one of these Mal'cev conditions. (Received July 29, 2013)

1092-08-86 **Ralph S Freese*** (ralph@math.hawaii.edu), Department of Mathematics, University of Hawaii at Manoa, Honolulu, HI 96822, and **Ralph N McKenzie** (ralph.n.mckenzie@vanderbilt.edu), Department of Mathematics, Vanderbilt University, Nashville, TN. *Maltsev products of congruence permutable varieties.*

We have shown that the Maltsev product of two congruence permutable (CP) varieties is 4-permutable. Matthew Valeriote has shown the join of two such varieties is 3-permutable. This leaves open the question: is the Maltsev product of two CP varieties 3-permutable? While trying to construct an example disproving this, we were able to prove it is true. (Received July 30, 2013)

1092-08-174 **Alexandr Kazda*** (alex.kazda@gmail.com). *How to decide absorption.* Preliminary report.

While studying the complexity of the Constraint Satisfaction Problem, Libor Barto and Marcin Kozik discovered the idea of absorption. If $B \leq A$ and B absorbs A, then many kinds of connectivity properties of A are also true for B. This is very useful for proofs by induction, and absorption has since played a role in several purely algebraic situations.

After giving a taste of how absorption works, we would like to talk about our current project (with Libor Barto): How to algorithmically decide, given an algebra A with finitely many basic operations and a $B \leq A$, if B absorbs A. (Received August 08, 2013)

1092-08-178 **David M. Clark*** (clarkd@newpaltz.edu). *Algebraic Terms through Simulated Evolution.*
We report on recent successful applications of evolutionary computation to the problem of finding terms to represent arbitrary term operations on a given finite groupoid. Evolution requires that small changes in a term result in small changes in the associated term operation. We will present two readily testable conditions under which a finite groupoid is guaranteed to have this continuity property: a relational condition and an asymptotic condition. We will show evidence that most finite groupoids satisfy both of these conditions, and will then display some very large discriminator terms that were found by evolution and are demonstrably not constructible by previously known methods. (Received August 08, 2013)

1092-08-180 **George F McNulty*** (mcnulty@math.sc.edu), Department of Mathematics, University of South Carolina, Columbia, SC 29208. *The Computational Complexity of the Minimal Variety Problem.* Preliminary report.

An *algebra* is a nonempty set equipped with a system of operations on that set, each having a finite rank. The *variety* generated by an algebra is the smallest class containing the algebra that is closed under the formation of direct products, subalgebras, and homomorphic images. A *minimal* variety is one that contains algebras of more than on element but whose only proper subvariety consists only of one-element algebras.

The Minimal Variety Problem

Input: A finite algebra $\mathbf{A}$ of finite signature.

Problem: Decide if the variety generated by $\mathbf{A}$ is minimal.

We prove that this problem is complete for deterministic doubly exponential time. (Received August 08, 2013)

1092-08-228 **Keith Kearnes**, **Ágnes Szendrei** and **Ross Willard*** (rdwillar@uwaterloo.ca). *Varieties with a difference term and Park's conjecture.*

In the early 1970s, Kirby Baker proved his celebrated finite basis theorem: if a variety $\mathcal{V}$ is finitely generated, congruence distributive, and has just finitely many fundamental operations, then the identities of $\mathcal{V}$ are logically implied by a finite subset of the identities. ($\mathcal{V}$ is said to be *finitely based*.) In his 1976 PhD thesis, Robert Park conjectured a bold generalization of Baker's theorem: if the variety $\mathcal{V}$ is finitely generated, has a finite residual bound, and has just finitely many fundamental operations, then $\mathcal{V}$ is finitely based. Since then, Ralph McKenzie confirmed Park's conjecture for congruence modular varieties (1987), and I confirmed it for congruence meet-semidistributive varieties (2000).

A *difference term* for a variety $\mathcal{V}$ is a term $d(x, y, z)$ which satisfies the identity $d(x, x, y) \approx y$ and the property that $(d(a, b, b), a) \in [\mathrm{Cg}^{\mathbf{A}}(a, b), \mathrm{Cg}^{\mathbf{A}}(a, b)]$ for all $\mathbf{A} \in \mathcal{V}$ and all $a, b \in A$. Every congruence modular variety or congruence meet-semidistributive variety has a difference term. We provide a common generalization of the previous finite basis theorems by confirming Park's conjecture for varieties with a difference term. (Received August 10, 2013)

1092-08-243 **Agnes Szendrei*** (szendrei@euclid.colorado.edu) and **Keith A. Kearnes** (kearnes@euclid.colorado.edu). *Dualizable algebras.* Preliminary report.

Let $\mathbf{A}$ be a finite algebra in a residually small variety with a cube term. I will discuss sufficient conditions which ensure that $\mathbf{A}$ is dualizable. (Received August 11, 2013)

1092-08-251 **Matthew Smedberg***, 1227 Stevenson Center, Department of Mathematics, Vanderbilt University, Nashville, TN 37240. *Permutability of abelian congruences in finitely decidable varieties.* Preliminary report.

Last year, the speaker together with R. McKenzie showed that, if $\mathcal{V}$ is a finitely decidable locally finite variety and $\mathbf{A} \in \mathcal{V}_{\mathrm{fin}}$, then every (strongly) solvable congruence on $\mathbf{A}$ is (strongly) abelian. McKenzie and P. Idziak independently asked whether every two abelian congruences on an algebra in $\mathcal{V}$ must permute. In particular, they conjecture that the largest strongly solvable congruence σ_1 must permute with the largest abelian congruence σ_2 which does not dominate any unary-type cover. In this talk, we discuss this conjecture, together with some of the known obstacles to a proof. (Received August 11, 2013)

1092-08-293 **Dejan Delic*** (ddelic@ryerson.ca), Department of Mathematics, Ryerson University, 350 Victoria St., Toronto, ON M5B 2K3, Canada. *Polymorphisms of Binary Treelike Structures.*

Let $\mathbf{A}$ be a finite relational structure of finite signature τ. Its incidence multigraph $Inc(\mathbf{A})$ is defined as the oriented bipartite multigraph with two parts: the vertices A of the structure and $Block(\mathbf{A})$, which consists of all tuples in relations of $\mathbb{A}$. A τ-structure $\mathbf{A}$ is said to be *treelike*, or a *τ-tree*, if its incidence multigraph $Inc(\mathbf{A})$ is a tree.

In this talk, we will investigate the treelike structures whose signature consists of a single binary relation and their polymorphisms. (Received August 12, 2013)

1092-08-297 **Ian Payne*** (ipayne@uwaterloo.ca) and **Ross Willard**. *Maltsev Conditions on the Feder-Vardi Reduction to Bipartite Graphs with Constants.* Preliminary report.

In 1998, in the same paper as their dichotomy conjecture for CSP complexity, Feder and Vardi showed that any constraint satisfaction problem is polynomially equivalent to that of a bipartite graph with constants. In fact, they explain how to construct the graph. This talk is an exploration of which Maltsev conditions satisfied by a relational structure are still satisfied by the graph associated to it via this construction. (Received August 12, 2013)

1092-08-332 **Keith A Kearnes*** (kearnes@euclid.colorado.edu). *Residually finite varieties.*

I will speak about what is known about residually finite varieties of finite type which contain infnitely many subdirectly irreducible algebras. (Received August 13, 2013)

1092-08-353 **Matthew D Moore*** (matthew.moore@vanderbilt.edu). *The Variety Generated by $\mathbb{A}(\mathcal{T})$ – Two Counterexamples.*

We show that McKenzie's $\mathcal{V}(\mathbb{A}(\mathcal{T}))$ does not have definable principal subcongruences or bounded Maltsev depth. When the Turing machine $\mathcal{T}$ halts, $\mathcal{V}(\mathbb{A}(\mathcal{T}))$ is an example of a finitely generated semilattice based (and hence congruence $\wedge$-semidistributive) variety with only finitely many subdirectly irreducible members, all finite. This is the first known example of a variety with these properties that does not have definable principal subcongruences or bounded Maltsev depth. (Received August 13, 2013)

1092-08-365 **Peter Mayr*** (peter.mayr@jku.at), Altenberger Straße 69, 4040 Linz, Austria, and **Nik Ruskuc**. *Finiteness properties of direct products.* Preliminary report.

It is well known that the direct product of two groups is finitely generated if and only if both factors are finitely generated. A corresponding result holds for lattices. We show that these facts are not particular for groups or lattices but special instances of results on Mal'cev algebras, idempotent algebras, respectively.

More generally we consider for which algebras and for which finiteness conditions P (finite presentability, residual finiteness, ...) the following statement is true: $A \times B$ has P iff A and B has P. This is joint work with Nik Ruskuc (University of St Andrews). (Received August 13, 2013)

11 ► Number theory

1092-11-4 **Victor Moll***, Tulane University, Department of Mathematics, New Orleans, LA. *2-adic valuations of classical sequences: A collection of examples.*

Given an integer x and a prime number p, the p-adic valuation of x is the highest power of p that divides x. This talk presents a variety of examples showing that, given a sequence $x[n]$ of integers, the sequence obtained by taking the p-adic valuations of $x[n]$ presents interesting challenges. The list of examples include basic sequences in Number Theory such as factorials, binomial coefficients, Fibonacci numbers and others as well as sequences appearing in Combinatorics, such as the Stirling numbers and the ASM numbers counting the number of Alternating Sign Matrices. Interesting phenomena occur even at the most elementary level. The case of sequences coming from quadratic polynomials already illustrate them. (Received March 18, 2012)

1092-11-21 **Dustin Moody*** (dustin.moody@nist.gov), 100 Bureau Drive, Stop 8930, Gaithersburg, MD 21703. *Applications of Edward Isogenies in Cryptography.* Preliminary report.

Isogenies are the structure preserving maps between elliptic curves. As such, isogenies play a key role many areas of elliptic curve cryptography. For example, they have been proposed as a mathematical primitive in the construction of hash functions, pseudo-random generators, as well as new post-quantum public key cryptosystems.

Moody and Shumow have presented a new isogeny formula for elliptic curves known as Edwards curves. This new formula is more efficient than using the standard Velu formula for isogenies. In this work, we examine applications of the Edwards isogeny formula in cryptography. (Received June 17, 2013)

1092-11-206 **Siyu Liu**, **Frank Kschischang** and **Felice Manganiello*** (manganm@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975.
Kötter interpolation in skew polynomial rings.

Skew polynomials are a noncommutative generalization of ordinary polynomials that, in recent years, have found applications in coding theory and cryptography. Viewed as functions, skew polynomials have a well-defined evaluation map; however, little is known about skew-polynomial interpolation. In this talk, we apply Kötter's interpolation framework to free modules over skew polynomial rings. As a special case, we introduce a simple interpolation algorithm akin to Newton interpolation for ordinary polynomials. (Received August 09, 2013)

12 ► Field theory and polynomials

1092-12-91 **Ray Perlner*** (ray.perlner@nist.gov) and **Daniel Smith** (dcsmit11@louisville.edu).
A Classification of Differential Invariants for Multivariate Post-Quantum Cryptosystems.

Multivariate Public Key Cryptography is one of the most promising candidates for designing public key cryptosystems which remain secure in the quantum model of computation. Nonetheless, while a few multivariate systems remain secure after years of cryptanalysis, many have fallen to a surprisingly small pool of cryptanalytic techniques.

This talk summarizes our research, most recently published at PQCrypto 2013, aimed at formalizing requirements for multivariate cryptosystems to resist broad classes of known attacks. The PQCrypto paper focused in particular on attacks based on invariant subspaces derived from the discrete differential of the quadratic maps, which are the public keys of existing multivariate schemes. The most notable cryptosystem which fell to this class of attacks was the balanced oil-and-vinegar scheme. Our research addresses the possibility of similar attacks in the case of big-field schemes, such as the currently unbroken scheme, pSFLASH. (Received July 31, 2013)

1092-12-236 **Tim Hodges*** (timothy.hodges@uc.edu). *Semi-regular Sequences.* Preliminary report.

Systems of multivariate equations $f_1(x_1,\dots,x_n)=0,\dots,f_m(x_1,\dots,x_n)=0$ over a finite field F with q elements are said to be semi-regular if the ideal generated by the highest degree terms $f_1^h(x_1,\dots,x_n),\dots,f_m^h(x_1,\dots,x_n)$ in the ring $F[x_1,\dots,x_n]/(x_1^q,\dots,x_n^q)$ has the 'expected' Hilbert series. It has long been conjectured that such systems are 'generic' in some sense. However little concrete is known about this conjecture. We discuss recent results and specific conjectures concerning semi-regular sequences. (Received August 10, 2013)

1092-12-323 **Maria Evelina Rossi** and **Liana M Sega*** (segal@umkc.edu). *Poincaré series of modules over compressed Gorenstein local rings.*

Given two positive integers e and s we consider Gorenstein Artinian local rings R whose maximal ideal $\mathfrak{m}$ satisfies $\mathfrak{m}^s\neq 0=\mathfrak{m}^{s+1}$ and $\operatorname{rank}_{R/\mathfrak{m}}(\mathfrak{m}/\mathfrak{m}^2)=e$. We say that R is a *compressed Gorenstein local ring* when it has maximal length among such rings. It is known that generic Gorenstein Artinian algebras are compressed. If $s\neq 3$, we prove that the Poincaré series of all finitely generated modules over a compressed Gorenstein local ring are rational, sharing a common denominator. A formula for the denominator is given. When s is even this formula depends only on the integers e and s. Note that for $s=3$ examples of compressed Gorenstein local rings with transcendental Poincaré series exist, due to Bøgvad. (Received August 12, 2013)

13 ► Commutative rings and algebras

1092-13-23 **William Hoffman** and **Haohao Wang*** (hwang@semo.edu), Math Department, MS6700, Cape Girardeau, MO 63701. *Minimal generators for the Rees algebra associated to the quadratically parametrized surface.*

Let f_0,f_1,f_2,f_3 be linearly independent homogeneous quadratic forms in the standard $\mathbf{Z}$-graded ring $R:=\mathbf{K}[s,t,u]$, and $\gcd(f_0,f_1,f_2,f_3)=1$. This defines a rational map $\phi:\mathbf{P}^2\to\mathbf{P}^3$. The Rees algebra $\operatorname{Rees}(I)=R\oplus I\oplus I^2\oplus\cdots$ of the ideal $I=\langle f_0,f_1,f_2,f_3\rangle$ is the graded R-algebra which can be described as the image of an R-algebra homomorphism h: $R[x,y,z,w]\to\operatorname{Rees}(I)$. This presentation discusses the free resolutions of I, and the structure of the $\ker(h)$. (Received June 25, 2013)

1092-13-39 **Stefan O Tohaneanu*** (stohanea@uwo.ca), Department of Mathematics, University of Idaho, Moscow, ID 83844. *Hyperplane arrangements with many (two) Euler vector fields.* Preliminary report.

Let $\mathcal{A} \subset \mathbb{P}^{k-1}$ be a rank k complex arrangement of n hyperplanes, containing the coordinate hyperplanes. Every hyperplane arrangement has an Euler vector field due to the Euler formula for homogeneous polynomials. Any other Euler vector field translates into a linear syzygy on the Jacobian ideal of the defining polynomial of $\mathcal{A}$. In this special case, the points dual to the hyperplanes lie on an eigen-scheme. The primary decomposition of the defining ideal of this scheme shows that $\mathcal{A}$ is a product of smaller arrangements. Also, we will see that this ideal is the edge ideal of a complete multipartite graph. (Received July 12, 2013)

1092-13-45 **Sankar P Dutta*** (dutta@math.illinois.edu), 1409 W. Green Street, Urbana, IL 61801. *The Order Ideal Conjecture.* Preliminary report.

In this talk first we introduce the Order Ideal Conjecture originating from the work of Evans & Griffith on characterization of the behavior of order ideals of minimal syzygies of modules of finite projective dimension on equicharacteristic local rings. We point out that a very special case of this conjecture on regular local rings implies the monomial conjecture due to Hochster. We derive a necessary and sufficient condition for the validity of this special case in terms of whether certain syzygies of canonical modules of normal domains possess free summands and present several aspects of this observation. Finally we extend a result of Bruns & Herzog on the order ideal theorem in equicharacteristic to mixed characteristic. (Received July 16, 2013)

1092-13-56 **Sema Gunturkun*** (gunturkun@ms.uky.edu) and **Uwe Nagel** (uwe.nagel@uky.edu). *A Construction of Homogeneous Gorenstein Ideals.* Preliminary report.

In 1983 Kustin and Miller introduced a construction of Gorenstein ideals in local rings. We review their construction in the case of graded rings and modify it by avoiding ring extensions. We also discuss this construction with respect to liaison theory. (Received July 22, 2013)

1092-13-57 **Pye Phyo Aung***, pye.aung@ndsu.edu. *Amalgamated Duplication, Pseudocanonical Covers, and Gorenstein Homological Algebra.* Preliminary report.

When E is a semidualizing module over a commutative ring, Holm and Jørgensen studied some connections between E-Gorenstein injectivity/projectivity and Nagata's trivial extension. We generalized some of those results to other general constructions including D'Anna and Fontana's amalgamated duplication of a ring along an ideal and Enescu's pseudocanonical covers. We also identified some key properties of those general constructions that enable their connections to Gorenstein injectivity and projectivity. (Received July 22, 2013)

1092-13-58 **Hannah Altmann*** (hannah.altmann@ndsu.edu). *Semidualizing modules (and complexes) over tensor products.* Preliminary report.

Let R be a commutative, noetherian ring with identity. An R-module C is *semidualizing* if C is finitely generated over R, the homethety map $\chi_C^R : R \to \mathrm{Hom}_R(C, C)$ is an isomorphism, and $\mathrm{Ext}^i_R(C, C) = 0$ for all $i > 0$. We will discuss the existence of nontrivial semidualizing modules (and complexes) over tensor products. (Received July 22, 2013)

1092-13-79 **Fabrizio Zanello*** (zanello@math.mit.edu), Department of Mathematics, Office 2-330, MIT, Cambridge, MA 02139-4307. *Some recent developments on the Interval Property.*

We discuss some recent results concerning the Interval Property (IP). A set S of integer sequences is said to have the IP if, for $h, h' \in S$ coinciding in all entries but one, say $h = (h_0, \dots, h_{i-1}, h_i, h_{i+1}, \dots)$ and $h' = (h_0, \dots, h_{i-1}, h_i + a, h_{i+1}, \dots)$ for some $a \geq 1$, we have $(h_0, \dots, h_{i-1}, h_i + b, h_{i+1}, \dots)$ also in S, for $b = 1, 2, \dots, a-1$.

The IP holds for many sequences of interest in combinatorial algebra and combinatorics, and has recently been studied in several new contexts. These include the Hilbert functions of level and Gorenstein algebras, where I first conjectured the IP and it is still wide open (J. Algebra, 2009); and pure O-sequences (the "BMMNZ" AMS Memoir, 2012). For these latter, it proved to be a helpful tool to solve Stanley's matroid h-vector conjecture in rank 3 (joint work with T. Hà and E. Stokes; Annals of Comb., 2013), and then it was disproved in large socle degree (Constantinescu-Varbaro, preprint).

In this talk, I show that the Interval Property fails in general for pure f-vectors (joint with A. Pastine; Proc. AMS, 2013), and for r-differential posets when r is large (joint with R. Stanley; E-JC, 2012), though some initial data suggests it might hold for the main class of 1-differential posets. (Received July 29, 2013)

1092-13-80 **Craig Huneke**, **Paolo Mantero**, **Jason McCullough** and **Alexandra Seceleanu*** (aseceleanu@unl.edu). *A tight bound for projective dimension: the case of codimension two quadratic ideals.*

Motivated by a question of Stillman, there has been a great surge of interest in bounding homological invariants of ideals in a polynomial ring using only intrinsic information on the ideal (namely the degree of its generators). In this talk, we discuss a sharp upper bound for the projective dimension of ideals of height two generated by quadrics in a polynomial ring with arbitrary large number of variables. We compare this with the exponential bound described more generally by Ananyan and Hochster for ideals generated by quadratic polynomials. (Received July 29, 2013)

1092-13-81 **Brian Harbourne** and **Alexandra Seceleanu*** (aseceleanu@unl.edu). *Regular versus symbolic powers for ideals of points.*

When I is the radical homogeneous ideal of a finite set of points in projective N-space, it has been conjectured by Harbourne and Huneke that $I^{(rN-N+1)}$ should be contained in I^r for all $r \geq 1$. A recent counterexample of Dumnicki, Szemberg and Tutaj-Gasinska shows that this can fail when $N = r = 2$. In this talk, we show that failures occur for infinitely many r in every characteristic $p > 2$ when $N = 2$ and we find additional positive characteristic failures when $N > 2$. (Received July 29, 2013)

1092-13-82 **Chris Francisco*** (chris@math.okstate.edu), Department of Mathematics, 401 MSCS, Oklahoma State University, Stillwater, OK 74078, and **Jeffrey Mermin** and **Jay Schweig**. *Catalan numbers, binary trees, and pointed pseudo-triangulations.* Preliminary report.

We describe explicit bijections between Eliahou-Kervaire symbols of certain Borel ideals and pointed psuedo-triangulations of the single chain, objects of interest in discrete geometry. Binary trees serve as a convenient intermediary between the two types of objects. (Received July 29, 2013)

1092-13-85 **Ananthnarayan Hariharan**, **Ela Celikbas** and **Zheng Yang*** (s-zyang8@math.unl.edu), 203 Avery Hall, Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Associated graded rings and connected sums.*

A connected sum is a construction that can be used to produce Gorenstein rings. We will explore some connections between associated graded rings and connected sums. In particular, we will look at conditions on the associated graded ring of a Gorenstein Artin k-algebra Q, which force Q to be a connected sum. We will see some applications if time permits. (Received August 14, 2013)

1092-13-103 **Craig Huneke**, **Srikanth Iyengar** and **Roger Wiegand*** (rwiegand@math.unl.edu). *Torsion in the tensor product $M \otimes_R M^*$.* Preliminary report.

Let $(R, \mathfrak{m})$ be a local Gorenstein domain and M a maximal Cohen-Macaulay R-module which is free on the punctured spectrum. In 1994 Huneke and Wiegand [Tensor products of modules and the rigidity of Tor, *Math. Ann.* **299** (1994), 449–476] conjectured that if $M \otimes_R M^*$ is maximal Cohen-Macaulay then M must be free. (Here M^* is the dual $\mathrm{Hom}_R(M, R)$.) The conjecture is still open (even when R is a one-dimensional complete intersection and M is an ideal of R). Here we discuss the related question: If $M \otimes_R M^*$ is torsion-free, must M be free? For complete intersections of even positive dimensions, the answer is "yes", but there are examples in odd dimensions ≥ 3 where the answer is negative. (Received August 02, 2013)

1092-13-111 **Yi ZHANG*** (zhang397@umn.edu), 1409 W Green St, Department of Mathematics, Urbana, IL 61801. *Toward an efficient algorithm for deciding the vanishing of local cohomology modules in prime characteristic.* Preliminary report.

Let $R = k[x_1, \cdots, x_n]$ be a polynomial ring over a field k of characteristic $p > 0$. If I is an ideal of R, we denote $H^i_I(R)$ the i-th local cohomology module of R with support in I. We describe an algorithms to determine the vanishing of $H^i_I(R)$. The method we use is the F-module theory. (Received August 04, 2013)

1092-13-118 **Brian Harbourne*** (bharbourne1@unl.edu), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588. *Computational aspects of resurgences.* Preliminary report.

The resurgence for a nontrivial homogeneous ideal I in a polynomial ring is the least value ρ such that $m/r > \rho$ guarantees that the power I^r contains the symbolic power $I^{(m)}$. I will discuss what is known about computing values of the resurgence. (Received August 05, 2013)

1092-13-128 **Ragnar-Olaf Buchweitz**, **Graham Leuschke*** (gjleusch@math.syr.edu) and **Michel Van den Bergh**. *Pieri maps and the bound Young quiver.*

The irreducible polynomial representations $L^\alpha V$ of $\mathrm{GL}(V)$ are well-known to be indexed by partitions α with at most $\dim(V)$ parts. The Pieri rules for decomposing the tensor products $V \otimes L^\alpha V$ and $V^* \otimes L^\alpha V$ into irreducibles defines, up to some choices of scalars, a system of split inclusions between those representations related by adding or removing a single box from the partitions. The scalars cannot be chosen with complete freedom; in particular there are some unavoidable non-commutativity relations among the Pieri maps. We build a quiver out of the data of partitions, maps, and relations, and show that the path algebra of this bound quiver is a non-commutative desingularization of a generic determinantal ring. (Received August 06, 2013)

1092-13-130 **Sandra Spiroff*** (spiroff@olemiss.edu), Department of Mathematics, P.O. Box 1848, Hume Hall 335, University, MS 38677, and **Sean Sather-Wagstaff**. *A result on maps of divisor class groups.*

We discuss a generalization of a result by P. Griffith and D. Weston regarding torsion elements in the kernel of the map on divisor class groups determined by restriction to hypersurfaces. For an ideal I of finite projective dimension in an excellent local normal domain A, there is map on divisor class groups from Cl(A) to Cl(A/I). We investigate whether the kernel of this map contains any torsion elements. (Received August 06, 2013)

1092-13-134 **David Cook II*** (dcook8@nd.edu), Department of Mathematics, 255 Hurley Building, University of Notre Dame, Notre Dame, IN 46556-4618. *Cellular resolutions of non-squarefree ideals associated to simplicial complexes.*

We introduce the uniform face ideal of a simplicial complex with respect to a given ordered proper vertex colouring. We show that this monomial ideal has a minimal cellular resolution supported on a cubical complex if the colouring satisfies a certain nesting property. Using this, we give the graded Betti numbers in terms of the face-vector of the underlying simplicial complex. (Received August 06, 2013)

1092-13-139 **Saeed Nasseh** and **Sean Sather-Wagstaff*** (sean.sather-wagstaff@ndsu.edu). *Local rings of codepth at most 3 have only trivial semidualizing complexes.* Preliminary report.

We show that a local ring of codepth at most 3 has only trivial semidualizing complexes up to shift-isomorphism, namely, the free module of rank 1 and the dualizing complex if one exists. (Received August 06, 2013)

1092-13-150 **Stephen Sturgeon*** (stephen.sturgeon@uky.edu) and **Uwe Nagel**. *Cellular Resolutions of some Gorenstein Rings.* Preliminary report.

Cellular resolutions are a way of giving a geometric structure to the resolution of a monomial ideal. Although several general methods have been investigated, the resulting resolutions are rarely minimal. Our work has focused on the Stanley-Reisner rings of some simplicial polytopes. These rings are Gorenstein. We construct cell complexes which are cellular decompositions of balls that support the minimal free resolutions of these ideals. The structure of our cell complex is very explicit and the relationships among cells is easy to see. In some cases we can show these cell complexes are actually polytopes and we give an embedding. We also propose a method for constructing cellular resolutions that we believe will generalize to a larger family of ideals. (Received August 07, 2013)

1092-13-162 **Javid Validashti***, Department of Mathematics, University of Illinois, Urbana, IL 61801, and **Craig Huneke** and **Ananth Hariharan**. *Inequalities for Multiplicities.* Preliminary report.

A classical inequality due to Lech states that $e(I) \leq d!\,\lambda(R/I)e(R)$, where $e(I)$ denotes the Hilbert-Samuel multiplicity of a zero-dimensional ideal I in a Noetherian local ring R of dimension d, and λ stands for the length. Simple examples show that this inequality gives a very weak bound for $e(I)$ in general. In this talk, we discuss some improvements and the resulting inequalities on the Hilbert coefficients of I. (Received August 07, 2013)

1092-13-171 **Craig Huneke**, **Paolo Mantero*** (mantero@math.ucr.edu), **Jason McCullough** and **Alexandra Seceleanu**. *Ideals having high multiplicity.* Preliminary report.

Initially motivated by our proof of a very special case of Stillman's Question, we prove an upper bound for the multiplicity of a wide class of Cohen-Macaulay ideals. Remarkably, ideals whose multiplicity achieve this upper bound have high depth and the Cohen-Macaulay property can be detected by a numerical condition. Moreover, there are several analogies between these ideals of 'maximal multiplicity' and ideals of multiplicity one.

We prove a sufficient (implicit) condition for ideals to have 'maximal multiplicity', and we employ it to exhibit classes of ideals satisfying this property (e.g. rational normal scrolls). Finally, we provide applications to

quasi-Gorenstein ideals and a multiplicity-based sufficient condition for quasi-Gorenstein ideals to be Gorenstein. (Received August 08, 2013)

1092-13-185 **Giulio Caviglia*** (gcavigli@math.purdue.edu), Purdue University, Mathematics Department, 150 N. University Street, West Lafayette, IN 47907, and **Manoj Kummini**. *Betti tables of p-Borel-fixed ideals.*

In this note we provide a counter-example to a conjecture of K. Pardue [Thesis, Brandeis University, 1994.], which asserts that if a monomial ideal is p-Borel-fixed, then its $\mathbb{N}$-graded Betti table, after passing to any field does not depend on the field. More precisely, we show that, for any monomial ideal I in a polynomial ring S over the ring $\mathbb{Z}$ of integers and for any prime number p, there is a p-Borel-fixed monomial S-ideal J such that a region of the multigraded Betti table of $J(S \otimes_{\mathbb{Z}} \ell)$ is in one-to-one correspondence with the multigraded Betti table of $I(S \otimes_{\mathbb{Z}} \ell)$ for all fields ℓ of arbitrary characteristic. There is no analogous statement for Borel-fixed ideals in characteristic zero. Additionally, the construction also shows that there are p-Borel-fixed ideals with non-cellular minimal resolutions. (Received August 08, 2013)

1092-13-191 **Anton Dochtermann*** (anton@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33146, and **Fatemeh Mohammadi**. *Cellular resolutions via mapping cones.*

Suppose I is a monomial ideal. One can iteratively obtain a free resolution of I by considering the mapping cone of the map of complexes associated to adding one generator at a time. Herzog and Takayama have shown that this procedure yields a minimal resolution if I has 'linear quotients', in which case the mapping cone in each step cones a Koszul complex onto the previous resolution.

Here we consider cellular realizations of these resolutions. Extending a construction of Mermin we describe a regular CW-complex that supports the resolutions of Herzog and Takayama in the case that I has a 'regular decomposition function'. By varying the choice of chain map we recover other known cellular resolutions, including the 'box of complexes' resolutions of Corso, Nagel, and Reiner and the related 'homomorphism complex' resolutions of Dochtermann and Engström. Other choices yield combinatorially distinct complexes with interesting structure, and suggests a notion of a 'space of cellular resolutions'. (Received August 09, 2013)

1092-13-207 **Ian M Aberbach*** (aberbachi@missouri.edu), Department of Mathematics, University of MIssour, Columbia, MO 65211, and **Aline Hosry** and **Janet Striuli**. *Uniform Artin-Rees results for resolutions.* Preliminary report.

Let (R, m) be a local Noetherian ring. Huneke and Eisenbud raised the question of if, given a finitely generated module M, there exists a uniform Arin-Rees number, i.e., if there exists a $t > 0$ such that for all ideals I and all syzygies of M, $N \subseteq F$ (where F is free), we have $I^n F \cap N \subseteq I^{n-t} N$. They proved some cases where this occurs, and Striuli proved the result when R has dimension one or two. We will outline here how a much more general result holds in general. (Received August 09, 2013)

1092-13-214 **Ela Celikbas**, **Christina Eubanks-Turner** and **Sylvia Wiegand*** (swiegand1@math.unl.edu), Department of Mathematics, University of Nebraska Lincoln, LINCOLN, NE 68588-0130. *Prime ideals in Noetherian polynomial and power series integral domains.* Preliminary report.

We describe the set Spec B of prime ideals of a homomorphic image B of a three-dimensional mixed polynomial/power series ring; that is, $B = R[[x]][y]/Q$, $R[y][[x]]/Q$ or $R[[x]][[y]]/Q$, where R is a one-dimensional Noetherian domain, x and y are indeterminates, Q is a height-one prime ideal of the appropriate ring, and $x \notin Q$. We present properties and a genetic code that describes Spec B as a partially ordered set, where the order is given by inclusion.

If R is a countable ring with infinitely many maximal ideals, these axioms characterize the prime spectra that occur; each genetic code can be realized with the coefficient ring $R = \mathbb{Z}$, the ring of integers. We also give the prime spectra that arise if R is countable and has finitely many maximal ideals; such prime spectra occur for R a localization of $\mathbb{Z}$, and for R a countable Henselian ring. (Received August 09, 2013)

1092-13-218 **Ashwini Bhat**, **Jennifer Biermann*** (jbierman@mtholyoke.edu) and **Adam Van Tuyl**. *Generalized cover ideals and the persistence property.*

Let I be a square-free monomial ideal in $R = k[x_1, \ldots, x_n]$, and consider the sets of associated primes $\mathrm{Ass}(I^s)$ for all integers $s \geq 1$. We introduce a family of square-free monomial ideals that can be associated to a finite simple graph G that generalizes the cover ideal construction. When G is a tree, we show our ideals satisfy the persistence property. We also describe the elements of $\mathrm{Ass}(I^s)$, and explicitly determine the index of stability. (Received August 10, 2013)

1092-13-223 **Andrew R. Kustin*** (kustin@math.sc.edu), University of South Carolina – Math Dept, Columbia, SC 29208, **Liana M. Sega**, University of Missouri, Kansas City, MO 64110, and **Adela Vraciu**, University of South Carolina, Columbia, SC 29208. *Quasi-complete intersection ideals and Tate complexes.*

We examine necessary and sufficient conditions for an ideal I in a local ring R to be a *quasi-complete intersection* (q.c.i.) ideal. Let E be the Koszul complex on a minimal generating set of I. The ideal I is a q.c.i. if $\mathrm{H}_1(E)$ is a free R/I-module and the canonical homomorphism $\bigwedge^{\bullet}_{R/I} \mathrm{H}_1(E) \to \mathrm{H}_\bullet(E)$ is an isomorphism of graded R/I algebras. (Received August 10, 2013)

1092-13-226 **Susan M. Cooper*** (s.cooper@cmich.edu), Department of Mathematics, Central Michigan University, Mt. Pleasant, MI 48859, **Robert Embree** (robertembree@gmail.com), Department of Mathematics and Statistics, Queen's University, Kingston, ON K7L 3N6, Canada, **Huy Tài Hà** (tai@math.tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA 70118, **Andrew H. Hoefel** (ahhoefel@mast.queensu.ca), Department of Mathematics and Statistics, Queen's University, Kingston, ON K7L 3N6, Canada, and **Gregory G. Smith** (ggsmith@mast.queensu.ca), Department of Mathematics and Statistics, Queen's University, Kingston, ON K7L 3N6, Canada. *Containment Problems for Monomial Ideals.*

Much work has gone into investigating the differences between symbolic and regular powers of homogeneous ideals. Motivated by work of Harbourne and Huneke, we explore for which m, i and j we have the symbolic power $I^{(m)}$ contained in $M^j I^i$ where $I \subset k[x_1, \ldots, x_n]$ is a monomial ideal and $M = (x_1, \ldots, x_n)$. For square-free monomial ideals we obtain a certain containment which recovers two conjectures; one of Harbourne–Huneke and one of Bocci–Cooper–Harbourne. We also introduce the symbolic polyhedron of a monomial ideal and use this to explore symbolic powers of non-square-free monomial ideals. (Received August 10, 2013)

1092-13-229 **Uwe Nagel** and **Augustine O'Keefe*** (abok222@uky.edu). *Cellular resolutions of some artinian level monomial ideals.* Preliminary report.

Nagel and Reiner showed that a mixed subdivision of the dilated simplicial complex $d\Delta_n$ supports a minimal cellular resolution of the d^{th} power of the maximal ideal in the ring $k[x_1, \ldots, x_n]$. In this talk we give a procedure on $d\Delta_n$ resulting in a cell complex supporting a minimal free resolution of $\mathfrak{m}^d + \langle x_1^{a_1}, \ldots, x_n^{a_n} \rangle$. (Received August 13, 2013)

1092-13-231 **Courtney Gibbons***, Department of Mathematics, Hamilton College, 198 College Hill Road, Clinton, NY 13323, and **Jack Jeffries**, **Sarah Mayes**, **Claudiu Raicu**, **Branden Stone** and **Bryan White**. *Nonsimplicial decompositions of Betti diagrams.*

We investigate decompositions of Betti diagrams over a polynomial ring within the framework of Boij–Söderberg theory. That is, given a Betti diagram, we decompose it into pure diagrams. Relaxing the requirement that the degree sequences in such pure diagrams be totally ordered, we are able to define a multiplication law for Betti diagrams that respects the decomposition and allows us to write a simple expression the decomposition of the Betti diagram of any complete intersection in terms of the degrees of its minimal generators. This work was done as part of a Mathematical Sciences Research Institute summer graduate workshop in 2011. (Received August 10, 2013)

1092-13-241 **Pinar Celebi Demirarslan**, **Mesut Sahin** and **Ivan Soprunov*** (i.soprunov@csuohio.edu), Department of Mathematics, Cleveland State University, 2121 Euclid Ave, Cleveland, OH 44115. *Self-dual toric complete intersection codes.* Preliminary report.

Toric codes, first introduced by Hansen around 2000, and their generalizations have provided a number of new examples of linear codes whose parameters are better than that of previously known linear codes. They are algebraic geometry codes constructed by evaluating a finite dimensional space of n-variate polynomials over a subset of the algebraic torus $\mathbb{F}^{*n}$. This construction has a nice connection with geometry of integer polytopes, which carry the information about the monomials appearing in the polynomials. We will talk about a recent construction of toric complete intersection codes (TCIC). We will see how the existence of self-dual TCIC translates into a geometric condition on the corresponding integer polytopes. This is a joint work with Pinar Celebi Demirarslan and Mesut Sahin. (Received August 11, 2013)

1092-13-245 **Craig Huneke**, **Paolo Mantero**, **Jason McCullough*** (jmccullough@rider.edu) and **Alexandra Seceleanu**. *Multiple Structures with Arbitrarily Large Projective Dimension.*

Let S be a polynomial ring over an algebraically closed field K. In his study of Stillman's Question, Engheta gave a finite classification of unmixed ideals of S of height 2 and multiplicity 2. For any other height and multiplicity

both at least 2, we give an explicit construction of unmixed ideals of arbitrarily large projective dimension; hence no extension of Engheta's result is possible. Our result also contrasts with Manolache's finite classification of Cohen-Macaulay multiple structures supported on linear subspaces. (Received August 11, 2013)

1092-13-254 **Saeed Nasseh*** (saeed.nasseh@gmail.com) and **Tirdad Sharif** (sharif@ipm.ir).
Andre-Quillen homology and complete intersection dimensions.

This talk is about the relation between the vanishing of Andre-Quillen homology and complete intersection dimensions, and its applications. (Received August 11, 2013)

1092-13-256 **Sara Faridi*** (faridi@dal.ca), Department of Mathematics & Statistics, Dalhousie University, 6316 Coburg Rd. PO BOX 15000, Halifax, NS B3H 4R2, Canada. *Counting the projective dimension of a graph.* Preliminary report.

A popular area of research is finding combinatorial interpretations of algebraic invariants associated to a monomial ideal. In this talk we discuss how to compute the projective dimension of the edge ideal of a graph by considering certain minimal edge covers for the graph itself. In particular, we show that this process is characteristic-free. (Received August 11, 2013)

1092-13-257 **G Colome-Nin**, **C Polini**, **B Ulrich** and **Y Xie*** (xieyucn@gmail.com). *Normalization of ideals.* Preliminary report.

Let R be a Noetherian local ring and I an ideal. Recall the normalization of I is $R[\bar{I}t]$, the integral closure in $R[t]$ of the Rees algebra $R[It]$. This construction is a standard step in the theory of desingularization. One can also use $R[\bar{I}t]$ to build the integral closure $\bar{I}$ of I (indeed, $\bar{I}$ is the degree one component of $R[\bar{I}t]$). It is very important that there are numerical measures to tell the two algebras $R[It]$ and $R[\bar{I}t]$ apart. Polini, Ulrich and Vasconcelos used the first Hilbert coefficient (defined only for ideals that are primary to the maximal ideal) to bound the number of steps of any algorithm that builds $R[\bar{I}t]$ by a succession of graded extensions satisfying Serre's condition S_2. In this talk, we are going to see how these results are generalized to ideals that are not necessarily primary to the maximal ideal. (Received August 11, 2013)

1092-13-258 **Sean Sather-Wagstaff** and **Richard Wicklein*** (wickleinr@morningside.edu).
Codualizing Modules And Complexes. Preliminary report.

Let R be a commutative, noetherian ring. A finitely generated R-module C is said to be semdualizing if $\operatorname{Ext}^i_R(C,C) = 0$ for all $i > 0$ and $R \xrightarrow{\cong} \operatorname{Hom}_R(C,C)$. When R is local, an artinian R-module T is said to be quasidualizing if $\operatorname{Ext}^i_R(T,T) = 0$ for all $i > 0$ and $\widehat{R} \xrightarrow{\cong} \operatorname{Hom}_R(T,T)$. Using the notion of I-cofiniteness, we introduce a unifying notion that recovers each of the above notions as special cases. (Received August 11, 2013)

1092-13-260 **Florian Enescu*** (fenescu@gsu.edu), Department of Mathematics and Statistics, 758 COE, Georgia State University, 30 Pryor Street, Atlanta, GA 30303, and **Sara Malec** (slcmalec@gmail.com), Department of Mathematics and Statistics, Georgia State University, 30 Pryor Street, Atlanta, GA 30345. *Intersection algebras in one variable.*

In this talk I will discuss the properties of the intersection algebra of two ideals in a polynomial ring with finitely many variables over a field, with special emphasis on the one variable case. (Received August 12, 2013)

1092-13-262 **Gioia Failla**, **Chris Peterson*** (peterson@math.colostate.edu) and **Rosanna Utano**.
Remarks on the growth of Numerical Semigroups.

A generalized numerical semigroup is a cofinite submonoid $S \subset \mathbb{N}^d$. The genus of S is the cardinality of $\mathbb{N}^d/S$. This talk will describe algorithms for generating the set of semigroups with a fixed genus and will discuss the asymptotic behavior for their growth. The talk will close with some open problems and some avenues for further research. (Received August 12, 2013)

1092-13-263 **Bruce Olberding*** (olberdin@nmsu.edu), Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003-8001. *One-dimensional local stable rings.* Preliminary report.

A ring R is stable provided every regular ideal of R is projective as a module over its ring of endomorphisms. When R is local, R is stable if and only if every regular ideal has a principal reduction of reduction number at most 1. The class of stable rings includes the one-dimensional local Cohen-Macaulay rings of multiplicity at most 2, as well as rings of higher multiplicity, necessarily analytically ramified. The former are important in the study of modules over Gorenstein rings, while the latter arise in a natural way from generic formal fibers and derivations of higher dimensional local rings. We discuss applications and characterizations of this class of rings. (Received August 12, 2013)

1092-13-265 **Andrew R. Kustin**, **Liana M. Sega** and **Adela N. Vraciu*** (vraciu@math.sc.edu). *Examples of quasi-complete intersection ideals.*

Quasi-complete intersection ideals are ideals that have "exterior" Koszul homology. They include complete intersection ideals and share many of the homological change of rings properties of complete intersections.

We will discuss several constructions and examples of quasi-complete intersections. (Received August 12, 2013)

1092-13-275 **Hamid Kulosman***, Department of Mathatics, University of Louisville, Louisville, KY 40292. *I-adic completions of modules over not necessarily Noetherian rings.* Preliminary report.

Let R be a not necessarily Noetherian commutative ring and I an ideal of R. We will talk about the I-adic completions of modules over R. (Received August 12, 2013)

1092-13-277 **Youngsu Kim*** (kim455@purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907. *Quasi-Gorensteiness of Extended Rees Algebras.*

A ring having a canonical module is called quasi-Gorenstein if it is isomorphic to the canonical module. A quasi-Gorenstein ring is Gorenstein if and only if it is Cohen-Macaulay. We show that for some classes of extended Rees algebras, the quasi-Gorenstein property implies the Gorenstein property. (Received August 12, 2013)

1092-13-296 **Daniel C. Smith*** (daniel-c.smith@louisville.edu). *Faulty Key Size Reduction Mechanisms in Multivariate Public Key Cryptography.*

We will discuss the limitations and weaknesses of some key size reduction tricks for multivariate public key schemes. (Received August 12, 2013)

1092-13-304 **Livia Hummel*** (hummell@uindy.edu). *A look at non-Noetherian grade.*

Several notions of grade have been developed for use in the non-Noetherian (coherent) context; early characterizations include Hochster's notion of polynomial-grade and Barger's notions of "Koszul" and "Rees" grades. Alfonsi later generalized these notions of grade. Polynomial grade, and its homological characteristics, played an important role in the development of the theories for non-Noetherian Cohen-Macaulay and Gorenstein rings. This talk will explore the connections between these non-Noetherian grades, their properties, and their applications. (Received August 12, 2013)

1092-13-312 **Emilie Dufresne** and **Jack Jeffries*** (jeffries@math.utah.edu). *How many invariants are needed to separate orbits?*

The study of separating invariants is a new trend in invariant theory. A separating set for a finite group $G \leq \mathrm{GL}_n(K)$ is a set of invariants whose elements separate the orbits of G. Separating sets often exhibit better behavior than generating sets for the ring of invariants: for example, there always exist separating sets consisting of elements of degree no greater than $|G|$.

We consider the question of what the least cardinality of a separating set is for G. Our main result is a lower bound on this size that generalizes the classical result of Serre that if the ring of invariants is polynomial then the group action must be generated by (pseudo-)reflections and related results by Dufresne. We find these bounds to be sharp in a wide range of examples. (Received August 12, 2013)

1092-13-326 **Janet Striuli*** (jstriuli@fairfield.edu), Fairfield, CT 06824. *Construction of Totally Reflexive modules.*

In this talk we will give a construction of totally reflexive modules under certain assumptions. The results are similar to the ones due to Celikbas, Gheibi, and Takahashi, but avoid the condition that certain rings are G-regular. (Received August 13, 2013)

1092-13-357 **Kosmas Diveris***, diveris@stolaf.edu, and **Marju Purin**. *Eventual vanishing of self-extensions over self-injective rings.*

The Auslander-Reiten (AR) quiver of an Artin algebra is a combinatorial device for organizing the indecomposable modules over the algebra. For commutative self-injective rings (and even a bit more generally), the combinatorial structure of this quiver is well suited for investigating modules with eventually vanishing self-extensions. In fact, one can determine when the vanishing of self-extensions must begin for any such module based on its position in the AR quiver. In this talk, we will explain how one can use the combinatorial data of the AR quiver to prove this and discuss connections with conjectures of Tachikawa, Auslander and Reiten. (Received August 13, 2013)

1092-13-360 **Florian Enescu** (fenescu@gsu.edu) and **Yongwei Yao*** (yyao@gsu.edu), Department of Math & Stat, Georgia State University, Atlanta, GA 30303. *The Frobenius Complexity.* Preliminary report.

Let R be a commutative ring with prime characteristic p. For any R-module M, there is *algebra of Frobenius operators*

$$\mathcal{F}(M) := \oplus_{e\geq 0}\mathcal{F}^e(M)$$

in which $\mathcal{F}^e(M)$ consists of all $\mathbb{Z}$-linear maps $h\colon M \to M$ such that $h(rm) = r^{p^e}h(m)$ for all $r \in R$ and $m \in M$. A very interesting case is when $M = E := E_R(R/\mathfrak{m})$ over a local ring $(R, \mathfrak{m})$; and there are several ways to interpret the ring $\mathcal{F}(E)$.

As $\mathcal{F}(E)$ may not be finitely generated over $\mathcal{F}^0(E)$ in general, we would like to find ways to measure how far away $\mathcal{F}(E)$ is from being finitely generated over $\mathcal{F}^0(E)$. In particular, we define the *Frobenius complexity* of $\mathcal{F}(E)$.

Moreover, cases of low dimension are examined. Some concrete examples are computed. This is joint work with Florian Enescu. (Received August 13, 2013)

1092-13-366 **Kosmas Diveris*** (diveris@stolaf.edu), diveris@stolaf.edu. *Exceptional modules over some Gorenstein rings.* Preliminary report.

A module M is said to be exceptional if $\mathrm{Ext}^1(M, M) = 0$. Over certain classes of Gorenstein rings, examples of non-projective exceptional modules are, as their name suggests, quite rare. In this talk we will present results that help us understand why this is so and discuss connections with some open homological questions. (Received August 13, 2013)

1092-13-374 **Jack Jeffries** (jeffries@math.utah.edu), Department of Mathematics, University of Utah, 155 S 1400 E, Salt Lake City, UT 84112, **Jonathan Montaño*** (jmontano@math.purdue.edu), Department of Mathematics, Purdue University, 150 North University Street, West Lafayette, 47904, and **Matteo Varbaro** (varbaro@dima.unige.it), Dipartimento di Matematica, Universit'a di Genova, Via Dodecaneso, 35, 16146, Genova, Italy. *Multiplicities of Classical Varieties.*

The j-multiplicity plays an important role in the intersection theory of Stückrad-Vogel cycles, while recent developments confirm the connections between the ϵ-multiplicity and equisingularity theory. In this talk, I will report joint work with Jack Jeffries and Matteo Varbaro, where we are able to compute the j-multiplicity of all the ideals defining rational normal scrolls by establishing a relationship between the j-multiplicity of an ideal and the degree of its fiber cone. We are also able to express the j- and ϵ-multiplicity of ideals defining determinantal varieties as the integral of a polynomial over a region. (Received August 13, 2013)

14 ► *Algebraic geometry*

1092-14-208 **Bill Robinson*** (robinsonwm@uky.edu). *On a Class of Determinantal Ideals.*

We will discuss a class of ideals determined by taking minors in a subregion of a matrix of indeterminates, called a skew tableau, and also in a reflected version of this considered as a subregion of a symmetric matrix. We will use liaison-theoretic tools to investigate properties of these ideals, and study their liaison classification. (Received August 09, 2013)

1092-14-300 **Sarah Anderson*** (sarah5@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975, **Gretchen L. Matthews** (gmatthe@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975, and **Akeel Omairi** (aomairi@clemson.edu), Department of Mathematical Sciences, Clemson University, Clemson, SC 29634-0975. *On stopping sets of algebraic geometry codes.* Preliminary report.

Stopping sets of Reed-Solomon codes and algebraic geometry codes from elliptic function fields have been determined. In this talk, we consider stopping sets of other algebraic geometry codes. (Received August 12, 2013)

1092-14-336 **Justin D. Peachey*** (jupeachey@davidson.edu). *Applications of function fields arising from certain linearized polynomials to compressed sensing.*

In 2012, Li, Gao, Ge, and Zhang constructed compressed sensing matrices from codes from the Hermitian function field. These matrices provided better parameters than previous deterministic constructions. The extended norm-trace function field $\mathbb{F}_{q^r}(x,y)/\mathbb{F}_{q^r}$ is defined by

$$x^u = L(y),$$

where $L(y) = \sum_{i=0}^{d} a_i y^{q^i}$ is a linearized polynomial with $a_0, a_d \neq 0$, and q^d distinct roots in $\mathbb{F}_{q^r}$. This function field generalizes both the norm-trace function field and the Hermitian function field.

Our work has yielded explicit bases for certain Riemann-Roch spaces of this function field. In this talk, we explore the applications of the resulting algebraic geometric codes to construction of compressed sensing matrices using the construction of Li, et al. We discuss when our results can yield better parameters than those previously known. (Received August 13, 2013)

15 ► Linear and multilinear algebra; matrix theory

1092-15-273 **Heide Gluesing-Luerssen** and **Carolyn Troha*** (carolyn.troha@uky.edu). *Irreducible Cyclic Orbit Codes.*

After subspace codes were introduced in 2008 by Koetter and Kschischang most constructions involved the lifting of matrix codes. However, Rosenthal et al. introduced in 2011 a new method of constructing constant dimension subspace codes by using a group action of $\mathrm{GL}_n(\mathbb{F}_q)$ on $PG(q,n)$, called orbit codes. A specific subset of these codes, which have been studied more in depth, are irreducible cyclic orbit codes. In this talk, I will introduce the construction of an irreducible cyclic orbit code as well as explore a method to find the cardinality and distance of such a code. This is based on joint work with Heide Gluesing-Luerssen. (Received August 12, 2013)

17 ► Nonassociative rings and algebras

1092-17-78 **Randall R. Holmes*** (holmerr@auburn.edu), Department of Mathematics and Statistics, 221 Parker Hall, Auburn University, Auburn, AL 36849, and **David P. Turner**. *The coefficient coalgebra of a symmetrized tensor space.*

The coefficient coalgebra of r-fold tensor space and its dual, the Schur algebra, are generalized in such a way that the role of the symmetric group Σ_r is played by an arbitrary subgroup of Σ_r. The dimension of the coefficient coalgebra of a symmetrized tensor space is computed and the dual of this coalgebra is shown to be isomorphic to the analog of the Schur algebra. (Received July 29, 2013)

18 ► Category theory; homological algebra

1092-18-151 **Furuzan Ozbek*** (furuzanozbek@uky.edu), **Sergio Estrada** (sestrada@um.es) and **Pedro Guil Asensio** (paguil@um.es). *A Sufficient Condition for Covering Ideals.* Preliminary report.

Ideal approximation theory has been recently introduced by Herzog, Fu, Guil Asensio and Torrecillas. In this talk we will give sufficient conditions for an ideal of morphisms to be covering and show how our result can be used to obtain an alternate proof for the existence of phantom covers. (Received August 07, 2013)

1092-18-259 **Olgur Celikbas**, **Lars Winther Christensen**, **Li Liang** and **Greg Piepmeyer*** (gpiepmeyer@columbiabasin.edu). *Stable Homology.* Preliminary report.

I will discuss a way to compute stable Tor which immediately and obviously computes Tate Tor when the ring is quasi- Frobenious, and which in general computes Tate Tor when the first module is of finite Gorenstein projective dimension and when Gorenstein projective modules are Gorenstein flat. The latter condition holds, for instance, when the ring is noetherian. (Received August 11, 2013)

1092-18-328 **Kiriko Kato*** (kiriko@mi.s.osakafu-u.ac.jp). *Triangulated subcategories of extensions and triangles of recollements.*

This is joint work with Peter Jørgensen. Let $\mathcal{T}$ be a triangulated category with triangulated subcategories $\mathcal{X}$ and $\mathcal{Y}$. We show that the subcategory of extensions $\mathcal{X} * \mathcal{Y}$ is triangulated if and only if every morphism from $\mathcal{X}$ to $\mathcal{Y}$ is factored through an object of $\mathcal{X} \cap \mathcal{Y}$. In this situation, we show that there is a stable t-structure $(\frac{\mathcal{X}}{\mathcal{X}\cap\mathcal{Y}}, \frac{\mathcal{Y}}{\mathcal{X}\cap\mathcal{Y}})$ in $\frac{\mathcal{X}*\mathcal{Y}}{\mathcal{X}\cap\mathcal{Y}}$. We use this to give a recipe for constructing recollements and triangles of recollements. (Received August 13, 2013)

20 ► Group theory and generalizations

1092-20-25 **Cecil A. Ellard*** (cellard@ivytech.edu). *Local Rationality.* Preliminary report.

We discuss a global characterization of rational group elements, and prove a similar local characterization, using Galois theory. We then give a separate proof that the global and local hypotheses are equivalent, using Dirichlet's theorem on prime numbers in arithmetic sequences. (Received June 29, 2013)

28 ► Measure and integration

1092-28-38 **Matthew Badger*** (badger@math.sunysb.edu) and **Raanan Schul**. *Multiscale analysis of 1-rectifiable measures.*

We repurpose tools from the theory of quantitative rectifiability to study the qualitative rectifiability of measures in n-dimensional Euclidean space, $n \geq 2$. To each locally finite Borel measure μ, we associate a function $\widetilde{J}_2(\mu, x)$ which uses a weighted sum to record how closely the mass of μ is concentrated on a line in the triples of dyadic cubes containing x. This function is a "geometric analogue" of a square function from harmonic analysis. We show that $\widetilde{J}_2(\mu, \cdot) < \infty$ μ-almost everywhere is a necessary condition for μ to give full mass to a countable family of rectifiable curves. This confirms a conjecture of Peter Jones from 2000. A novelty of this result is that no assumption is made on the upper Hausdorff density of the measure. Thus we are able to analyze general 1-rectifiable measures, including measures which are singular with respect to 1-dimensional Hausdorff measure. (Received July 12, 2013)

34 ► Ordinary differential equations

1092-34-15 **Daniel C. Biles*** (daniel.biles@belmont.edu), Dept. of Math. and CS, Belmont University, 1900 Belmont Blvd., Nashville, TN 37212, and **John S. Spraker**. *Existence of positive solutions for a fourth order differential inclusion.*

We prove an existence result for positive solutions of a fourth order differential inclusion. The proof is accomplished through the use of Green's functions and a fixed point theorem. One of the technical assumptions is explored in detail. (Received May 18, 2013)

1092-34-24 **Johnny Henderson*** (johnny_henderson@baylor.edu), Department of Mathematics, Baylor University, Waco, TX 76798-7328. *Existence of local solutions for second order boundary value problems with integral conditions.*

Several basic fixed point theorems are applied for the existence of local solutions of the second order ordinary differential equation, $y'' + f(x, y, y') = 0$, satisfying the respective Dirichlet and nonlocal integral boundary conditions, $y(a) = A$ and $\int_a^b y(x)dx = B$. (Received June 26, 2013)

1092-34-32 **Douglas R. Anderson*** (andersod@cord.edu), Department of Mathematics, 901 8th Street S, Concordia College, Moorhead, MN 56562. *Green's functions for fourth-order four-point boundary value problems.*

We determine Green's functions and their positivity for two fourth-order four-point boundary value problems, namely

$$-y^{(4)}(t) = 0, \quad 0 < t < 1$$
$$y(0) = y(1) = y''(\xi) = y''(1 - \xi) = 0$$

for the interior inflection point $\xi \in (1/3, 1/2)$, and

$$-y^{(4)}(t) = 0, \quad 0 < t < 1$$
$$y(0) = y''(p) = y'(q) = y'''(1) = 0,$$

where the boundary points p and q satisfy $\frac{2}{3}q < p < q \leq \frac{1}{2}$. These boundary conditions are not covered in the literature. Upper and lower bounds for Green's functions are also found. (Received July 10, 2013)

1092-34-96 **Jeffrey Thomas Neugebauer*** (jeffrey.neugebauer@eku.edu), Eastern Kentucky University, Richmond, KY 40475. *Existence of Positive Solutions of a Right Focal Fractional Boundary Value Problem.*

A recent fixed point theorem, an extension of the Leggett-Williams fixed point theorem, is applied to a fractional differential equation with order between 1 and 2 satisfying right focal boundary conditions to show the existence of positive solutions of the boundary value problem. (Received August 01, 2013)

1092-34-97 **M N Islam*** (mislam1@udayton.edu), Department of Mathematics, University of Dayton, Dayton, OH 45469-2316. *Fractional differential equations of Caputo type and asymptotically stable solutions.* Preliminary report.

The existence of asymptotically stable solutions of a fractional differential equation of Caputo type has been studied in this paper. The results are obtained from an equivalent Volterra integral equation which is derived by inverting the fractional differential equation. The kernel function of this integral equation is weakly singular and hence the standard techniques that are normally applied on Volterra integral equations do not apply here. This hurdle is overcomed using a resolvent equation and then applying some known properties of the resolvent. In addition to the resolvent, the fixed point theorem of Schauder has been employed in the analysis. (Received August 01, 2013)

1092-34-129 **Jeffrey W. Lyons*** (jlyons@nova.edu), FAR-MCT, Nova Southeastern University, 3301 College Avenue, Fort Lauderdale, FL 33314, and **Jeffrey T. Neugebauer**. *Existence of symmetric and anti-symmetric solutions for second order boundary value problems with periodic and anti-periodic boundary conditions.*

A recent fixed point theorem of Leggett-Williams type is applied to a second order boundary value problem with periodic and anti-periodic boundary conditions to show the existence of symmetric and anti-symmetric solutions. (Received August 13, 2013)

1092-34-135 **Paul Eloe*** (peloe1@udayton.edu). *Forced Monotone Methods Applied to Boundary Value Problems for Ordinary Differential Equations.*

We consider a boundary value problem of the form

$$y''(t) = f(t, y(t), y'(t)), \quad a \leq t \leq b, \quad y(a) = a_1, y(b) = a_2, \tag{1}$$

where $a < b$, $f : [a, b] \times \mathbb{R}^2 \to \mathbb{R}$ is continuous and a_1 and a_2 are real. The method of upper and lower solutions, coupled with monotone methods, is useful if f is independent of y'. If the conjugate conditions, $y(a) = a_1, y(b) = a_2$, are replaced by right focal conditions $y(a) = a_1, y'(b) = a_2$, then the method of upper and lower solutions, coupled with monotone methods, is useful in the case that f depends on y and on y'. In this talk, we construct a boundary value problem of the form

$$y''(t) = f(t, y(t), y'(t)), \quad a \leq t \leq b, \quad y(a) = a_1, y'(b) = g(y, y'),$$

which is equivalent to (1) and obtain sufficient conditions on f and on g such that the method of upper and lower solutions, coupled with monotone methods, is useful. (Received August 06, 2013)

1092-34-198 **Sarah S. King*** (sarah.schulz@louisville.edu), Louisville, KY 40202. *Extremal Points and Positive Solutions of a Fourth Order Three Point Boundary Value Problem.*

Extremal points for the fourth order boundary value problem $u^{(4)} + q(t)u = 0$, $0 \leq t \leq 1$, with three point boundary conditions $u(0) = u'(p) = u''(b) = u'''(b) = 0$ where $1 - \frac{\sqrt{3}}{3} \leq p \leq b \leq 1$ are classified. These results are applied to show the existence of a positive solution to the nonlinear boundary value problem $u^{(4)} + f(t, u) = 0$, $0 \leq t \leq 1$, with similar boundary conditions. (Received August 09, 2013)

1092-34-233 **Xueyan Liu*** (xueyan-liu@utc.edu), Mathematics Department/Dept 6956, University of Tennessee at Chattanooga, Chattanooga, TN 37403. *Nonlocal Boundary Value Problems with Even Gaps in Boundary Conditions for Third Order Differential Equations.*

We use solution matching to study the uniqueness and existence of solutions for the nonlocal boundary value problem for the third order differential equation, $y'''(x) = f(x, y(x))$, on an interval $[a, c]$ satisfying $y(a) -$

$\int_a^b y(x)d\alpha(x) = y_1$, $y'(b) = y_2$, $\int_b^c y(x)d\beta(x) - y(c) = y_3$, where $\int_a^b y(x)d\alpha(x)$ and $\int_b^c y(x)d\beta(x)$ are Riemann-Stieltjes integrals with positive measures $d\alpha(x)$ and $d\beta(x)$, respectively. We match solutions on $[a, b]$ with solutions on $[b, c]$. Monotonicity conditions and some growth conditions on f are imposed. (Received August 10, 2013)

1092-34-276 **Yun Kang*** (yun.kang@asu.edu), Sciences and Mathematics Faculty, School of Letters and Sciences, Mesa, AZ 85212, and **Carlos Castillo-Chavez**, Arizona State University, Tempe, AZ. *Dynamics of SI models with both horizontal and vertical transmissions as well as Allee effects.*

A general SI (Susceptible-Infected) model with both horizontal and vertical transmissions is studied within a host population whose fitness, net reproduction term, is impacted by Allee effects with infected individuals experiencing pathogen-induced reductions in reproductive ability. SI models that incorporate frequency-dependent (SI-FD model) or density-dependent (SI-DD model) horizontal transmission are analyzed and compared. The analysis identifies conditions involving reproduction numbers linked to horizontal and vertical transmission that determined the dynamics of SI-FD and SI-DD models, respectively. Specifically, we identify conditions that lead to disease-driven extinction,or disease-free dynamics, or susceptible-free dynamics or endemic disease patterns. We observe that the SI-FD model supports richer dynamics than the SI-DD model. In both SI models, small horizontal transmission rates can lead to susceptible-free dynamics while low levels of reproductive ability within the infective population can lead to disease-driven extinction scenarios. In addition, we identified conditions under which diffusive instability can occur for general SI models as well as prey-predator models. This is a joint work with Carlos Castillo-Chavez. (Received August 12, 2013)

1092-34-319 **D Xu*** (dashunxu@siu.edu), 1245 Lincoln Dr., Carbondale, IL 62901, and **J. T. Cronin**, **J. D. Reeve** and **M. Xiao**. *Modeling a host-parasitoid system.*

Understanding the mechanisms promoting stability of predator-prey/parasitoid-host interactions has been a fertile and critically important area of theoretical and empirical research for the past century. Theoretical studies have demonstrated that stability is enhanced by invulnerable host stages, that the interaction between parasitoid and host can induce generation cycles in the host, and recently that variability in host (or parasitoid) development can strongly henhance stability. To examine these theoretical predictions, we used the cowpea weevil Callosobruchus maculatus and its parasitoid Anisopteromalus calandrae as a model predator-prey system and obtained a large set of empirical data. In this talk, I will present a mathematical model describing the system and some priliminary model results. (Received August 12, 2013)

1092-34-322 **jin shang*** (j0shan03@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292, and **Bingtuan Li**. *Period-doubling Bifurcation and Period-undoubling Bifurcation in a Discrete-time Model.* Preliminary report.

We provided rigorous analysis for a discrete-time model composed of the Ricker function and Beverton-Holt function. This model was proposed by Lewis and Li [Bull. Math. Bio. 74 (2012), 2383-2402] in the study of a population in which reproduction occurs at discrete instants of time whereas death and competition take place continuously during the season. We show analytically that a period-doubling bifurcation and period-undoubling bifurcation occur in the model. The population becomes unstable when when the period-doubling bifurcation occurs and becomes stable when the period-undoubling bifurcation occurs. We also demonstrate that between the period-doubling bifurcation and period-undoubling bifurcation it is possible for the model to have a cascade of period-doubling bifurcations which may lead to the formation of a chaotic attractor. (Received August 12, 2013)

1092-34-340 **Gnana Bhaskar Tenali*** (gtenali@fit.edu), 150 West University Boulevard, Melbourne, FL 32904. *Fixed Point Theorems in Partially Ordered Metric Spaces and applications to Set Differential Equations.*

We give a brief survey of the recent developments in fixed point theorems in partially ordered metric spaces. We discuss the application of some of these results in establishing the existence theorems to first order Set Differential Equations. (Received August 13, 2013)

1092-34-342 **Sabrina Heike Streipert*** (shsbrf@mst.edu), Sabrina Streipert, 1610 North Rolla Street, Apartment E, Rolla, MO 65401. *Abel Dynamic Equations.*

The motivation is the definition and analysis of Abel equations on a general time scale. By using a particular nature of the Abel differential equation of the second kind, expressions of its analogue on a general time scale are formulated, Abel dynamic equations of the second kind. A special class of the dynamic Abel equation of the first kind is then derived by a relation to the Abel dynamic equation of the second kind that is similar to the

real time scale case. This enables the definition of the canonical Abel dynamic equation. Well-known relations between Abel equations and other differential equations are established also in the time scales case. (Received August 13, 2013)

35 ► Partial differential equations

1092-35-6 **Alexander Pankov*** (alexander.pankov@morgan.edu), 1700 E. Cold Spring Lane, Baltimore, MD 21251. *Nonlinear Periodic Schrödinger Equation, Photonic Crystals, and Gap Solitons.*

A photonic crystal is an optical medium that has spatially periodic (or close to periodic) structure. The main fiture of such a medium is that the spectrum of allowed frequences may gaps tha consit of forbidden frequences. However, if the medium is nonlinear, it possesses spatially localized light patterns with forbidden frequences - the so-called gap solitons.

In certain cases gap solitons can be described as localized solutions of a periodic stationary nonlinear Schrödinger equations. In this talk we present a result on the existence of gap solitons in dimensions one and two. (Received February 21, 2013)

1092-35-16 **Thinh Tri Kieu*** (thinh.kieu@ttu.edu), 4306 16th Street Quaker Pines Apt#5, Lubbock, TX 794126, **Luan T Hoang** (luan.hoang@ttu.edu), Department of Mathematics and Statistics, Box 41042 Lubbock, TX 79409–1042, Lubbock, TX 79409, and **Tuoc Phan** (phan@math.utk.edu), Department of Mathematics, 227 Ayress Hall, 1403 Circle Drive, Knoxville, TN 37996. *Properties of generalized Forchheimer flows in porous media.*

The nonlinear Forchheimer equations are used to describe the dynamics of fluid flows in porous media when Darcy's law is not applicable. In this article, we consider the generalized Forchheimer flows for slightly compressible fluids and study the initial boundary value problem for the resulting degenerate parabolic equation for pressure with the time-dependent flux boundary condition. We estimate L^∞-norm for pressure and its time derivative, as well as other Lebesgue norms for its gradient and second spatial derivatives. The asymptotic estimates as time tends to infinity are emphasized. We then show that the solution (in interior L^∞-norms) and its gradient (in interior $L^{2-\delta}$-norms) depend continuously on the initial and boundary data, and coefficients of the Forchheimer polynomials. These are proved for both finite time intervals and time infinity. The De Giorgi and Ladyzhenskaya-Uraltseva iteration techniques are combined with uniform Gronwall-type estimates, specific monotonicity properties, suitable parabolic Sobolev embeddings and a new fast geometric convergence result. (Received June 10, 2013)

1092-35-27 **Alexei Novikov*** (anovikov@math.psu.edu). *Exit times of diffusions with incompressible drift.*

Consider a Brownian particle in a prescribed time-intependent incompressible flow in a bounded domain. We investigate how the strength of the flow and its geometric properties affect the expected exit time of the particle. The two main questions we analyze in this talk are as follows. 1. Incompressible flows are known to enhance mixing in many contexts, but do they also always decrease the exit time? We prove that the answer is no, unless the domain is a disk. 2. Suppose the flow is cellular with amplitude A, and the domain is of size L. What could be said about the exit time when both L and A are large? We prove that there are two characteristic regimes: a) if $L \ll A^4$, then the exit time from the entire domain is compatible with the exit time from a single flow cell, and it can be determined from the Freidlin–Wentzell theory; b) if $L \gg A^4$, then the problem 'homogenizes' and the exit time is determined by the effective diffusivity of cellular flows. (Received July 02, 2013)

1092-35-29 **Christophe Prange*** (cp@math.uchicago.edu), Dept. of Mathematics, 5734 S. University Avenue, CHICAGO, IL 60637. *Boundary layers in homogenization.*

This talk is concerned with the homogenization of elliptic systems in divergence form, with periodically oscillating coefficients and boundary data:

$$\begin{cases} -\nabla \cdot A\left(\frac{x}{\varepsilon}\right) \nabla u^\varepsilon &= 0, & x \in \Omega \\ u^\varepsilon &= \varphi\left(x, \frac{x}{\varepsilon}\right), & x \in \partial\Omega \end{cases}.$$

These boundary layer systems arise for example when improving the accuracy of multiscale expansions near the boundaries in periodic homogenization.

The two main problems one encounters in the homogenization of such systems are: the lack of uniform bounds on u^ε in $H^1(\Omega)$, and the fact that the boundary breaks the periodic microstructure. One of the questions is to

understand the connection between the behaviour of u^ε far from the boundary $\partial\Omega$ and the way the boundary intersects the microstructure.

The talk will focus on the case when $\Omega \subset \mathbb{R}^2$ is a polygonal domain. Results on this problem have been obtained under various assumptions on the normals of the edges: rationality, small divisors. We will review the different settings and explain the recent results obtained without any assumption on the normals [C.P. SIMA 2013]. (Received July 05, 2013)

1092-35-33 **Kazuo Yamazaki*** (kyamazaki@math.okstate.edu), 401 Mathematical Sciences Building, Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Remarks on the regularity criteria of generalized MHD and Navier-Stokes systems.*

We discuss component reduction type result on the Serrin-type regularity criteria of fluid dynamics partial differential equations, in particular the magnetohydrodynamical systems and Navier-Stokes equations. We also discuss recent developments in the stochastic Navier-Stokes and magnetohydrodynamics systems. (Received July 10, 2013)

1092-35-43 **Michael V. Klibanov*** (mklibanv@uncc.edu), 9201 University City Blvd, Charlotte, NC 28223, and **Larisa Beilina** and **Thanh T. Nguyen**. *Global convergence for inverse problems.*

Coefficient Inverse Problems for PDEs are both nonlinear and ill-posed. Thus, least squares cost functionals for them usually suffer from the phenomena of multiple local minima and ravines. This causes local convergence of conventional numerical methods, e.g. Newton method and gradient method.

Since 2007 this group has developed a new approach, the so-called "approximately globally convergent" method. The only approximation is the truncation of a WKB-like series on the first iteration only. Within the framework of this approximation, this method delivers some points in a sufficiently small neighborhood of the unknown coefficient.

We will present this method as well as its results for experimental data including the most challenging case of blind data. (Received July 15, 2013)

1092-35-48 **Ajay Mahato*** (amahato7@gmail.com), Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294, and **Ian Knowles** (iknowles@uab.edu), Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294. *The Inverse Volatility Problem for American Options.*

The inverse problem of determining equity volatility from a knowledge of American option prices for a range of exercise prices and maturities is solved by minimization of a convex functional. We illustrate the method using examples drawn from recent market data. (Received July 17, 2013)

1092-35-50 **Hongyu Liu*** (hongyu.liuip@gmail.com), Department of Mathematics and Statistics, University of North Carolina, Charlotte, University City Blvd, Charlotte, NC 28223. *Locating Multiscale Scatterers by A Single Electromagnetic Far-field Measurement.*

In this talk, I shall describe several inverse scattering schemes of locating multiple multiscale scatterers by a single electromagnetic far-field measurement. The proposed methods can work in an extremely general setting. The number of scatterer components is not required to be known. The physical properties of each scatterer component is not required to be known either. There might be both small-size components and regular-size components (compared to the detecting EM wavelength) presented at the same time. For the regular-size components, we need know the possible shapes in advance. The locating of both space and ground objects will be discussed. (Received July 18, 2013)

1092-35-51 **Thanh Trung Nguyen*** (tnguy152@uncc.edu), 9201 University City Blvd, Charlotte, NC 28223, and **Larisa Beilina** and **Michael V. Klibanov**. *A coefficient identification problem for the wave equation with backscattering experimental data.*

In this talk we consider the problem of reconstruction of the coefficient $\epsilon(x)$ of the wave equation

$$\epsilon^2(x)u_{tt}(x,t) - \Delta u(x,t) = 0, x \in \mathbb{R}^3, t \in (0,\infty)$$

with the initial conditions

$$u(x,0) = 0, \quad u_t(x,0) = \delta(x - x0), x \in \mathbb{R}^3.$$

In electromagnetic wave theory, ϵ represents the refractive index of the medium. Assume that $\epsilon(x) \in [1, 1+d]$ with $d > 0$. Moreover, $\epsilon(x) = 1$ outside a bounded domain $\Omega \subset \mathbb{R}^3$ and $x_0 \notin \Omega$. We make use of the boundary data

$$u(x,t) = g(x,t), (x,t) \in \Gamma \times (0,\infty),$$

where Γ is the back scattering boundary.

In this talk, we discuss this inverse problem using experimental data. The main challenge working with experimental data is a *huge misfit* between these data and computationally simulated ones. Hence, any inversion algorithm would fail to produce satisfactory results, if being applied to the raw data. We propose a data pre-processing procedure which helps to convert the data to somewhat similar to computational simulations. Then, we show reconstruction results obtained by a globally convergent method. (Received July 19, 2013)

1092-35-52 **Shijie Gu*** (albertku123@163.com), 1605 N Virginia ST APT36, Reno, NV 89503.
Application of Shannon Function Basis Runge-Kutta Galerkin Method in the Nonlinear Schrödinger's Equation. Preliminary report.

In this paper, Shannon function basis and modified Shannon function basis are applied in Runge-Kutta Galerkin (RKG) method. The aim is to seek the numerical solutions to the nonlinear Schrödinger's equation(NLS), and compare with the solutions generated by Crank-Nicolson scheme. However, one difficulty encountered with the implementation of Galerkin method is the coefficients of some terms are integrals having singularities, namely, sinc and cosc functions:$(\sin x)/x, (\cos x)/x$ and $(\cos x)/x^2$ when I use Shannon basis function instead of polynomial basis or trigonometric basis. So, it's useful to apply quadrature technique, mainly Gaussian-Legendre Quadrature to approxmiate the integrals. (Received July 20, 2013)

1092-35-55 **Roger Lui*** (rlui@wpi.edu), Department of Mathematics, WPI, 100 Institute Road, Worcester, MA 01609. *Variational Method in the Study of Reaction-Diffusion Equations.*

The purpose of this talk is to demonstrate how a variational approach may be used to obtain many of the known results of scalar reaction-diffusion equations. It turns out that traveling wave solutions of such equations correspond to minima of the functional. By solving the Euler-Lagrange equation, one can find, or estimate, the minimum wave speed, which is the same as the asymptotic speed of propagation of solutions of the reaction-diffusion equations. Convergence to traveling wave solutions will also be considered. This is an ongoing joint work with Professor Hirokazu Ninomiya from Meiji University, Japan. (Received July 22, 2013)

1092-35-61 **Robert Pertsch Gilbert*** (gilbert@math.udel.edu), Robert Pertsch Gilbert, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, **Alex Panchenko** (anpanchenko@gmail.com), Department of Mathematical Sciences, Washington State University, Pullman, WA 99164, and **Ana Vasilic** (vasilic@uaeu.ac.ae), Department of Mathematical Sciences, UAE University, Al Ain, United Arab Emirates.
Biphasic Acoustic Behavior of a Non-periodic Porous Medium.

We study the problem of derivation of an effective model of acoustic wave propagation in a two-phase, non-periodic medium modeling a fine mixture of linear elastic solid and a viscous Newtonian fluid. Bone tissue is an important example of a composite material that can be modeled in this fashion. We extend known homogenization results for periodic geometries to the case of a stationary random, scale-separated microstructure. The ratio ε between a typical size of microstructural inhomogeneity and the macroscopic length scale is a small parameter of the problem. We employ stochastic two-scale convergence in the mean to pass to the limit $\varepsilon \to 0$ in the governing equations. The effective model describes a biphasic viscoelastic material with long time history dependence. Homogenized system describes macroscopically anisotropic media and is more general than the Biot system. (Received July 24, 2013)

1092-35-68 **Dehua Wang*** (dwang@math.pitt.edu), Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. *Incompressible limits for magnetohydrodynamics.*

The zero Mach number limit and hydrodynamic limit will be discussed for magnetohydrodynamics. (Received July 27, 2013)

1092-35-70 **Jinrui Huang** (huangjinrui1@163.com), School of Mathematics, South China Normal University, Guangzhou, Guangdong 513630, Peoples Rep of China, **Fanghua Lin** (linf@cims.nyu.edu), CIMS, New York University, New York, NY 10012, and **Changyou Wang***, Department of Mathematics, University of Kentucky, Lexington, KY 40506.
Regularity and existence of global solution of the Ericksen-Leslie system in R^2. Preliminary report.

I will discuss the regularity theorem for suitable weak solutions to the Ericksen- Leslie system in R^2. Building on such a regularity, we then establish the existence of a global weak solution to the Ericksen-Leslie system in R^2 for any initial data in the energy space, under the physical constraint conditions on the Leslie coefficients ensuring the dissipation of energy of the system, which is smooth away from at most finitely many times. (Received July 27, 2013)

1092-35-71 **Xiang Xu*** (xuxiang@andrew.cmu.edu), Carnegie Mellon University, Wean Hall 6113, Pittsburgh, PA 15213, and **Gautam Iyer** and **Arghir Zarnescu**. *Dynamical aspects of the cubic instability in the Landau-de Gennes energy for nematic liquid crystals.*

We consider a four-elastic-constant Landau-de Gennes energy characterizing nematic liquid crystal configurations. It is known that certain physical considerations require the presence of a cubic term, which nevertheless makes the energy unbounded from below. We study the dynamical effects produced by the gradient flow generated by this energy. We work mostly in dimension two and provide an understanding of the relations between the physicality of the initial data and the global well-posedness of the system. (Received July 27, 2013)

1092-35-72 **Jun Geng*** (gengjun@lzu.edu.cn), School of Mathematics and Statistics, Lanzhou University, Lanzhou, 730000, Peoples Rep of China, and **Zhongwei Shen** (zshen2@uky.edu), Department of Math., University of Kentucky, Lexington, KY 40506. *Uniform Regularity Estimates in Parabolic Homogenization.*

We consider a family of second-order parabolic systems in divergence form with rapidly oscillating and time-dependent coefficients, arising in the theory of homogenization. We obtain uniform interior $W^{1,p}$, Hölder, and Lipschitz estimates as well as boundary $W^{1,p}$ and Hölder estimates, using compactness methods. (Received July 28, 2013)

1092-35-95 **Chuntian Wang*** (wang211@umail.iu.edu), 800 N. Union Street, Apt. 206, Bloomington, IN 47408. *Local Existence of Strong Solutions to the 3D Zakharov-Kuznestov Equation in a Bounded Domain.*

We consider here the local existence of strong solutions for the Zakharov-Kuznestov (ZK) equation posed in a limited domain $\mathcal{M} = (0,1)_x \times (-\pi/2, \pi/2)^d$, $d = 1, 2$. We prove that in space dimensions 2 and 3, there exists a strong solution on a short time interval, whose length only depends on the given data. We use the parabolic regularization of the ZK equation as in our previous paper (Jean-Claude Saut, Roger Temam, and Chuntian Wang, *An initial and boundary-value problem for the Zakharov-Kuznestov equation in a bounded domain*, J. Math. Phys. 53 (2012)) to derive the global and local bounds independent of ϵ for various norms of the solution. In particular, we derive the local bound of the nonlinear term by a singular perturbation argument. Then we can pass to the limit and hence deduce the local existence of strong solutions. (Received August 01, 2013)

1092-35-100 **Michele Coti Zelati*** (micotize@indiana.edu). *Invariant measures of nonlinear Galerkin schemes.*

We consider the invariant measures of a nonlinear temporal discretization of the two-dimensional Navier-Stokes equations. Exploiting a uniform finite time regularization property, we prove that the stationary statistical properties of the fully implicit Euler scheme converge, as the time-step parameter vanishes, to the stationary statistical properties of the Navier-Stokes equations. (Received August 02, 2013)

1092-35-102 **Steve Hofmann**, **Marius Mitrea** and **Andrew J Morris*** (andrew.morris@maths.ox.ac.uk). *The method of layer potentials in L^p and endpoint spaces for elliptic operators with L^∞ coefficients.*

We consider the layer potentials associated with operators $L = -\mathrm{div} A\nabla$ acting in the upper half-space $\mathbb{R}^{n+1}_+$, $n \geq 2$, where the coefficient matrix A is complex, elliptic, bounded, measurable, and t-independent. A "Calderón–Zygmund" theory is developed for the boundedness of the layer potentials under the assumption that solutions of the equation $Lu = 0$ satisfy interior De Giorgi–Nash–Moser type estimates. In particular, we prove that L^2 estimates for the layer potentials imply sharp L^p and endpoint space estimates. The method of layer potentials is then used to obtain solvability of boundary value problems. (Received August 02, 2013)

1092-35-105 **Scott N Armstrong** and **Hung V Tran*** (hung@math.uchicago.edu). *Stochastic homogenization of viscous Hamilton–Jacobi equations.*

We present qualitative stochastic homogenization results for viscous Hamilton–Jacobi equations under very general assumptions. The argument is new and based only on the subadditive structure of maximal subsolutions (solutions of the "metric problem"). The hypotheses allow for non-uniformly coercive Hamiltonians which satisfy an averaging condition. (Received August 02, 2013)

1092-35-113 **Anna L Mazzucato*** (alm24@psu.edu) and **Victor Nistor**. *Well-posedness and regularity for elliptic equations on polyhedral domains.*

We discuss well-posedness and regularity for strongly elliptic, linear systems, like the system of elasticity, on polyhedral domains using weighted Sobolev spaces. We utilize coercive estimates. The domain need not be convex and can have curvilinear sides. (Received August 04, 2013)

1092-35-115 **Murat Akman**, **John L Lewis** and **Andrew L Vogel*** (alvogel@syr.edu), Mathematics Department, 215 Carnegie, Syracuse, NY 13244. *Hausdorff dimension and σ finiteness of p-harmonic measures in space when $p \geq n$.*

In this paper we study a measure, $\hat{\mu}$, associated with a positive p harmonic function $\hat{u}$ defined in an open set $O \subset \mathbb{R}^n$ and vanishing on a portion Γ of ∂O. If $p > n$ we show $\hat{\mu}$ is concentrated on a set of σ finite H^{n-1} measure while if $p = n$ the same conclusion holds provided Γ is uniformly fat in the sense of n capacity. (Received August 05, 2013)

1092-35-146 **Oleksandr Misiats*** (omisiats@purdue.edu), Department of Mathematics, 150 N University str., West Lafayette, IN 47907, and **Michael Dos Santos** and **Petru Mironescu**. *Ginzburg-Landau model of composite superconductors with small superconducting inclusions.*

This talk is devoted to some aspects of modeling composite superconductors. The work was motivated by the physical models of vortex pinning (i.e., fixing the positions of vortices), which is done by introducing inclusions into a homogeneous superconductor. Mathematically, composite superconductors are modeled via Ginzburg-Landau type functional with a piecewise constant pinning term a in the potential $(a^2 - |u|^2)^2$, which takes two different values in the medium and in the inclusions. We study the minimization problem for such functional subject to Dirichlet boundary conditions with zero topological degree on the boundary. We obtain the homogenized description of Ginzburg-Landau minimizers in the limit of large number of inclusions and small ε (where ε is the inverse Ginzburg-Landau parameter). We next proceed with modeling a superconductor with finitely many small superconducting inclusions in the presence of vortices. We show that even the inclusions of vanishingly small size (e.g. shrinking to single points) capture the vortices of minimizers. This way we reduce the problem of finding the locations of the vortices to a discrete minimization problem for a finite-dimensional functional of renormalized energy. (Received August 07, 2013)

1092-35-147 **Adina Ciomaga*** (adina@math.uchicago.edu), **Panagiotis Souganidis** and **Hung Tran**. *Stochastic homogenization of interfaces moving by oscillatory normal velocity.*

In this talk I will present some recent results concerning the behavior of moving interfaces in random environments, driven by oscillatory normal velocity

$$\begin{cases} u_t^\varepsilon + a\left(\frac{x}{\varepsilon}, \omega\right) |Du^\varepsilon| = 0 & \text{in } (0,\infty) \times \mathbb{R}^n \times \Omega, \\ u^\varepsilon(0, x, \omega) = u_0(x) & \text{on } \mathbb{R}^n \times \Omega. \end{cases}$$

The problem has been studied in great detail in the case when the Hamiltonian is coercive, i.e. $a(\cdot) \geq a_0 > 0$. However, the non-coercive case remained an open problem for a long time. Recently (2009) Cardaliaguet, Lions, and Souganidis provided new results in the periodic setting, when $a(\cdot)$ changes sign. We extend their results to the stationary ergodic environment and we show that under sharp assumptions, fronts homogenize, i.e. as $\varepsilon \to 0$ the equation averages to a deterministic Hamilton Jacobi equation. (Received August 07, 2013)

1092-35-152 **Fang Zeng**, **Fioralba Cakoni** and **Jiguang Sun*** (jiguangs@mtu.edu), Fisher 313, Michigan Tech, 1400 Townsend Dr., Houghton, MI 49931. *An inverse electromagnetic scattering problem for cavity.*

We consider the inverse electromagnetic scattering problem of determining the shape of a perfectly conducting cavity from measurement of scattered electric field due to electric dipole sources on a surface inside the cavity. We prove a reciprocity relation for the scattered electric field and a uniqueness theorem for the inverse problem. Then the near field linear sampling method is employed to reconstruct the shape of the cavity. Preliminary numerical examples are provided to show the viability of the method. (Received August 07, 2013)

1092-35-161 **Lizheng Tao*** (leedstao@gmail.com), Department of Mathematics, 1409 W. Green St, Urbana, IL 61820. *Super-Critical SQG Equations with Small Initial Data.*

In this talk, we will present the global regularity result of the super critical SQG equation with small data condition. The method combine the OSS condition of Constantin and Vicol and the modulus of continuity from Kiselev, Nazarov and Volberg. (Received August 07, 2013)

1092-35-166 **Jorge Rivera-Noriega*** (rnoriega@uaem.mx), Facultad de Ciencias, Universidad Autónoma del Estado de Morelos, Av. Universidad 1001, Col. Chamilpa, CP62209 Cuernavaca, Morelos, Mexico. *Perturbation and solvability of initial L^p Dirichlet problems for parabolic equations over non-cylindrical domains.*

We observe that by adapting a technique due to L. Escauriaza one can prove the preservation under small perturbations as well as the solvability of initial L^p Dirichlet problems for certain linear parabolic equations in divergence form over non-cylindrical domains. Both results assume certain Carleson measure type conditions on the coefficients. (Received August 08, 2013)

1092-35-172 **Tao Huang*** (txh35@psu.edu) and **Changyou Wang**. *Regularity and uniqueness for a class of weak solutions to the hydrodynamic flow of nematic liquid crystals.*

We establish an ϵ-regularity criterion for any weak solution (u, d) to the nematic liquid crystal flow such that $(u, \nabla d) \in L_t^p L_x^q$ for some $p \geq 2$ and $q \geq n$ satisfying the condition $\frac{n}{q} + \frac{2}{p} = 1$. As consequences, we prove the interior smoothness and uniqueness of any such a solution when $p > 2$ and $q > n$. (Received August 08, 2013)

1092-35-173 **Jessica C Lin*** (jessica@math.uchicago.edu). *Stochastic Homogenization for Fully Nonlinear Uniformly Parabolic Equations in Stationary Ergodic Spatio-Temporal Media.*

We present some recent results regarding the stochastic homogenization for fully nonlinear uniformly parabolic equations in stationary ergodic spatio-temporal media. We show that under suitable hypotheses, solutions to such equations homogenize almost surely. In addition, we obtain a logarithmic rate of convergence for this homogenization in measure, assuming that the environment is strongly mixing with a prescribed logarithmic rate. Our approach follows the "obstacle problem method" introduced by Caffarelli, Souganidis, and Wang, and Caffarelli and Souganidis in the stochastic homogenization for fully nonlinear uniformly elliptic equations. We develop a number of new arguments to overcome the difficulties introduced by parabolic structure of the problem. (Received August 08, 2013)

1092-35-175 **Wenzhang Huang*** (huang@math.uah.edu), 301 Sparkman Dr., Huntsville, AL 35758. *Traveling Wave Solutions for a Class of Predator-Prey Systems.*

We use a shooting method to show the existence of traveling wave fronts and to obtain an explicit expression of the minimum wave speed for a class of predator-prey systems. Our approach is a significant improvement of techniques introduced by Dunbar. The advantage of our method is that it does not need the notion of Wazewski's set used in Dunbar's approach. Moreover, one nontrivial step in Dunbar's approach is to show the boundedness of solutions in the Wazewski's set before the construction of a Liapunov function and the application of LaSalle's invariance Principle. In our approach, we first convert the equations for traveling wave solutions to a system of first order equations by a "non-traditional transformation". For this converted system, we are able to construct a Liapunov function. With the use of this Liapunov function we can give a straightforward proof of the boundedness of a relevant class of solutions that correspond to traveling wave fronts. Our method provides a more efficient way to study the existence of traveling wave solutions for more general predator-prey systems. (Received August 08, 2013)

1092-35-190 **Hiroyoshi Mitake*** (mitake@math.sci.fukuoka-u.ac.jp), Fukuoka, 814-0180, Japan. *Homogenization of weakly coupled systems of Hamilton-Jacobi equations with fast switching rates.*

This talk is based on a joint work with Hung V. Tran (The University of Chicago). We consider homogenization for weakly coupled systems of Hamilton–Jacobi equations with fast switching rates. The fast switching rate terms force the solutions to converge to the same limit, which is a solution of the effective equation. We discover the appearance of the initial layer and the boundary layer, which naturally appear when we consider the systems with the different initial or boundary data. In the talk, we first consider the initial layers in a heuristic mode by finding inner and outer solutions, and using the matching asymptotic expansion method to identify matched solutions and show the rigorous result on the rate of convergence. Then, we discuss the effective initial data and the effective boundary data from the optimal control point of view. (Received August 09, 2013)

1092-35-197 **Xiaosheng Li*** (xli@fiu.edu), Department of Mathematics and Statistics, Florida International University, Miami, FL 33199. *Inverse coefficient problems in unbounded domains.*

The inverse coefficient problems consist of recovering the coefficients of partial differential equations from measurements of the solutions. In this talk we study such problems for Schroeding equations in some types of unbounded domains. We show the unique determination results when the measurements are made on only part of the boundaries. (Received August 09, 2013)

1092-35-199 **William M Feldman*** (wfeldman10@math.ucla.edu). *Homogenization of Oscillating Dirichlet Boundary Condition in General Domains.*

We will discuss some issues in the homogenization elliptic problems with periodically oscillating Dirichlet boundary data. In half spaces the problem homogenizes when the normal direction is not aligned with any direction from the periodicity lattice of the boundary data. For general domains we will explain how the problem homogenizes despite the lack of averaging at the boundary points with bad normal directions. This essentially amounts to showing a comparison principle for sub and supersolutions ordered only on a sufficiently large subset of the boundary. (Received August 09, 2013)

1092-35-200 **Patricia Bauman*** (bauman@math.purdue.edu), 150 No. University Street, Dept. of Mathematics, West Lafayette, IN 47907, and **Guanying Peng** (gpeng@math.purdue.edu), 150 No. University Street, West Lafayette, IN 47907. *Analysis of the Lawrence-Doniach Model for Superconductivity in Perpendicular Applied Magnetic Fields.* Preliminary report.

We analyze minimizers of the Lawrence-Doniach energy for layered superconductors in a bounded generalized cylinder, $\Omega \times (0, L)$, with Josephson coupling between the layers. This model has been used to model high-temperature superconductors. For an applied magnetic field $h_e \vec{e}_3$ that is perpendicular to the layers with $|\ln \epsilon << h_e << \epsilon^{-2}$ as $\epsilon \to 0$, where ϵ is the reciprocal of the Ginzburg-Landau parameter, we prove an asymptotic formula for the minimum Lawrence-Doniach energy as ϵ and the interlayer distance s tend to zero. Under appropriate assumptions on s versus ϵ we establish comparison results between the minimum Lawrence-Doniach energy and the minimum anisotropic Ginzburg-Landau energy. (Received August 09, 2013)

1092-35-209 **Daniel Phillips*** (phillips@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University Street, West Lafayette, IN 47907, and **Sean Colbert-Kelly** (sac3@nist.gov), Applied and Comp Math Div, NIST, Gaithersburg, MD 8910. *Analysis of defects in minimizers for a planar Frank energy.*

Smectic C* liquid crystal films are modeled by a relaxed Frank energy, where the elasticity splay and bend constants are positive but may differ. Our film is modeled by a two dimensional vector field on a planar domain where the field has fixed boundary data with degree d>0.

We study the limiting pattern for a sequence of minimizers of the energy and prove that the pattern contains d degree one defects and that it has a either a radial or circular asymptotic form near each defect depending on the relative values of the elasticity constants. We further characterize a renormalized energy for the problem and show that it is minimized by the limit. (Received August 09, 2013)

1092-35-212 **Justin Lee Taylor*** (jtaylor52@murraystate.edu). *The Green Function for Elliptic Systems in Two Dimensions.*

We construct the fundamental solution for a divergence form elliptic system in two dimensions with bounded and measurable coefficients. We consider the operator with mixed boundary conditions in a Lipschitz domain and require a non-tangential accessibility condition on the set where we specify Dirichlet boundary data. We show that the fundamental solution for this operator is in a variant of the space of functions of bounded mean oscillation. We proceed to show pointwise estimates including a logarithmic pointwise bound. This is joint work with Seick Kim and Russell Brown. (Received August 09, 2013)

1092-35-215 **Yuxiang Zhang*** (yzha42@uottawa.ca), 585 King Edward Avenue, Department of Mathematics and Statistics, University of Ottawa, Ottawa, ON K1N 6N6, Canada. *Bistable Traveling Waves for A Reaction and Diffusion Model with Seasonal Succession.*

This work is devoted to the study of a periodic reaction-diffusion competition model, which describes the propagation of two competitive species in bad and good seasons. The existence and global stability of time-periodic bistable traveling waves are established for such a system under appropriate conditions. The methods involve the upper and lower solutions, spreading speeds of monostable systems, and the monotone semiflow approach. This is a joint work with Dr.Xiaoqiang Zhao. (Received August 09, 2013)

1092-35-235 **Ko-Shin Chen*** (koshchen@indiana.edu), Dept. of Math., Indiana U., 831 E. Third St., Bloomington, IN 47405. *Ginzburg-Landau Vortices: Gradient Flow of Point Vortices on the Sphere.*

We consider the dissipative heat flow associated with the Ginzburg-Landau energy posed on a 2-manifold $\mathcal{M}$. We will show that as $\varepsilon \to 0$, the vortices of the solution to this problem evolve according to the gradient flow associated with the renormalized energy. We then specialize to the case where $\mathcal{M} = \mathcal{S}^2$ and study the limiting system of ODE's and establish an annihilation result. (Received August 10, 2013)

1092-35-237 **Mimi Dai*** (mimi.dai02@gmail.com) and **Maria E Schonbek**. *Stability of Solutions to the Dissipative Quasi-Geostrophic Equation.*

We consider the 2D steady-state Quasi-Geostrophic equation in the whole space R2 driven by a forcing function f. The class of source functions f under consideration yield the existence of at least one solution with finite Dirichlet integral ($\|\nabla\Theta\|_{L^2} < \infty$). Under the additional assumptions that f is absent of low modes and the ratio of f to viscosity is sufficiently small in a natural norm we construct solutions which have finite energy (finite L^2 norm). These solutions are unique among all solutions with finite energy and finite Dirichlet integral. The constructed solutions are also shown to be stable in the following sense: If Θ is such a solution then any viscous, incompressible flow in the whole space, driven by f and starting with finite energy, will return to Θ. (Received August 10, 2013)

1092-35-244 **Nestor Guillen*** (nestor@math.ucla.edu), Los Angeles, CA 9049, and **Inwon Kim**. *Stochastic homogenization of free boundary problems in perforated domains.*

The homogenization of free boundary problems in random domains is connected with a number of important geometric questions, such as the behavior of Brownian motion in infinite percolation clusters (better understood in the discrete setting) and the closely related problem of isoperimetric inequalities in random domains. In recent work with Inwon Kim, it is shown that the Hele-Shaw problem in a perforated domain homogenizes almost surely to an anisotropic free boundary problem in all of euclidean space, the free boundaries converging in the Hausdorff topology almost surely. This result is new even in the periodic setting. (Received August 11, 2013)

1092-35-272 **Changbing Hu*** (changbing.hu@louisville.edu). *Large time behavior of derivatives of the solutions to the alpha Navier Stokes equations on the plane.* Preliminary report.

Large time behavior of solutions of alpha Navier Stokes has been studied by many authors. In this talk we extend the results to their derivatives of the system on the plane. We first study the classical Navier Stokes equations with a forcing term, and then regard alpha Navier Stokes as the Navier Stokes equations perturbed by external forcing to derive some large time behaviors. (Received August 12, 2013)

1092-35-278 **Ian Tice*** (iantice@andrew.cmu.edu). *Instability theory of gaseous stars.*

A simple astrophysical model of stars considers them to be a compact mass of self-gravitating compressible fluid. Such a fluid obeys the compressible Navier-Stokes-Poisson equations. In the case of "polytropic gases," in which the pressure behaves like $P = K\rho^\gamma$ for $K > 0$ an entropy constant and $\gamma > 1$ an adiabatic constant, one may construct compactly supported, finite mass, radially symmetric equilibrium solutions by reducing to the Lane-Emden ODE (at least when $6/5 < \gamma < 2$). A fundamental question in astrophysics is the stability of such equilibria, and it was believed that they should be unstable for $6/5 < \gamma < 4/3$ and stable for $4/3 \leq \gamma < 2$. In this talk we will prove that the Navier-Stokes-Poisson system, perturbed around a Lane-Emden equilibrium configuration, is nonlinearly unstable when $6/5 < \gamma < 4/3$. This is joint work with Juhi Jang. (Received August 12, 2013)

1092-35-279 **Russell W. Schwab*** (rschwab@math.msu.edu), 619 Red Cedar Rd., East Lansing, MI 48824, and **Nestor Guillen**. *Integro-Differential Methods for Neumann Homogenization.* Preliminary report.

We use a recent result about the representation of the Dirichlet-to-Neumann operator for fully nonlinear equations as an integro-differential operator on the boundary of the domain to guide the analysis of the homogenization problem with oscillatory Neumann data. This allows to use methods already established for integro-differential equations. We will present the case of a periodic environment with a half-space domain whose boundary is an irrationally oriented hyperplane, and this results in the study of a global almost periodic nonlocal equation on the hyperplane. This is joint work with Nestor Guillen. (Received August 12, 2013)

1092-35-301 **Elena Cherkaev*** (elena@math.utah.edu), University of Utah, Department of Mathematics, 155 South 1400 East, JWB 233, Salt Lake City, UT 84112. *Inverse problem for the structure of composite materials.*

The talk discusses inverse homogenization problem which is a problem of deriving information about the microgeometry of a two-component composite media from given effective properties. The approach is based on reconstruction of the spectral measure of a self-adjoint operator that depends on the geometry of composite. Stieltjes analytic representation of the effective property relates the n-point correlation functions of the microstructure to the moments of the spectral measure, which contains all information about the microgeometry. I show that the problem of identification of the spectral function from effective measurements known in an interval of frequency, has a unique solution. In particular, the volume fractions of materials in the composite and an inclusion separation parameter, as well as the spectral gaps at the ends of the spectral interval, can

be uniquely recovered. The talk discusses reconstruction of microstructural parameters from electromagnetic and viscoelastic effective measurements, coupling different effective properties, and an extension to nonlinear composites. (Received August 12, 2013)

1092-35-311 **Ryan Hynd*** (rhynd@math.upenn.edu), Department of Mathematics, 209 South 33rd St., Philadelphia, PA 19104. *Hamilton-Jacobi Equations in the space of measures.* Preliminary report.

We discuss recent advances made in understanding solutions of Hamilton-Jacobi Equations in the space of measures with applications to mechanics and homogenization. (Received August 12, 2013)

1092-35-325 **Ning Ju*** (ning.ju@okstate.edu), 401 Mathematical Sciences, Oklahoma State University, Stillwater, OK 74078. *Long-time dynamics of large scale oceanic and atmospheric flow modeled by 3D Primitive Equations.*

The system of Primitive Equations (PEs) for 3D viscous incompressible fluid flow is one of the most fundamental mathematical models for large scale dynamics of oceanic and atmospheric flows in Geophysical Fluid Dynamics.

In the early 1990's, Lions, Temam and Wang formulated the mathematical framework of the 3D PEs for viscous fluid flows in the atmosphere and the ocean . They defined the notions of weak and strong solutions and proved existence of weak solutions. Existence of strong solutions *local in time* and their uniqueness were later obtained by several researchers. Existence of strong solutions *global in time* was recently proved independently by Cao and Titi and by Kobelkov. Similar global regularity with some different boundary conditions were later proved by Kukavica and Ziane. The existence of the global attractor for the strong solutions of 3D viscous PEs was proved by Ju.

In this talk, some very recent new progress on the long time dynamics of the solutions of the 3D viscous PEs will be reported and discussed. (Received August 13, 2013)

1092-35-333 **Qingshan Chen*** (qsc@clemson.edu). *Computation of the shallow water equations.*

Climate prediction relies on long-term simulations of the ocean and atmosphere. Maintaining dynamical balances within these geophysical flows is essential for a candidate numerical scheme to succeed in such simulations. The system of shallow water equations is instrumental in the study of geophysical flows, because it is a barotropic approximation of the world ocean and atmosphere. In this talk, we will go over certain issues that need to be considered when designing numerical schemes for the shallow water equations. Some recent results will be presented at the end. (Received August 13, 2013)

1092-35-335 **Ariel Barton*** (barto106@math.umn.edu), 202 Mathematical Sciences Building, University of Missouri, Columbia, MO 65211, and **Svitlana Mayboroda**. *Layer potentials and boundary-value problems for second order elliptic operators with data in Besov spaces.*

We treat second order divergence form elliptic operators with bounded measurable t-independent coefficients beyond the classical L^p context, in the realm of Besov spaces.

We establish mapping properties for the double and single layer potentials, as well as the Newton potential, on Besov spaces. We use these mapping properties to prove extrapolation-type solvability results: that is, we show that solvability of the Dirichlet or Neumann boundary value problem at any given L^p space automatically assures their solvability in an extended range of Besov spaces. We will also establish well-posedness for non-homogeneous boundary value problems.

In particular, we prove well-posedness of the non-homogeneous Dirichlet problem with data in Besov spaces for operators with real, not necessarily symmetric coefficients. (Received August 13, 2013)

1092-35-337 **Joel Kilty*** (joel.kilty@centre.edu), 600 W. Walnut Street, Centre College, Danville, KY 40422. *The L^p Regularity Problem for the Stokes System on Lipschitz Domains.*

The goal of this talk is to present two results concerning the stationary Stokes system on bounded Lipschitz domains. The first result establishes a necessary and sufficient condition for the solvability of the $L^p(\partial\Omega)$ regularity problem when $p > 2$ in terms of a weak reverse Hölder inequality for $L^2(\partial\Omega)$ solutions which vanish on part of the boundary. The second result establishes the $W^{1,p}(\Omega)$ estimate for solutions of a Poisson-type Dirichlet problem when $|\frac{1}{p} - \frac{1}{2}| < \frac{1}{2d} + \varepsilon$ on a bounded Lipschitz domain $\Omega \subset \mathbb{R}^d$. (Received August 13, 2013)

1092-35-339 **Gregory C Verchota***, Dept. Mathematics, Syracuse University, Syracuse, NY 13244. *Constructing coercive bilinear forms for Neumann problems.* Preliminary report.

Constant coefficient coercive integro-differential bilinear (sesquilinear) forms over the full Sobolev space $W^{1,2}(\Omega)$ are known to not generally exist in bounded convex domains Ω of $\mathbb{R}^n$ for a class of elliptic constant coefficient operators including 2nd order strongly elliptic systems. Application of the classical Lax-Milgram theorem in

order to identify Neumann boundary operators and prove existence of corresponding solutions is therefore not possible with constant coefficient forms. Nor is solvability by way of Rellich identities in the standard way for the more recent strong pointwise theory in Lipschitz domains. Failing also then is the method of layer potentials on Lipschitz boundaries. Preliminary investigations seem to show that classical nonconstant coefficient forms will also not suffice. Maz'ya and Verbitsky have characterized bounded forms with distributional coefficients for general 2nd order scalar operators over $\mathbb{R}^n$, showing that such coefficients must satisfy certain BMO and trace inequality conditions. We discuss these and their extension to bounded domains, association to specific operators and the coercivenss problem. (Received August 13, 2013)

1092-35-352 **Matthew Wright***, mwright@missouristate.edu. *Spectral Properties for Layer Potentials on Sobolev Spaces.* Preliminary report.

The method of layer potentials highlights the natural connections between the Dirichlet, Neumann, and Regularity problems and their associated boundary integral operators. By exploiting the connections between transmission problems and these other boundary value problems, we can form concrete connections between the spectrum of the boundary integral operator $K : L^p(\partial\Omega) \to L^p(\partial\Omega)$ associated with the Dirichlet problem and the analogous operator $K : L^q_1(\partial\Omega) \to L^q_1(\partial\Omega)$ associated with the Regularity problem. (Received August 13, 2013)

1092-35-363 **Marius Mitrea*** (mitream@missouri.edu), University of Missouri, Department of Mathematics, Columbia, MO 65211. *The oblique derivative problem without transversality.* Preliminary report.

The origin of the oblique derivative problem goes back to the work of H. Poincare on the theory of tides. Ever since this groundbreaking work, it has been of interest to consider this problem in an as general geometric measure theoretic setting as possible. In my talk, I will discuss the version of this problem without the familiar transversality condition typically imposed on the direction vector field used to formulate the boundary condition. (Received August 13, 2013)

1092-35-368 **Gung-Min Gie***, 831 E. Third St., Bloomington, IN 47405, and **James P Kelliher**, **Milton C Lopes Filho**, **Anna L Mazzucato** and **Helena J Nussenzveig Lopes**. *Vanishing viscosity limit of some symmetric flows.*

We study the boundary layers of Navier-Stokes equations at small viscosity, especially when a certain symmetry is imposed to the flow. More precisely, for the case of ill-prepared initial data, asymptotic behavior of radially symmetric, plane-parallel, and infinite-pipe flows are discussed. Concerning such models, using the method of correctors, we prove the vanishing viscosity limit, and a version of weak convergence of Navier-Stokes vorticity to Euler vorticity up to a measure on the boundary. (Received August 13, 2013)

1092-35-371 **Jay L Hineman*** (jay.hineman@gmail.com), Department of Mathematics, Fordham University, 441 E. Fordham Rd., Bronx, NY 10458, and **Changyou Wang**, Department of Mathematics, University of Kentucky, Lexington, KY 40506. *Well-Posedness of Nematic Liquid Crystal Flow in $L^3_{uloc}(\mathbb{R}^3)$.*

We discuss the local well-posedness of the Cauchy problem for a simplified version of hydrodynamic flow of nematic liquid crystals in $\mathbb{R}^3$ for any initial data (u_0, d_0) having small L^3_{uloc}-norm of $(u_0, \nabla d_0)$. Here $L^3_{\text{uloc}}(\mathbb{R}^3)$ is the space of uniformly locally L^3-integrable functions. (Received August 13, 2013)

1092-35-373 **Maria-Carme Calderer*** (mcc@math.umn.edu), Department of Mathematics, University of Minnesota, Minneapolis, MN 55455. *Liquid crystal elastomers and phase transitions in rod networks.*

We analyze models of anisotropic crosslinked polymers employing tools from the theory of liquid crystal elastomers. The anisotropy of these systems stems from the presence of rigid-rod molecular units in the network. We study minimization of the energy for incompressible as well as compressible materials, combining methods of isotropic nonlinear elasticity with the theory of lyotropic liquid crystals. We apply our results to the study of phase transitions in networks of rigid rods, in order to model the behavior of actin filament systems found in the cytoskeleton (Received August 13, 2013)

1092-35-380 **Mickaël D. Chekroun**, Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, **Michael Ghil**, Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, **Honghu Liu*** (hliu@atmos.ucla.edu), Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, and **Shouhong Wang**, Department of Mathematics, Indiana University, Bloomington, IN 47405. *On approximation formulas of stochastic invariant manifolds.*

In this talk, we present explicit analytic formulas for the leading-order Taylor approximation of stochastic invariant manifolds associated with a broad class of stochastic partial differential equations (SPDEs) driven by linear multiplicative white noise. The focus will be on stochastic critical manifolds that are built naturally as graphs over a fixed number of critical modes, which lose their stability as the system control parameter λ varies. Results for stochastic hyperbolic manifolds will also be mentioned.

An interesting and practically useful pullback characterization of the approximating manifolds will be presented by Mickaël D. Chekroun in this session, where a general analytic stochastic-reduction procedure based on the approximation formulas will also be shown, and the efficiency of the reduction will be demonstrated on a stochastic Burgers-type equation.

This is a joint work with Mickaël D. Chekroun, Michael Ghil, and Shouhong Wang. (Received August 14, 2013)

1092-35-381 **Mickaël D. Chekroun*** (mchekroun@atmos.ucla.edu), Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, **Michael Ghil**, Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, **Honghu Liu**, Department of Atmospheric & Oceanic Sciences, University of California, Los Angeles, CA 90095, and **Shouhong Wang**, Department of Mathematics, Indiana University, Bloomington, IN 47405. *Pullback characterization of stochastic approximating manifolds: Non-Markovian stochastic reduced equations, and applications.*

In this talk, we will first present how the approximating manifolds presented in Honghu Liu's talk can be described by a pullback characterization of the non-critical modes from the critical modes.

A general stochastic reduction procedure — based on this pullback characterization — will be then presented. It yields in particular to reduced systems of non-Markovian stochastic differential equations (SDEs) derived rigorously from the original SPDE.

These non-Markovian SDEs involve random coefficients that convey memory effects via the history of the noise, and arise from the nonlinear, leading-order interactions between the critical and non-critical modes, embedded in the "noise bath."

The approach will be then illustrated on a stochastic Burgers-type equation. It will be shown that the contribution of the memory effects become determinant as some spectral gaps decrease while the amount of the noise increases. In particular, it will be emphasized how such memory effects may turn out to play a significant role in the capture of the statistics of extreme events.

This is a joint work with Michael Ghil, Honghu Liu, and Shouhong Wang. (Received August 14, 2013)

1092-35-384 **Noel Walkington***, Department of Mathematics, Carnegie Mellon University, Pittsburgh, PA 15213. *Numerical studies of the Ericksen-Leslie equations modelling nematic liquid crystal flows.*

Numerical approximation of the flow of liquid crystals governed by the Ericksen-Leslie equations is considered. Care is taken to develop numerical schemes which inherit the Hamiltonian structure of these equations and associated stability properties. For a large class of material parameters compactness of the discrete solutions is established which guarantees convergence. (Received August 14, 2013)

37 ► Dynamical systems and ergodic theory

1092-37-54 **Magdalena Foryś**, **Jian Li** and **Piotr Oprocha*** (oprocha@agh.edu.pl), AGH University of Science and Technology, 30-617 Kraków, Poland. *Invariant scrambled sets and completely scrambled systems.* Preliminary report.

A dynamical system is completely scrambled if all nondiagonal pairs are Li-Yorke (i.e. are proximal but not asymptotic). A less restrictive condition is existence of an uncountable invariant (not necessarily closed) scrambled set. In this talk I will survey known results and open problems related to completely scrambled systems. If time permists, I will present results on relations between invariant scrambled sets and weak mixing obtained recently with my collaborators. (Received July 22, 2013)

1092-37-64 **Andrew Dykstra** and **Ayşe A Şahin*** (asahin@depaul.edu). *Kakutani equivalence in the nearly continuous category: Part I.* Preliminary report.

A nearly continuous dynamical system is the action of a group by measure preserving homeomorphisms on a Polish probability space. The category was introduced by Keane and Smorodinsky and the foundations were established by Denker and Keane in the 1970's. The field gained renewed interest in the 1990's when Keane and Hamachi proved that the binary and ternary odometers are nearly continuously orbit equivalent. In this talk we will describe the current state of nearly continuous orbit equivalence theory. We will also describe templates, a powerful combinatorial tool. Introduced by Roychowdhury and Rudolph, templates have played an essential role in the proof of several results as the means to generalize machinery introduced by Keane and Hamachi. They are also central in the proof of the latest result in this category: that the Morse minimal system and the binary odometer are nearly continuously Kakutani equivalent. (Received July 25, 2013)

1092-37-90 **Aimee S.A. Johnson*** (aimee@swarthmore.edu), Department of Mathematics and Statistics, Swarthmore College, Swarthmore, PA 19081, and **David M. McClendon**, Ferris State University, Big Rapids, MI 49307. *Speedups of $\mathbb{Z}^d$-actions.*

Speedups were introduced in 1985 by Arnoux, Ornstein, and Weiss when they showed that given any two aperiodic measure-preserving transformations, one could "speed up" one to be isomorphic to the other. More recently, Babichev, Burton, and Fieldsteel gave a relative version of this result which considers ergodic group extensions. In this talk we consider what a speedup means when considering d commuting transformations and discuss results for $\mathbb{Z}^d$-actions. (Received July 31, 2013)

1092-37-157 **Lluís Alsedà** and **Michał Misiurewicz***, mmisiure@math.iupui.edu. *Mystery of the Vanishing Attractor.*

Consider a skew product $F : B \times X \to B \times X$, given by $F(b, x) = (R(b), f(b, x))$. It can be regarded as a random system, Strange Nonchaotic Attractor, Iterated Function System, nonautonomous system, etc. In many cases the dynamics of R in the base is well understood, and one investigates what happens in the fibers. Therefore it makes sense to consider an attractor which is a graph of a (measurable or Borel) function $\varphi : B \to X$, and "attractor" means that the distance (in the corresponding fiber) of the second component of $F^n(b, x)$ from the value of φ at the first component goes to 0 as $n \to \infty$ for almost all starting points (b, x). If (B, R) is a Bernoulli shift, we can consider one-sided and two-sided systems. We give two examples (one very simple and one more complicated) where the attractor exists for the two-sided system, but not for the one-sided one. This is a paradox, since the definition of the attractor involves only the future, but the attractor vanishes when we forget about the past. Moreover, the past and future are independent of each other! (Received August 07, 2013)

1092-37-210 **Vitaly Bergelson*** (vitaly@math.ohio-state.edu). *Some Recent Results and Open Problems in Ergodic Ramsey Theory.*

We will review some recent advancements in Ergodic Ramsey Theory and discuss some natural open problems and conjectures. (Received August 09, 2013)

1092-37-222 **Mahesh G Nerurkar*** (nmahesh@crab.rutgers.edu), 311 N 5th street, Department of Mathematics, Rutgers University, Camden, NJ 08081. *Regional Proximality Relation in Topological Dynamics.*

One of the most fundamental theorem in topological dynamics says that, (under various conditions on the acting group or its action) the regional proximality relation is an equivalence relation. Several different proofs of this result are available, (due to Furstenberg, Ellis, Veech, McMahon, Auslander-Guerin). We shall present another proof based on capturing this relation in terms of 'Birkhoff ultrafilters' and showing that these ultrafilters has a semigroup structure. The advantage in our proof is that it can be extended to the study of the notion of 'order d regional proximality' recently introduced by Host, Kra and Maass. (Received August 10, 2013)

1092-37-224 **Alistair Windsor*** (awindsor@memphis.edu), Department of Mathematical Sciences, University of Memphis, Memphis, TN 38152-3240. *D-sets and a Sarkozy Theorem for Countable Fields.*

Using essential idempotent ultrafilters we establish a version of Sarkozy's Theorem for the action of countable fields of characteristic p. Rather than attempt to sketch the whole proof we will will focus on illustrating where the essential and idempotent nature of the ultrafilter is used. This is joint work with Randall McCutcheon. (Received August 10, 2013)

1092-37-269 **Matthew D Foreman*** (mforeman@math.uci.edu), Mathematics Dept., UC Irvine, Irvine, CA 92697. *Smooth measure preserving transformations on the torus are unclassifiable.*

The talk discusses joint work the B. Weiss showing that smooth measure preserving transformations of the torus are not classifiable up to isomorphism by measure preserving transformations. Possible extensions to the relation of conjugacy by homeomorphisms will be discussed. (Received August 12, 2013)

1092-37-271 **Kelly B Yancey*** (kbyancey1@gmail.com) and **Rachel L Bayless**. *Rigidity in the Infinite Setting.* Preliminary report.

In this talk we will discuss rigid transformations that preserve an infinite measure. We will also discuss the various notions of mixing in this setting and how constructions are obtained via cutting and stacking. This is joint work with Rachel Bayless. (Received August 12, 2013)

1092-37-282 **Judy Anita Kennedy*** (kennedy9905@gmail.com), Dept. Mathematics, PO box 10047, Lamar University, Beaumont, TX 77710. *Turning a set-valued function into a surjective continuous function.* Preliminary report.

We discuss inverse limits with set-valued functions, or generalized inverse limits, a fairly new object of study by continuum theorists. If X is a compact metric space and F is an upper semicontinuous function from X into the closed subsets of X, then Y:= <x(0),x(1),...> : x(i-1) is in F(x(i)), i > 0 is also a compact metric space. The shift map S from Y to Y defined by S(<x(0),x(1),...>) = <x(1),x(2),...> is surjective and continuous even though it is induced by an object that is not even a function in the usual sense. The price paid is that the new space Y is generally more complicated topologically than the original space. We give an overview of what is presently known about these new spaces and the dynamics of S. (Received August 12, 2013)

1092-37-298 **James Keesling*** (kees@ufl.edu), Department of Mathematics, University of Florida, Gainesville, FL 32611-8105, and **James Maissen** (jmaissen@yahoo.com), Department of Mathematics, University of Texas, Brownsville, Brownsville, TX 78520. *A characterization of the irrational points of the Sierpiński Carpet.*

Krasinkiewicz proved that the Sierpiński Carpet, X, is $\frac{1}{2}$-homogeneous, that is, there are just two orbits of the homeomorphism group of X. In this paper we give a characterization of these orbits as spaces. The result generalizes to higher dimensional spaces with similar construction. We give some applications of the result. (Received August 12, 2013)

1092-37-303 **Andrew Dykstra*** (adykstra@hamilton.edu), 198 College Hill Road, Clinton, NY 13323, and **Ayse Sahin**. *Kakutani equivalence in the nearly continuous category: part II.*

We outline a proof of the following result: The Morse minimal system and the binary odometer are nearly continuously Kakutani equivalent. We construct our equivalence using induction, as is typical of orbit equivalence constructions in the measure theoretic category. But in addition to being a measurable orbit equivalence, our equivalence must also preserve the topological structure of the underlying actions. Specifically, it must be a homeomorphism between full-measure, dense G_δ subsets, and must restrict to a measurable isomorphism between induced systems where the sets on which we induce have positive measure and are within measure zero of an open set and within measure zero of a closed set. To achieve all of this, our construction relies heavily on the template machinery introduced by Roychowdhury and Rudolph. In addition to discussing what a template is in general, we describe the form templates must take in our context to address the dynamical differences between the Morse system and the odometer. (Received August 12, 2013)

1092-37-305 **Alica Miller** (a0mill01@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292, and **Chad Money*** (cpmone02@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292. *Sensitivity in Arbitrary Semiflows.* Preliminary report.

If a cascade (X, f) is transitive with dense periodic points, then it must be sensitive. A natural question is whether the same is true for a general semiflow (T, X). We will see that, in general, if a semiflow (T, X) is transitive with dense periodic points, but is not sensitive, it must be compact, minimal and uniformly equicontinuous. Also, we will give some corollaries of this. (Received August 12, 2013)

1092-37-309 **Xuan Zhang*** (zhang_x@math.psu.edu), Penn State Univeristy, Department of Mathematics, 109 McAllister Building, University Park, PA 16802. *Poisson limit law for Gibbs-Markov systems.* Preliminary report.

We will discuss some new Poisson laws arising in dynamical systems. In particular, We will discuss this in connection with extreme value distributions in dynamics and Gibbs-Markov maps. Also we will relate this to a

classic result of Doeblin for continued fractions. This is a joint work with Prof. Manfred Denker. (Received August 12, 2013)

1092-37-324 **David B. Ellis*** (ellis@beloit.edu), Beloit College, 700 College Street, Beloit, WI 53511, and **Robert Ellis**. *Equivalence Relations and Automorphisms in Topological Dynamics.* Preliminary report.

The fact that there exists a (unique up to isomorphism) universal minimal flow M means that every minimal flow is a quotient of the form M/R for some *icer* (closed invariant equivalence relation) R on M. Thus minimal flows can be studied via the icers on M. Here the group G of automorphisms of M and its relation to the natural semigroup structure on M play a crucial role. Various subgroups of G and the so-called τ-topology on G can be exploited to understand the structure of the icers on M and hence develop the algebraic theory of minimal sets. In this talk I will preview some of the results in this direction which will appear in an upcoming volume in the Cambridge University Press London Mathematical Society Lecture Notes Series (co-authors David B. Ellis and Robert Ellis) (Received August 12, 2013)

1092-37-338 **Joseph Rosenblatt*** (rosnblt@illinois.edu), Department of Mathematics UIUC, 273 Altgeld Hall, 1409 West Green Street, Urbana, IL 61801. *Optimal Norms in Ergodic Theory.* Preliminary report.

Classical ergodic averages give good norm approximations, but these averages are not necessarily giving the best norm approximation among all possible averages. We consider 1) what the optimal Cesaro norm approximation can be in terms of the transformation and the function, 2) when these optimal Cesaro norms are not (or are) comparable to the norm of the usual ergodic average, and 3) size and oscillatory behavior of the optimal norms and the classical norms. (Received August 13, 2013)

1092-37-343 **Stefan Müller***, Department of Mathematics, 1409 W Green Street, Urbana, IL 61801. *Topological Hamiltonian and contact dynamics.*

In classical mechanics the dynamics of a Hamiltonian vector field model the motion of a particle in classical phase space, and the dynamics of a contact vector field play a similar role in geometric optics (in the mathematical model of Huygens' principle). Topological Hamiltonian dynamics and topological contact dynamics are recent theories that explore natural questions regarding the regularity of such dynamical systems. In a nutshell, they admit genuine generalizations to non-smooth dynamical systems with non-smooth generating (contact) Hamiltonian functions.

The talk begins with examples that illustrate the central ideas and lead naturally to the key definitions. The main technical ingredient is the well-known energy-capacity inequality for displaceable subsets of a symplectic manifold. We use it to prove an extension of the classical 1-1 correspondence between isotopies and their generating Hamiltonians. This crucial result turns out to be equivalent to certain rigidity phenomena for smooth Hamiltonian and contact dynamical systems. The rest of the talk addresses sample applications to topological dynamics and to Riemannian geometry. In particular, we prove a rigidity result for the geodesic flows associated to a uniformly weakly convergent sequence of Riemannian metrics. (Received August 13, 2013)

1092-37-344 **Nicholas Ormes*** (normes@du.edu), 2360 S. Gaylord St., Denver, CO 80208, and **Ronnie Pavlov** (rpavlov@du.edu), 2360 S. Gaylord St., Denver, CO 80208. *Extender sets and multidimensional subshifts.* Preliminary report.

In this talk, we consider a $\mathbb{Z}^d$ extension of the well-known fact that one-dimensional shifts with only finitely many follower sets are sofic. As in a paper of Kass and Madden, we adopt a natural $\mathbb{Z}^d$ analog of a follower set, called an extender set. The extender set of a finite word w in a $\mathbb{Z}^d$ symbolic system is the set of all configurations of symbols on the complement of w which, when concatenated with w, form a legal point of the system. We show that for any $d \geq 1$ and any $\mathbb{Z}^d$ subshift X, if there exists n so that the number of extender sets of words on a d-dimensional hypercube of side length n is less than or equal to n then X is sofic, i.e. a topological factor of a $\mathbb{Z}^d$ shift of finite type. There are easy examples of non-sofic systems for which this number of extender sets is $n+1$ for every n. (Received August 13, 2013)

1092-37-359 **Minghu Wang*** (wmhmax@gmail.com), 2203 James Guthrie Ct. Apt. 2, Louisville, KY 40217, and **Jiaxu Li** and **James D Johnson**. *Mathematical studies on the anti-apoptotic effects on pancreatic beta-cells.*

The progression of type 2 diabetes is along with the apoptosis of pancreatic beta-cells. Thus it is critical to investigate the causes of the loss of beta-cells and how to prevent and/or stop the progression. We formulate a mathematical model to this end. The analysis of our fast-slow dynamical model reveals its interesting features. Through the model, we preliminarily found that the intermittent rests of beta-cells in secretion are critical for

the cells to survive. Our preliminary data fitting of Pima Indian diabetics validates our findings. (Received August 13, 2013)

39 ► Difference and functional equations

1092-39-183 **Lan Nguyen*** (lan.nguyen@wku.edu) and **Constantin Buse**. *Asymptotic Stability of Discrete Non-autonomous System via Discrete Evolution Semigroups.*

Consider the discrete evolution family $\mathcal{U} = \{U(n,m) : n \geq m \in Z^+\}$ of bounded, linear operators on a Banach space E. We study different types of stability of $\mathcal{U}$ ((non)uniform strong stability, (non)uniform exponential stability, etc.) by studying the corresponding stability of the evolution semigroup $\mathcal{T} = \{T(n)\}_{n\in Z^+}$ defined by

$$(T(n)f)(k) := U(k, k-n)f(k-n)$$

in a suitable space $l(Z^+, E)$ of sequences from Z^+, the set of non-negative integers, to E. We show that the stability conditions on semigroup $\mathcal{T}$ in different spaces $l(Z^+, E)$ are not the same and we obtain each type of stability of $\mathcal{U}$ by choosing the right sequence space. (Received August 08, 2013)

1092-39-188 **M. J. Bohner** and **Nasrin Sultana*** (nsq4d@mail.mst.edu), 1512 Watts Dr., Rolla, MO 65401. *Bounded solution of a discrete Volterra equation.*

In this article we study the existence of a continuous and bounded solution of a nonlinear discrete Volterra equation. The technique and the tools employed in the analysis, Schaefer's fixed point theorem and Liapunov's direct method, are based on the applications of discrete cases analogous to ordinary differential equations. Our work unifies the study of the continuous and the corresponding discrete versions. (Received August 08, 2013)

1092-39-239 **Ying Zhou*** (yzhou@amath.washington.edu). *Niche deficits in climate warming.* Preliminary report.

Climate warming has caused species across the globe to shift their geographic ranges in recent years.This phenomenon has inspired us to consider an integrodifference equation (IDE) model for a single-species population whose suitable spatial range changes over time. The model admits traveling pulse solutions, and is very versatile for prescribing various scenarios of climate warming. It is shown that climate warming outruns the shifting population distribution in various warming scenarios. I will use the term "niche deficits" to refer to the distance that the population lags behind. The accumulation of niche deficits is shown to be drastically different between the constant-seed warming case and the accelerated-warming case. (Received August 11, 2013)

1092-39-329 **Martin Bohner*** (bohner@mst.edu), Department of Mathematics and Statistics, 400 West 12th Street, Rolla, MO 65409-0020. *Positive periodic solutions of higher-order functional q-difference equations.*

In this talk, using the recently introduced concept of periodic functions in quantum calculus, we study the existence of positive periodic solutions of a certain higher-order functional q-difference equation. Just as for the well-known continuous and discrete versions, we use a fixed point theorem in a cone in order to establish the existence of a positive periodic solution. (Received August 13, 2013)

41 ► Approximations and expansions

1092-41-196 **Miao-jung Yvonne Ou*** (mou@math.udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *On reconstruction of dynamic permeability and tortuosity of poroelastic materials.*

Dynamic permeability refers to the permeability of poroelastic media subjecting to oscillatory pressure gradient. It depends on both the frequency and the pore space geometry. The dynamic tortuosity is inversely related to the dynamic permeability and plays an important role in the mechanism of energy dissipation of waves through poroelastic materials. Numerically, dynamic tortuosity is the kernel in the memory term in the dissipation term for time domain wave equations; it is known to associated with fractional derivative of order 1/2.

In this talk, we will present our results on reconstructing the dynamic permeability as a function of frequency from partial data by utilizing its analytical properties when extending to the complex frequency plane. Using the relation between tortuosity and permeability, a set of quadratures are constructed for handling the memory term in the poroelastic wave equations. (Received August 09, 2013)

42 ► Fourier analysis

1092-42-28 **Steve Hofmann*** (hofmanns@missouri.edu), Department of Mathematics, University of Missouri, Columbia, MO 65211. *Uniform rectifiability and elliptic equations.* Preliminary report.

We discuss recent progress on an ongoing project to understand the relationship between estimates for harmonic functions (or more generally, solutions of divergence form elliptic equations) in an open set $\Omega \subset \mathbb{R}^d$, and quantitative rectifiability properties of $\partial\Omega$.

(Received July 04, 2013)

1092-42-69 **Ciprian Demeter*** (demeterc@indiana.edu). *Progress on the discrete restriction problem for the sphere.* Preliminary report.

We discuss new estimates for exponential sums associated with lattice points on the sphere. (Received July 27, 2013)

1092-42-264 **Eric Stachura*** (eric.stachura@temple.edu). *A Unified Approach to Weighted Estimates of Commutators with BMO Functions.*

Since the introduction of commutators by Calderón in the early 1960's, commutators of singular integral operators with certain functions have played an important role in Harmonic Analysis. Even now there is a plethora of results concerning commutators in the literature. Independently, for the same operators, it is common to find a well established weighted norm theory. An important step in estimating commutators in L^p was initiated by Coifman, Rochberg, and Weiss in 1976 when they used the tools of Complex Analysis to obtain L^p estimates for commutators of Calderón-Zygmund operators with functions belonging to the John-Nirenberg space of Bounded Mean Oscillation. Since then, much has been done in this direction, but all at an ad-hoc level. In this talk I will discuss how the weighted estimates for commutators follow nearly automatically from the weighted norm theory. Thus, provided the weighted norm inequalities have been proved, the ad-hoc arguments for the commutators may be skipped. The general method of proof we give allows for applications to many families of operators, some of which include Calderón-Zygmund operators, the Riesz Transforms, and operators associated with the Kato conjecture. This is joint work with Arpad Benyi, José María Martell, Kabe Moen, and Rodolfo Torres. (Received August 12, 2013)

1092-42-361 **Dorina Mitrea*** (mitread@missouri.edu), University of Missouri, Department of Mathematics, Columbia, MO 65211. *A general jump-formula in the class of tempered distributions.* Preliminary report.

Since the pioneering work of Sokhotsky and Plemelj, jump formulas for singular integral operators have been of basic importance in the treatment of boundary value problems via boundary layer methods. In my talk, I will discuss a result, formulated in the language of tempered distributions, which isolates the active ingredient in any such jump formula. Several applications to problems in PDEs in harmonic analysis will be presented as well. (Received August 13, 2013)

1092-42-362 **Akram Aldroubi**, **Jacqueline Davis*** (jacqueline.t.davis@email.vanderbilt.edu) and **Ilya Krishtal**. *Reconstruction of spatially undersampled signals in dynamical systems.*

We propose a new type of inverse problem that arises from sampling an evolving field at various times. We show that coarse samplings taken at varying times often contain the same information as a finer sampling taken at the earliest time. In other words, under some conditions on the evolving system, we can trade spatial samples for time samples.

This talk explores the recovery of a signal $x \in \ell^2(\mathbb{Z})$ in a dynamical system with evolution rule given by the operator $A : \ell^2(\mathbb{Z}) \to \ell^2(\mathbb{Z})$, where $Ax = a * x$ for some $a \in \ell^1(\mathbb{Z})$. In other words, the signal at time $t = n$ is given by $A^n x = (\underbrace{a * \cdots * a}_{n}) * x$. Undersampling the original signal by a rate m can be offset by $m-1$ additional time samples and a few extra samples of the original signal. (Received August 13, 2013)

43 ► Abstract harmonic analysis

1092-43-290 **Ryan Alvarado*** (rjamt9@mail.missouri.edu) and **Marius Mitrea** (mitream@missouri.edu). *Atomic and Molecular Characterizations of Hardy Spaces in Ahlfors-David Regular Quasi-Metric Spaces.* Preliminary report.

In this talk we will survey some recently obtained results pertaining to the theory of Hardy spaces (H^p spaces) in the setting of d-dimensional Ahlfors-David regular quasi-metric spaces. More specifically, we will introduce Hardy spaces defined via a grand maximal function and prove that this notion of H^p has atomic and molecular characterizations in the above context. We will also discuss the dual of H^p as well as present some criterion for the boundedness of linear operators on H^p, including the class of singular integral operators of Calderón-Zygmund type. (Received August 12, 2013)

45 ► Integral equations

1092-45-314 **Dominic Lanphier*** (dominic.lanphier@wku.edu), Department of Mathematics, Western Kentucky University, Bowling Green, KY 42101. *An integral formula for the Taylor coefficients of products of functions and applications to orthogonal polynomials.*

We give an integral formula which can be interpreted either as a formula for the Taylor coefficients of a product of holomorphic functions or as an interpolation-type formula. The main ingredients in the proof are Fourier analysis and Ramanujan's Master Theorem. We then give applications to several orthogonal polynomials. (Received August 12, 2013)

1092-45-347 **Irina Mitrea*** (imitrea@temple.edu), 1805 N. Broad St., Department of Mathematics, Temple University, Wachman Hall, Philadelphia, PA 19122. *Szegö Projections and Kerzman-Stein Formulas.*

Hardy spaces constitute a classical topic at the interface between Complex Analysis and Harmonic Analysis and progress in a deeper understanding of their geometric and functional analytic properties can have a fundamental impact on related issues. For example, the direct topological sum decomposition of $L^2(\Sigma)$ into $\mathcal{H}^2_{\pm}(\Sigma)$ (traces on Σ of holomorphic functions on either side of Σ) in the case when Σ is a Lipschitz curve in the plane is equivalent to the boundedness of the principal value version of the Cauchy operator on $L^2(\Sigma)$ (a famous result due to Calderón for small Lipschitz constants, and to Coifman, McIntosh and Meyer in full generality). In this talk I will address the question whether the orthogonal projection S of the Hilbert space $L^2(\Sigma)$ onto the closed subspace $\mathcal{H}^2_+(\Sigma)$ (or $\mathcal{H}^2_-(\Sigma)$) has a bounded extension as an operator on $L^p(\Sigma)$ with $p \neq 2$. This is a rather delicate issue, which interfaces tightly with the geometric character of Σ. The main tools are a new generation of commutator estimates and a far-reaching extension of the so-called Kerzman-Stein formula from Complex Analysis. This is joint work with M. Mitrea and M. Taylor. (Received August 13, 2013)

46 ► Functional analysis

1092-46-194 **Paul D McKenney*** (pmckenney@gmail.com), 325 Foxfire Dr, Apt 202, Oxford, PA 45056. *Forcing axioms and corona algebras.*

Certain independence phenomena in set-theoretic topology have recently been shown to extend to the setting of operator algebras. For instance, in analogy to Shelah's landmark proof of the consistency of the statement "All automorphisms of $\mathcal{P}(\omega)/\text{fin}$ are induced by an almost-permutation of ω", Farah has shown that, consistently, every automorphism of the Calkin algebra over a separable Hilbert space must be inner. I will discuss how both of these results are subsumed by a wide-reaching conjecture of Coskey and Farah, concerning the rigidity of corona algebras under forcing axioms; and some of my recent results in proving specific instances of this conjecture. (Received August 09, 2013)

1092-46-350 **Alexander A. Katz*** (katza@stjohns.edu), Dep. of Math & CS, St. John's College of LAS, St. John's University, 8000 Utopia Parkway, SJH-334-i, Queens, NY 11439. *On representations of locally m-convex involutory algebras.*

In the paper we show that each complex locally m-convex involutory algebra has a *-representation as an involutory algebra of continuous linear operators acting on a locally convex inner product space. (Received August 13, 2013)

47 ► Operator theory

1092-47-66 **Robert Haller-Dintelmann*** (haller@mathematik.tu-darmstadt.de), TU Darmstadt, FB Mathematik, Schlossgartenstr. 7, 64289 Darmstadt, Germany. *Square roots of divergence form operators on L^p spaces.*

We consider the square root of a second order divergence form operator $-\mathrm{div}\mu\nabla + 1$ with mixed boundary conditions in $L^p(\Omega)$ for a class of domains Ω that in particular comprises all Lipschitz domains. Assume that the operator has the Kato square root property, i.e. the domain of its square root in $L^2(\Omega)$ is equal to $W^{1,2}_D(\Omega)$, where the index D refers to the boundary condition. Then it turns out that the square root also is an isomorphism between $W^{1,p}_D(\Omega)$ and $L^p(\Omega)$ for all $1 < p < 2$. In this general setting this result is even new for pure Dirichlet or pure Neumann conditions.

The result is based on an adapted version of the Calderón-Zygmund decomposition for Sobolev functions that respects the partial Dirichlet boundary condition.

In addition we give a criterion for the Kato square root property to be valid for these operators. It allows to deduce this property from regularity properties of the corresponding Laplace operator with the same boundary condition and thus decouples the treatment of the coefficient functions μ from the geometric issues. (Received July 26, 2013)

1092-47-195 **Clement Boateng Ampadu*** (drampadu@hotmail.com), 31 Carrolton Road, Boston, MA 02132. *On a fixed point theorem in G-metric spaces satisfying a general contractive condition of integral type.*

We establish a fixed point theorem for a mapping satisfying a general contractive inequality of the integral type in the sense of B.E Rhoades [IJMMS 2003: 63, 4007-4013] (Received August 09, 2013)

49 ► Calculus of variations and optimal control; optimization

1092-49-136 **Jason Bintz*** (bintz@math.utk.edu). *Optimal Control of Resource Coefficient In A Diffusive Population Model.* Preliminary report.

We study the problem of allocating resources to maximize the net benefit in the conservation of a single species with a fixed amount of resources. The population model is a parabolic differential equation with density dependent growth and spatial-temporal resource control coefficient. Recent work considered such control for a steady state population. The existence of an optimal control is established and the uniqueness and characterization of the optimal control are investigated. Numerical simulations illustrate several cases. (Received August 06, 2013)

1092-49-201 **Horst Behncke** and **Wandi Ding*** (wandi.ding@mtsu.edu), 1301 E. Main Street, MTSU Box 34, Murfreesboro, TN 37132, and **Suzanne Lenhart**. *Discrete Time Optimal Harvesting of Fish Populations with Age Structure.*

We consider an optimal fishery harvesting problem using an age-structured population model with nonlinear recruitment. The motivating example is Atlantic Cod. The goal is to maximize the profit (total gain) of fishing. The feature is not only we seek to find the optimal harvesting strategy for each age class, but also to find the optimal net size. Using the extension of Pontryagin's Maximum Principle to discrete systems, we are able to derive the necessary conditions and the characterizations for the optimal harvesting strategies. Numerical simulations are provided. (Received August 09, 2013)

1092-49-385 **Marta Lewicka***, lewicka@pitt.edu. *Dimension reduction for a liquid glass model.* Preliminary report.

We derive the Gamma-limit, as the thickness of a thin film goes to 0, of the non-Euclidean elastic energies where the prestrain tensor is of the form $Id + \vec{n} \otimes \vec{n}$, pertaining to a model of liquid glass. (Received August 14, 2013)

51 ► Geometry

1092-51-20 **David A Herron**, University of Cincinnati, and **Poranee K Julian*** (julianpk@ucmail.uc.edu), University of Cincinnati - Blue Ash College. *Blaschke's Rolling Ball Property and Conformal Metric Ratios.*

This research is focused on a generalization of Blaschke's Rolling Ball Property that has been used to study various problems from mathematical morphology, image analysis, and smoothing. The purpose of this work was to characterize the closed sets in Euclidean space that satisfy a two-sided rolling ball property and to show that certain conformal metric ratios have a boundary value of one as an application. A closed set satisfies the two-sided rolling ball property provided it is possible to freely roll a ball with fixed radius inside and outside the closed set along its boundary. The main theorem proved by a geometric approach can be summarized as follows:

A non-empty and closed set has the two-sided rolling ball property if and only if it is an orientable $C^{1,1}$ smooth embedded submanifold, and there is a globally defined Lipschitz continuous unit normal vector field along it.

The size of a singular set was also studied in this work. Here, the singular set for a C^1 hypersurface is the set of points where the associated unit normal vector field is not differentiable. (Received June 16, 2013)

1092-51-122 **Junhua Wu*** (jwu@lanecollege.edu), Lane College, Jackson, TN 38301. *On an LDPC Code Related to a Bukenhout-Metz Unital in $PG(2, q^2)$.*

Low Density Parity Check (LDPC) codes are one of the hottest topics in coding theory today. Originally invented in the early 1960's, they have experienced an amazing comeback in the last few years. In this talk, we study an LDPC code arising from the $\mathbb{F}_2$-null space of the incidence matrix of the points in a speical Bukenhout-Metz unital versus its secant lines in the finite projective plane of order q^2. In particular, we provide a proof for the conjecture on the dimension of this code. This work is supported in part by NSF HBCU-UP Grant Award 0929257 at Lane College. (Received August 05, 2013)

52 ► Convex and discrete geometry

1092-52-119 **Akihiro Higashitani*** (a-higashitani@cr.math.sci.osaka-u.ac.jp). *Minkowski sums of edge polytopes.*

Let G be a connected simple graph on the vertex set $\{1, \ldots, d\}$ with the edge set $E(G)$ and let $\mathcal{P}_G$ be the edge polytope of G, which is the convex hull of $\{\mathbf{e}_i + \mathbf{e}_j : \{i, j\} \in E(G)\}$, where $\mathbf{e}_1, \ldots, \mathbf{e}_d$ are the unit coordinate vectors of $\mathbb{R}^d$. For an integral convex polytope $\mathcal{P} \subset \mathbb{R}^N$, we say that $\mathcal{P}$ possesses the integer decomposition property if for any positive integer k and for any $\alpha \in k\mathcal{P} \cap \mathbb{Z}^N$, there exist $\alpha_1, \ldots, \alpha_k \in \mathcal{P} \cap \mathbb{Z}^N$ such that $\alpha = \alpha_1 + \cdots + \alpha_k$. It is a fundamental and interesting problem to give a complete characterization when the Minkowski sum $\mathcal{P}_G + \mathcal{P}_{G'}$ of two edge polytopes of graphs G and G' on the same vertex set possesses the integer decomposition property. In this talk, some partial answers of this problem will be presented. (Received August 05, 2013)

54 ► General topology

1092-54-22 **M. S. Khan*** (mohammad@squ.edu.om), College of Science, Department of Mathematics, 123 Muscat, Al-Khod, Oman. *Some fixed point theorems with applications.* Preliminary report.

In this paper, we prove some fixed point results in the setting of two metric spaces endowed with a partial order satisfying a generalized contractive condition. The proved result generalize and extend some known results in the literature. As application, we establish an existence result for a nonlinear first order differential equation. (Received June 24, 2013)

55 ► Algebraic topology

1092-55-1 **Michael Hill***, University of Virginia, Department of Mathematics, Charlottesville, VA. *Framed manifolds and equivariant homotopy: A solution to the Kervaire Invariant One problem.*

The Kervaire Invariant One problem was one of the oldest outstanding problems in algebraic topology, and in 2009, Hopkins, Ravenel, and the speaker announced a solution using a variety of techniques from both classical

and equivariant algebraic topology. This talk will describe the problem, explaining what the Kervaire invariant is and some of its importance in differential topology, and then it will explain the ideas that go into the solution. (Received March 18, 2012)

60 ► Probability theory and stochastic processes

1092-60-7 **Richard C. Bradley*** (bradleyr@indiana.edu), Department of Mathematics, Indiana University, Bloomington, IN 47405. *On a "replicating character string" model.*

In a paper of Chaudhuri and Dasgupta [Statistica Sinica 16 (2006) 29-43], a certain stochastic model for "replicating character strings" (such as in DNA sequences) was studied. In their model, a random "input" sequence was subjected to random mutations, insertions, and deletions, resulting in a random "output" sequence. In this talk, their model will be set up in a slightly different way, in an effort to facilitate further development of the theory for their model. In their paper, Chaudhuri and Dasgupta showed that under certain conditions, strict stationarity of the "input" sequence would be preserved by the "output" sequence, and they proved a similar "preservation" result for the property of strong mixing with exponential mixing rate. In our setup, we shall in spirit slightly extend their "preservation of stationarity" result, and also establish a "preservation" result for the property of absolute regularity with summable mixing rate. (Received March 25, 2013)

1092-60-26 **Wlodek Bryc*** (wlodzimierz.bryc@uc.edu), Department of Mathematical Sciences, University of Cincinnati, Cincinnati, OH 45221, and **Jacek Wesolowski**. *Infinitesimal generators of q-Meixner processes.*

We show that the weak infinitesimal generator of a class of Markov processes acts on bounded continuous functions with bounded continuous second derivative as a singular integral with respect to the orthogonality measure of the explicit family of polynomials. (Received July 01, 2013)

1092-60-30 **Manfred Denker*** (denker@math.psu.edu), Mathematics Department, Pennsylvania State University, University Park, State College, PA 16802. *Von Mises Functionals For Mixing Processes.*

A von Mises functional has the form

$$\sum_{1_1,\ldots,i_d\le n} h(X_{i_1},\ldots,X_{i_d})$$

where X_n $(n \ge 1)$ is a stochastic process and h an element in some L_p-space. I will give some conditions which ensure that the above expression is well defined and state several theorems concerning the a.s. and distributional behavior when the stochastic process is weakly mixing and stationary.

This is joint work with M. Gordin. (Received July 09, 2013)

1092-60-53 **Florence Merlevède**, **Costel Peligrad** and **Magda Peligrad*** (peligrm@ucmail.uc.edu), Department of Mathematical Sciences, University of Cincinnati, PO Box 210025, Cincinnati, OH 45221-0025. *The universality of spectral limit for random matrices with martingale differences entries.*

For a class of symmetric random matrices whose entries are martingale differences adapted to an increasing filtration, we prove that under a Lindeberg-like condition, the empirical spectral distribution behaves asymptotically similarly to a corresponding matrix with independent centered Gaussian entries having the same variances. Under a slightly reinforced condition, the approximation holds in the almost sure sense. We also point out several sufficient regularity conditions imposed to the variance structure for convergence to the semicircle law or the Marchenko-Pastur law and other convergence results. In the stationary case we obtain a full extension from the i.i.d. case to the martingale case of the convergence to the semicircle law as well as to the Marchenko-Pastur one. Our results are well adapted to study several examples including non linear ARCH-infinite random fields. (Received July 20, 2013)

1092-60-65 **Dalibor Volny*** (dalibor.volny@univ-rouen.fr), Laboratoire/department, of mathematics, F 76801 St.Etienne-Rouvray, France, and **Jana Klicnarova** and **Yizao Wang**. *On Hannan s Condition.*

A powerful condition guaranteeing the CLT for stationary processes was found in 1973 by Australian statistician E.J. Hannan. The Hannan assumption is independent of much more recent conditions, like Maxwell-Woodroofe Condition. I am going to present some results of the research on limit theorems using the Hannan Condition in last ten years, in particular on the invariance principle and quenched/non quenched versions of the limit theorems and on Hannan s Condition for random fields. (Received July 26, 2013)

1092-60-74 **Dalibor Volny** (dalibor.volny@univ-rouen.fr) and **Yizao Wang*** (yizao.wang@uc.edu). *Invariance principle for stationary random fields under Hannan's condition.*

We establish an invariance principle for a general class of stationary random fields indexed by Z^d, under Hannan's condition generalized to Z^d. To do so we first establish a uniform integrability result for stationary orthomartingales, and second we establish a coboundary decomposition for certain stationary random fields. At last, we obtain an invariance principle by developing an orthomartingale approximation. Our invariance principle improves known results in the literature, and particularly we require only finite second moment. (Received July 29, 2013)

1092-60-83 **Robert J Niichel*** (rjniichel@gmail.com), 504 E Graham Pl, Bloomington, IN 47401. *A "Weak-Type" Law for Sampled Periodograms Under Rho-Prime Mixing.*

It is natural to ask whether dependent random variables under mixing conditions obey any of the classical Laws of Large Numbers. I will discuss a result that resembles the Weak Law of Large Numbers for periodograms of a rho-prime mixing random field with sampled frequencies. (Received July 30, 2013)

1092-60-84 **Michael B Woodroofe*** (michaelw@umich.edu). *Quenched Convergence for Normalized Sums of a Stationary Process.*

Consider a stationary Markov chain $W_0, W_1, \cdots$ with transition function Q and marginal distribution π, $Q(w, B) = P[W_{n+1} \in B | W_n = w]$ and $\pi\{B\} = P[W_n \in B]$. Given a $g \in L^2(\pi)$ for which $\int g d\pi = 0$, let $X_k = g(W_k)$, $S_n = X_1 + \cdots + X_n$, $\sigma_n^2 = E(S_n^2)$, and $F_n(z) = P[S_N/\sigma_n \le z]$. Interest center on cases in which F_n converges weakly to the standard normal distribution function Φ. In touch cases, the convergence is said to be annealed. Next, let $G_n(w; z) = P[S_n/\sigma_n \le z | W_0 = w]$, so that $D_n(w; \cdot)$ is the conditional distribution function of S_n/σ_n given $W_0 = w$. If $G_n(w; \cdot)$ converges (weakly) to Φ for *a.e.* $w(\pi)$, then the convergence is said to b quenched. Another possibility it that $G_n(W_0; \cdot)$ converges to Φ in probability. In this case, the convergence is said to be weakly quenched. The definitions extend directly to a stationary process $\cdots X_{-1}, X_0, X_1, \cdots$ with mean 0 and finition variance by letting $W_n = (\cdots, X_{n-1} X_n)$. Recent research on quenched convergence are known is reviewed and some new results presented. (Received July 30, 2013)

1092-60-92 **Steven T Morrow*** (steven.morrow@fairmontstate.edu). *A 'Cousin of Coboundary' Theorem for $C[0,1]$-Valued Random Fields with Moment Conditions.* Preliminary report.

Klaus Schmdit proved the following in 1977: Given a strictly stationary sequence $(X_k, k \in \mathbb{Z})$ of real-valued random variables, such that the family of distributions of the sequence of partial sums is tight, there exists a strictly stationary sequence $(Y_k, k \in \mathbb{Z})$ such that for each k, $X_k = Y_k - Y_{k+1}$. We say that the sequence (X_k) is a "coboundary".

In 1995, Richard Bradley improved this to include non-stationary sequences, while retaining the result of Schmidt as a corollary. Furthermore, in 1997 Bradley extended this result to $C[0,1]$-valued random variables. In 2000, for real-valued random variables, Aaronson and Weiss proved a coboundary theorem involving moments, which we refer to as an L^p-coboundary theorem, for $p \in [1, \infty)$. The condition of tightness was replaced by L^p-boundedness of the partial sums, and the resulting sequence (Y_k) had the property that $\|Y_k\|_p < \infty$ for all k.

The talk will discuss a new result, which is an L^p-coboundary theorem for $C[0,1]$-valued random variables. (Received July 31, 2013)

1092-60-101 **Herold G Dehling*** (herold.dehling@rub.de), Department of Mathematics, Ruhr-University Bochum, NA 3/33, 44780 Bochum, Germany, and **Aeneas Rooch** and **Murad S Taqqu**. *Asymptotic distribution of nonparametric change-point tests for long-range dependent data.*

We investigate nonparametric tests for change-points in long-range dependent time series. We consider observations

$$X_i = \mu + \Delta\, 1_{i>\tau} + \epsilon_i,$$

where μ, Δ, τ are unknown parameters, and where $(\epsilon_i)_{i \ge 1}$ is a long-range dependent stationary process with mean zero, subordinated to a Gaussian process. Based on the observations $X_1, \ldots, X_n$, we test the hypothesis $H : \tau \ge n$ that there is no change in the means against the alternative that there is a level shift, i.e. $\tau < n$. We study test statistics of the type

$$T_n = \max_{k=1,\ldots,n} \left| \sum_{i=1}^{k} \sum_{j=k+1}^{n} h(X_i, X_j) \right|,$$

where $h : \mathbb{R}^2 \to \mathbb{R}$ is a given kernel function. For the kernels $h(x, y) = y - x$ and $h(x, y) = 1_{\{x<y\}}$, we obtain the CUSUM test and the Wilcoxon change-point test, respectively. We investigate the asymptotic distribution of these test statistics, both under the null hypothesis as well as under local alternatives. Our results allow us to compute the asymptotic relative efficiency of the CUSUM and the Wilcoxon change-point test. (Received August 02, 2013)

1092-60-104 **Andreas Basse-O'Connor** and **Jan Rosinski*** (rosinski@math.utk.edu), Department of Mathematics, University of Tennessee, Knoxville, TN 37996. *On the Uniform Convergence of Random Series In Skorohod Space with Applications to Volterra-type Processes.*

The Itô–Nisio Theorem connects the weak convergence of finite dimensional distributions of certain processes with the almost sure pathwise convergence. It implies that various series expansions of a Brownian motion, and of other sample continuous Gaussian processes, converge uniformly pathwise. In order to obtain the uniform convergence for series expansions of sample discontinuous processes, we prove an extension of the Itô–Nisio Theorem to Skorohod space of càdlàg functions in [1]; such an extension was surprisingly lacking in the literature. The main difficulties of dealing with the Skorohod space in this context are its non-separability under the uniform metric and the discontinuity of addition under Skorohod's J_1-topology. We illustrate our results providing applications to Volterra stable processes.

References

[1] A. Basse-O'Connor and J. Rosiński, *On the uniform convergence of random series in Skorohod space and representations of càdlàg infinitely divisible processes.* Ann. Probab., to appear.

(Received August 02, 2013)

1092-60-110 **Sana Louhichi*** (sana.louhichi@imag.fr). *Functional convergence to stable Lévy motions for iterated random lipschitz mappings.*

It is known that, in the dependent case, partial sums processes which are elements of D([0,1]) (the space of right-continuous functions on [0,1] with left limits) do not always converge weakly in the J1-topology sense. The purpose of our paper is to study this convergence in D([0,1]) equipped with the M1-topology, which is weaker than the J1 one. We prove that if the jumps of the partial sum process are associated then a functional limit theorem holds in D([0,1])equipped with the M1-topology, as soon as the convergence of the finite-dimensional distributions holds. We apply our result to some stochastically monotone Markov chains arising from the family of iterated Lipschitz models. This is a join work with E. Rio (Received August 04, 2013)

1092-60-133 **Boris Buchmann**, **Ross Maller** and **David M Mason*** (davidm@udel.edu). *Laws of the Iterated Logarithm for Self-normalized Lévy Processes at Zero.*

We develop tools and methodology to establish laws of the iterated logarithm (LILs) for small times (as $t \downarrow 0$) for the "self-normalized" process $(X_t - at)/\sqrt{V_t}$, $t > 0$, constructed from a Lévy process $(X_t)_{t\geq 0}$ having quadratic variation process $(V_t)_{t\geq 0}$, and an appropriate choice of the constant a. We apply them to obtain LILs when X_t is in the domain of attraction of the normal distribution as $t \downarrow 0$, when X_t is symmetric and in the Feller class at 0, and when X_t is a strictly $\alpha-$ stable process. When X_t is attracted to the normal distribution, an important ingredient in the proof is a Cramér-type theorem which upper bounds the distance of the distribution of the self-normalized process from the standard normal distribution, a result which might be of separate interest. We shall show by example how self-normalizing by $\sqrt{V_t}$ nicely stablizes the behavior of X_t as t goes to zero. We shall also provide a brief overview of what is known about the asymptotic distribution at zero of such self-normalized Lévy processes. Our paper will soon appear in the *Transactions of the AMS*. (Received August 06, 2013)

1092-60-202 **Igor Cialenco** (igor@math.iit.edu), Engineering 1, Room 125B, 10 W. 32nd Street, Chicago, IL 60616, and **Liaosha Xu*** (lxu29@hawk.iit.edu), 2800 S Lowe Ave. Side 2R, Chicago, IL 60616. *On Convergence in Probability and Hypothesis Testings for Stochastic PDEs.*

In this paper, we exploit some technics on weak convergence to study hypothesis testing problem for the drift/viscosity coefficient for stochastic fractional heat equation driven by additive space-time white noise. We assume that the first N Fourier modes of the solution are observed continuously over time interval $[0, T]$. We introduce the notion of asymptotically the most powerful test, and find explicit forms of such test in two asymptotic regimes: large time asymptotics $T \to \infty$, and increasing number of Fourier modes $N \to \infty$. The proposed statistics are derived based on Maximum Likelihood Ratio. Over the course of proving the main results, we obtain a series of technical results on the asymptotic behaviors of the probabilities related to likelihood ratio, which are also, in some sense, of high value for study in probability theory. In particular, we find the cumulant

generating function of the log-likelihood ratio, we obtain some sharp large deviation type results for both $T \to \infty$ and $N \to \infty$, and develop some useful strategies in probability convergence for studying asymptotic properties of the power of the likelihood ratio type tests. (Received August 09, 2013)

1092-60-261 **Arnab Ganguly*** (arnab.gang@gmail.com), Department of Mathematics, University of Louisville, 328 Natural Sciences Building, Louisville, KY 40292. *A few approaches to large deviations for stochastic differential equations.*

In this talk I will give an overview of some general approaches to study large deviations of stochastic differential equations (SDEs). These methods also extend to the case of in finite-dimensional SDEs. Since many Markov processes can be represented as solutions of appropriate SDEs, these methods provide a systematic way to investigate large deviation principle of a large class of Markov processes (Received August 12, 2013)

1092-60-292 **Cristina Tone*** (cristina.tone@louisville.edu). *Limit theorems for random fields satisfying an interlaced mixing condition.*

For strictly stationary Hilbert-space valued random fields satisfying the interlaced ρ'-mixing condition, a CLT is obtained. We then apply the finite dimensional case to obtain a functional central limit theorem for empirical processes endowed with real values from a strictly stationary random field satisfying the same ρ'-mixing condition. Next we introduce a CLT for a sequence of strictly stationary random fields that are uniformly ρ'-mixing and satisfy a Lindeberg condition. This "Lindeberg CLT" is then used to prove a CLT for some kernel estimators of probability density for some strictly stationary random fields satisfying the ρ'-mixing, and whose probability density and joint densities are absolutely continuous. (Received August 12, 2013)

1092-60-354 **David Barrera*** (jdbarrer@gmail.com), Terrace Ave 560, Apt 1, Cincinnati, OH 45220. *An Extension of Liverani's CLT.*

Liverani's "Central Limit Theorem for Deterministic Systems" is valid in the case of an initial function in L^2. We show how his argument, which was written under the hypothesis of a bounded initial function, is also valid in this more general setting via two elementary remarks from Functional Analysis. (Received August 13, 2013)

1092-60-367 **Jana Klicnarova*** (klicnarova@ef.jcu.cz), Studentska 13, 37005 Ceske Budejovice, Czech Rep, and **Dalibor Volny** and **Yizao Wang**. *Central limit theorem for stationary processes with summation over general sets.*

We will present a central limit theorem for stationary processes by martingale approximation, we will use a summation over general sets.

Volny and Wang (2013) has established a central limit theorem for random fields with summation over rectangles. (Received August 13, 2013)

62 ► Statistics

1092-62-47 **Feng-Chang Lin*** (flin@bios.unc.edu). *Robust analysis of semiparametric renewal process models.*

A rate model is proposed for a modulated renewal process comprising a single long sequence, where the covariate process may not capture the dependencies in the sequence as in standard intensity models. We consider partial likelihood-based inferences under a semiparametric multiplicative rate model, which has been widely studied in the context of independent and identical data. Under an intensity model, gap times in a single long sequence may be used naively in the partial likelihood, with variance estimation utilizing the observed information matrix. Under a rate model, the gap times cannot be treated as independent and studying the partial likelihood is much more challenging. We employ a mixing condition in the application of limit theory for stationary sequences to obtain consistency and asymptotic normality. The estimator's variance is quite complicated, owing to the unknown gap times dependence structure. We adapt block bootstrapping and cluster variance estimators to the partial likelihood. Simulation studies and an analysis of a semiparametric extension of a popular model for neural spike train data demonstrate the practical utility of the rate approach in comparison with the intensity approach. (Received July 17, 2013)

1092-62-75 **Manfred Denker** (denker@math.psu.edu) and **Lucia Tabacu*** (lmt203@psu.edu). *An almost sure central limit theorem for rank statistics.*

I will discuss an almost sure central limit theorem for linear rank statistics $T_n(J)$, where J is a bounded C^2-score function:

$$\lim_{N\to\infty}\frac{1}{\log N}\sum_{n=1}^{N}\frac{1}{n}\mathbb{I}(T_n(J)\le t)=\frac{1}{\sigma\sqrt{2\pi}}\int_{-\infty}^{t}e^{-x^2/2\sigma^2}dx \text{ a.s.},$$

for some variance $\sigma^2>0$. The essential assumption is that the random variables are structured as a sequence of independent random vectors. This work is part of my dissertation. (Received July 29, 2013)

1092-62-120 **Soutir Bandyopadhyay***, Department of Mathematics, 14 E Packer Avenue, Bethlehem, PA 18015. *A Test for Spatial Second Order Stationarity of a Spatial Random Field.*

An important assumption that is often made when analyzing spatial data is that it is at least second order stationary. A large proportion of the spatial literature is based on this assumption. If the assumption is not properly tested and the analysis is performed, the resulting model may be misspecified and the forecasts obtained may be inappropriate. Therefore, it is important to check whether the process is second order stationary. Over the years, various statistical tests have been proposed. The underlying important assumption, on which these tests for stationarity are based, is on a delicate, subjective, choice of segments of the data. This can make the test extremely sensitive to the segment length. In this work we propose a test based on the discrete Fourier transforms, which is based on the entire length of data, thus avoiding a subjective choice of segment length and its associated problems. Unlike most tests for stationarity, which are comparison based, the proposed test is motivated by a property unique to second order stationary spatial data. (Received August 05, 2013)

65 ► Numerical analysis

1092-65-87 **Yu-Yu Liu*** (yuyul@ncku.edu.tw). *Turbulent Flame Speeds of G-equation models in Steady/Unsteady Cellular Flows.*

Joint work with Jack Xin and Yifeng Yu (UC Irvine). Turbulent combustion is a nonlinear multiscale dynamical process. By level set formulation, G-equations describe the motion of the flame front by an advection term, a chemistry term and further nonlinear (diffusion, curvature, strain) terms. We perform numerical study of the asymptotic flame propagation speeds (turbulent flame speeds) which correspond to the effective Hamiltonian of the homogenized G-equations. (Received July 31, 2013)

1092-65-93 **Kui Ren*** (ren@math.utexas.edu), 2515 Speed Way, C1200, RLM 8.100, Austin, TX 78712. *On an inverse coefficient problem in quantitative photoacoustic tomography: theory and numerical analysis.*

We present in this talk some mathematical and computational results for an inverse coefficient problem in quantitative photoacoustic tomography aiming at reconstructing coefficients in linear transport equations with interior data. In simplified settings, we show some analytical reconstruction methods. (Received August 01, 2013)

1092-65-99 **J Ding*** (jiudin@gmail.com), Department of Mathematics, University of Southern Mississippi, 118 College Dr., Box 5045, Hattiesburg, MS 39406, **N Rhee** (rheen@umkc.edu), Department of Mathematics and Statistics, University of Missouri at Kansas City, Kansas City, MO 64110, and **C. Zhang** (chenhua.zhang@usm.edu), Department of Mathematics, University of Southern Mississippi, 118 College Dr, Box 5045, Hattiesburg, MS 39406. *Solving Moment Problems using Maximum Entropy Method with Orthogonal Polynomials.*

The classic Hausdorff moment problem is hard to solve numerically due to the ill-conditioning. We propose to use orthogonal polynomials as the moment functions. The system of nonlinear equations for the Lagrange multipliers can be modified so that it is much simpler to solve. Numerical experiments have shown some advantages of the approach. (Received August 14, 2013)

1092-65-125 **Youngjoon Hong*** (hongy@indiana.edu), 831 E. Third St., Bloomington, IN 47405, **Chang-Yeol Jung** (cjung@unist.ac.kr), Department of Mathematical Sciences, School of Natural Science, UNIST-gil 50, Ulsan, 689-798, South Korea, and **Roger Temam** (temam@indiana.edu), 831 E. Third St., Bloomington, IN 47405. *The numerical approach of the singularly perturbed problems.*

In this talk, I will present the numerical solutions of singularly perturbed problems in a circular domain and provide as well approximation schemes, error estimates and numerical simulations. To resolve the oscillations of

classical numerical solutions due to the stiffness of our problem, we construct, via boundary layer analysis, the so-called boundary layer elements which absorb the boundary layer singularities. Using a P1 classical finite element space enriched with the boundary layer elements, we obtain an accurate numerical scheme in a quasi-uniform mesh. The talk includes a joint work with C.-Y. Jung and R. Temam. (Received August 05, 2013)

1092-65-170 **Jianliang Qian*** (qian@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48823, and **Songting Luo** and **Robert Burridge**.
High-Order Factorization Based High-Order Hybrid Fast Sweeping Methods for Point-Source Eikonal Equations.

The solution for the eikonal equation with a point-source condition has an upwind singularity at the source point as the eikonal solution behaves like a distance function at and near the source. As such, the eikonal function is not differentiable at the source so that all formally high-order numerical schemes for the eikonal equation yield first-order convergence and relatively large errors. Therefore, it is a long standing challenge in computational geometrical optics how to compute a uniformly high-order accurate solution for the point-source eikonal equation in a global domain. In this paper, we propose high-order factorization based high-order hybrid fast sweeping methods for point-source eikonal equations to compute just such solutions. Observing that the *squared* eikonal is differentiable at the source, we propose to factorize the eikonal into two multiplicative or additive factors one of which is specified to approximate the eikonal up to arbitrary order of accuracy near the source, and the other of which serves as a higher-order correction term. This decomposition is achieved by using the eikonal equation and applying power series expansions to both the squared eikonal and the squared slowness function. (Received August 08, 2013)

1092-65-186 **Songting Luo*** (luos@iastate.edu). *Numerical approximation for effective Hamiltonians for homogenization of a class of Hamilton-Jacobi equations.*

We propose a new formulation to compute effective Hamiltonians for homogenization of a class of Hamilton-Jacobi equations. Our formulation utilizes an observation made by Barron-Jensen about viscosity supersolutions of Hamilton-Jacobi equations. The key idea is to link the effective Hamiltonian to a suitable effective equation. The main advantage of our formulation is that only one auxiliary equation needs to be solved in order to compute the effective Hamiltonian $\bar{H}(p)$ for all p. Error estimates and stability are proved and numerical examples are presented to demonstrate the performance. (joint with Yifeng Yu and Hongkai Zhao) (Received August 08, 2013)

1092-65-203 **Florentina Tone*** (ftone@uwf.edu), Department Mathematics and Statistics, University of West Florida, Pensacola, FL 32514, and **Theodore Tachim Medjo** (tachimt@fiu.edu), Department of Mathematics and Statistics, Florida International University, Miami, FL.
Long time stability of the implicit Euler scheme for an incompressible two-phase flow model.

In this talk we present results on the stability for all positive time of the fully implicit Euler scheme for an incompressible two-phase flow model. More precisely, we consider the time discretisation scheme and with the aid of the discrete Gronwall lemma and of the discrete uniform Gronwall lemma we prove that the numerical scheme is stable. (Received August 09, 2013)

1092-65-216 **Yu-Min Chung*** (yumchung@indiana.edu), 405 Snow Hall, 1460 Jayhawk Blvd, Lawrence, KS 66045, and **Michael S. Jolly** (msjolly@indiana.edu) and **Ricardo M. S. Rosa** (rrosa@ufrj.br). *On computations of foliations, inertial manifolds, and tracking initial conditions.*

The Hartman-Grobman Theorem provides a local foliation for an ODE near a hyperbolic point; through each nearby (base) point there is a pair of leaves that define a conjugacy to the linearized flow. In the classic case where the base point is the hyperbolic point itself, one leaf is its unstable manifold, the other its stable manifold. In that case the leaves are invariant; for a general base point they are not. They can, however, be characterized by the exponential growth/decay rates of the differences between solutions that start on them. If the gap in the spectrum of the linear part sufficiently dominates the Lipschitz constant for the nonlinear part in a large enough neighborhood, and the spectrum is positioned properly, the unstable manifold is an inertial manifold. Each solution is attracted at an exponential rate to a particular "tracking" solution on the inertial manifold. A unified algorithm will be presented. Finally, a number of Newton-like methods have been generalized to this infinite dimensional case. The algorithms are demonstrated on a test problem and the Kuramoto-Sivashinsky equation. (Received August 12, 2013)

68 ► Computer science

1092-68-98 **L. Egri**, **P. Hell**, **B. Larose*** (benoit.larose@concordia.ca) and **A. Rafiey**. *Space complexity of list H-coloring: a dichotomy.*

The Dichotomy Conjecture for constraint satisfaction problems (CSPs) states that every CSP is in P or is NP-complete (Feder-Vardi, 1993). It has been verified for conservative problems (also known as list homomorphism problems) by A. Bulatov (2003). We augment this result by showing that for digraph templates H, every conservative CSP, denoted LHOM(H), is solvable in logspace or is hard for NL. More precisely, we introduce a digraph structure we call a circular N, and prove the following. if $\mathbf{A}(H)$ denotes an algebra whose term operations are the conservative polymorphisms of the digraph H, then the following conditions are equivalent: (1) the variety generated by $\mathbf{A}(H)$ admits only the Boolean type; (2) the variety generated by $\mathbf{A}(H)$ is congruence k-permutable for some k; (3) the digraph H contains no circular N. If one of these conditions holds then the problem LHOM(H) is solvable in logspace, otherwise it is NL-hard. Moreover, we show that the presence of a circular N can be decided in time polynomial in the size of H. (Joint work with L. Egri, P. Hell and A. Rafiey.) (Received August 01, 2013)

1092-68-126 **Hang T. Dinh*** (htdinh@iusb.edu), Indiana University South Bend, Department of Computer & Information Sciences, 1700 Mishawaka Ave. P.O. Box 7111, South Bend, IN 46634. *The Hardness of Code Equivalence for Shor-like Quantum Algorithms and its Application to Post-quantum Cryptography.* Preliminary report.

The Code Equivalence problem is to determine whether two linear codes are identical up to a permutation of the coordinates. This problem is related to the security of McEliece-type cryptosystems in the case where the private code is known to the adversary. On the other hand, Code Equivalence has a direct reduction to a nonabelian hidden subgroup problem (HSP), suggesting a possible quantum algorithm analogous to Shor's algorithms for factoring or discrete log, i.e., algorithms based on measurements of a coset state. However, we show that for certain linear codes, solving this case of the HSP requires rich, entangled measurements. Our results apply to many families of linear codes of cryptographic interest, including rational Goppa codes (or generalized Reed Solomon codes), alternant codes, and Reed-Muller codes. This suggests that code-based cryptosystems using these codes are likely resistant against "Shor-like" quantum attacks, although most such systems have classical weaknesses when the private code is known. We will also discuss how our results can be extended to Linear Code Equivalence – a general version of Code Equivalence. This is joint work with Alexander Russell and Cristopher Moore. (Received August 05, 2013)

1092-68-204 **Gregory V. Bard*** (bardg@uwstout.edu), Dept. of Math., Stat., and Comp. Sci., Jarvis Hall, Science Wing, University of Wisconsin—Stout, Menomonie, WI 54751, and **Damien Koeppel**. *Reducing the Number of Variables in a System of Equations during Algebraic Cryptanalysis, by Constructing a Forest.* Preliminary report.

Algebraic cryptanalysis is a two-phase process. First, one converts a cipher into a system of equations—usually polynomial and over a finite field (char 2). Second, one solves the equations to recover a secret key or plaintext. Often the polynomial system is huge, with thousands of variables. We propose an approach that introduces a middle phase.

We make use of a data structure called "a forest" which is a set of "trees." (By tree is meant a binary tree, but where each node can have any natural number of descendants, not merely 0 or 2.) Every variable in the system of equations is found exactly once in the forest; all variables in a given tree are either known to be equal to each other or known to be additive inverses, after all the original equations have been written. The entire system of equations is rewritten when the forest is complete. Every variable in the old system of equations is represented in the new, by the variable which is the unique "root" of its tree.

This results in the new system having far fewer variables than the old. In turn, that will significantly reduce the running time of solving the system. We will use the "scalable encryption algorithm" to demonstrate how this process can be applied in the case of the cryptanalysis of a block-cipher. (Received August 09, 2013)

76 ► Fluid mechanics

1092-76-76 **Michael Renardy*** (mrenardy@math.vt.edu), Department of Mathematics, 225 Stanger St, Blacksburg, VA 24061-0123. *Prandtl boundary layers in viscoelastic fluids.*

We study the well-posedness of the Prandtl boundary layer equations for the upper convected Maxwell fluid, as well as the Phan-Thien Tanner and Giesekus fluids. Rather remarkably, it turns out that proving well-posedness is easier when elastic effects are important than it is for the Newtonian case. (Received July 29, 2013)

1092-76-114 **Xiaoming Wang*** (wxm@math.fsu.edu). *Mathematical Analysis of the Cahn-Hilliard-Hele-Shaw Model.*

We investigate the Cahn-Hilliard-Hele-Shaw system that models two phase flow in a Hele-Shaw cell or porous media under the phase field approach. The global in time well-posedness in the two-dimensional case as well as the local in time well-posedness in the three-dimensional case will be presented. Long time asymptotic behavior of the solutions will be characterized as well. This is joint work with Hao Wu and Zhifei Zhang. (Received August 04, 2013)

1092-76-159 **Xianpeng Hu*** (xianpeng@cims.nyu.edu), 251 mercer st, New York, NY 10012. *Wellposedness of Magnetohydrodynamic fluids.*

In this talk, the wellposedness of magnetohydrodynamic fluids is considered in both incompressible and compressible cases. (Received August 07, 2013)

1092-76-164 **Animikh Biswas**, **Michael S. Jolly**, **Vincent R. Martinez*** (vinmarti@indiana.edu) and **Edriss S. Titi**. *Smallest scale estimates for the Navier-Stokes equations.*

The radius of analyticity of the Navier-Stokes equations indicates a length scale below which viscous effects dominate the inertial ones, and in the context of 3D turbulence, it can be couched in terms of the so-called Kolmogorov length-scale, the unique length scale determined by the viscosity and energy dissipation rate alone. This talk will address a refinement of the semigroup method initiated by [Biswas-Swanson '07] for obtaining a lower bound on this radius in terms of the Gevrey norm of the initial data and forcing. This approach recovers the best-known estimate in 2D obtained by [Kukavica '98] on a significant portion of the attractor, and suggests that it can be improved. The method also applies in 3D as well, in which case the estimate made by [Doering-Titi '95] is generalized to include forcing. Consequently, their estimate of the radius in terms of the Kolmogorov length-scale can be improved on a large portion of the weak attractor. In addition to these results, the method itself is elementary and robust, being easily applicable to a wide class of dissipative equations. (Received August 07, 2013)

1092-76-168 **Eka Oche Ogbaji*** (ogbajieka@yahoo.com), Department of mathematics and statistics, federal university p.m.b1020 wukari., Wukari, Taraba , Nigeria, and **Emmanuel Innocent Agene** (emmanuel.innocent@yahoo.com), Department of mathematics and computer sc., Kwararafa university wukari, wukari, Taraba , Nigeria. *Flow rate of gas at variable optical depths.*

In this study of nonlinear differential equation of order two, model of flow rate of gas was formulated, were finite difference was used to study the behaviour of flow rate of gas at various optical depths were 0.3m radius of vertical plate was consider hypothetically. Pascal programming language was used to code the numerical method. Graph show the increase of flow rate at various increases of optical depths of gas. Finally, flow rate of gas increases as optical depth increase. (Received August 08, 2013)

1092-76-377 **Tian Ma** and **Shouhong Wang*** (showang@indiana.edu), Rawles Hall 332, Indiana University, Bloomington, IN 47405. *Interplay between Mathematics and Physics.*

In this talk, we present two examples demonstrating the symbiotic interplay between modern mathematics and physics. The first example is the dynamics of fluid flows, leading a new dynamical transition theory. The second example is on the introduction of two physical principles—the principle of interaction dynamics (PID) and the principle of representation invariance (PRI), leading a complete new avenue for field theory and particle physics. We shall focus on the mathematical and physical significances of these two principles. (Received August 13, 2013)

78 ► Optics, electromagnetic theory

1092-78-63 **Gang Bao** (bao@math.msu.edu), Department of Mathematics, Zhejiang University, Michigan State University, East Lansing, MI 48824, and **Peijun Li*** (lipeijun@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayette, IN 47907. *Near-Field Imaging of Infinite Rough Surfaces.*

This talk is concerned with an inverse infinite rough surface scattering problem in near-field optical imaging, which is to reconstruct the scattering surface with a resolution beyond the diffraction limit. The surface is assumed to be a small and smooth deformation of a plane surface. Based on a transformed field expansion, the boundary value problem with complex scattering surface is converted into a successive sequence of a two-point boundary value problems in the frequency domain, where an analytic solution for the direct scattering problem is derived from the method of integrated solution. By neglecting the high order terms in the asymptotic expansion, the nonlinear inverse problem is linearized and an explicit inversion formula is obtained. The method works for sound soft, sound hard, and impedance surfaces, and requires only a single illumination at a fixed frequency and is realized efficiently by the fast Fourier transform. Numerical results show that the method is simple, stable, and effective to reconstruct scattering surfaces with subwavelength resolution. (Received July 25, 2013)

91 ► Game theory, economics, social and behavioral sciences

1092-91-318 **Benjamin J Thirey*** (benjamin.thirey@soc.mil), Box 531, New Vienna, OH 45159, and **Lee A Evans** (lee.a.evans14.mil@mail.mil), PO Box 531, New Vienna, OH 45159. *Effect of Persistent States in Cellular Automata.*

Cellular Automata have been studied with great interest due to the inherent complexity which arises from repeated use of a simple set of rules which deterministically results in the state of the system at the next time interval. The set of rules governing cell transitions between discrete intervals is adjusted to accommodate states which persist over multiple time-steps, reflecting real world systems whereby the composition of a system at a particular point in time has the potential to produce lasting effects for the duration of several subsequent intervals. We investigate the effect that persistent cells have upon CA phenomena over longer time-frames and observe generalized effects resulting from the composition of the initial state. (Received August 12, 2013)

92 ► Biology and other natural sciences

1092-92-5 **Suzanne Lenhart*** (lenhart@math.utk.edu), University of Tennessee, Mathematics Department, Knoxville, TN 37996-1320. *Using optimal control of PDEs to investigate population questions.*

Optimal control of partial differential equations can be used to investigate questions in diffusive population models. Managing resources is a crucial issue. One example is how to allocate limited resources to increase the population size. A second example considers this question: Given a resource function, what direction would the population choose to move to increase its size. Movement may cause costs due to the risks in movement. (Received August 07, 2013)

1092-92-19 **Maia Martcheva*** (maia@ufl.edu), Department of Mathematics, 358 Little Hall, Gainesville, FL 32611, and **Xue-Zhi Li** (xzli66@126.com), Department of Mathematics, Xinyang Normal University, Xinyang, 464000, Peoples Rep of China. *Competitive Exclusion in a Infection-Age Structured Model with Environmental Transmission.*

It has been shown in the past that for the most basic multi-strain ordinary differential equation (ODE) model of SIR-type a competitive exclusion principle holds. The competitive exclusion principle means that the strain with the largest reproduction number persists but eliminates all other strains with suboptimal reproduction numbers. In this talk, we extend the competitive exclusion principle to a multi-strain age-since-infection structured model of SIR/SI-type. We also include environmental transmission for each of the pathogens. Using Lyapunov functional, we are able to establish global stability of the disease-free equilibrium if all reproduction numbers are smaller or equal to one. If $\mathcal{R}_j$, the reproduction number of strain j is larger than one, then a single-strain equilibrium, corresponding to strain j exists. This single strain equilibrium is always locally stable whenever it exists. If $\mathcal{R}_1 > 1$ is the maximal reproduction number, using a Lyapunov functional, we establish that the corresponding

single-strain equilibrium $\mathcal{E}_1$ is globally stable. That is, strain one eliminates all other strains, independently of their reproduction numbers as long as they are smaller than $\mathcal{R}_1$. (Received June 15, 2013)

1092-92-121 **Nathan Gilbert Marculis*** (ngmarculis@wpi.edu), Department of Mathematical Sciences, Stratton Hall, 100 Institute Road, Worcester, MA 01609. *Integro-difference modeling for the invasion of Carcinus maenas (The European Green Crab).* Preliminary report.

Carcinus maenas (European Green Crab) has been introduced to the east and west coasts of North America. It has spread to become an established invasive species and impacted resident species causing severe economic damage. This talk presents two integro-difference models; one for the spread of the crab and one to model the control of the crab by introducing *Sacculina carcini* (a castrating parasite). Under certain conditions, the parasite has been shown to be an effective biological control agent. (Received August 05, 2013)

1092-92-141 **Glenn F. Webb*** (glenn.f.webb@vanderbilt.edu), Department of Mathematics, Vanderbilt University, Nashville, TN 37240. *Mathematical Models of Antibiotic Resistant Epidemics in Hospitals.* Preliminary report.

The development of drug-resistant strains of bacteria is an increasing threat to society, especially in hospital settings. Many antibiotics that were formerly effective in combating bacterial infections are no longer effective due to the evolution of resistant strains. The objectives of this study are to develop both deterministic and probabilistic models for these epidemics and to compare the two approaches. The solutions of the models will be analyzed for qualitative behavior based on parametric input. The results will be interpreted for strategies that may mitigate the epidemics. (Received August 06, 2013)

1092-92-144 **Folashade B Agusto*** (fbagusto@gmail.com), Department of Mathematics and Statistics, Austin Peay State University, Clarksville, TN 37044. *The Impact of Bed-net Use on Malaria Prevalence.*

Malaria infection continues to be a major problem in many parts of the world including the Americas, Asia, and Africa. Insecticide treated bed-nets have shown to reduce malaria cases by 50%; however, improper handling and human behavior can diminish their effectiveness. We formulate and analyze a mathematical model that considers the transmission dynamics of malaria infection in mosquito and human populations and investigate the impact of bed-nets on its control. The effective reproduction number is derived and existence of backward bifurcation is presented. The backward bifurcation implies that the reduction of $\mathcal{R}$ below unity alone is not enough to eradicate malaria, except when the initial cases of infection in both populations are small. Our analysis demonstrate that bed-net usage has a positive impact in reducing the reproduction number $\mathcal{R}$. The results show that if 75% of the population were to use bed-nets, malaria could be eliminated. We conclude that more data on the impact of human and mosquito behavior on malaria spread is needed to develop more realistic models and better predictions. (Received August 06, 2013)

1092-92-148 **Sebastien Motsch*** (smotsch@cscamm.umd.edu). *Towards 'crowd weather' prediction.*

Optimizing pedestrian flow efficiency and crowd safety is a critical issue in contemporary urban societies. We advocate the need for "Crowd Weather" forecasting systems using similar concepts as those used in weather forecast. Such a system requires carefully validated models on high quality data. In this talk, we use real time tracking experiments based on automatic motion capture techniques to calibrate a macroscopic model for pedestrian dynamics. It relies on a Bi-directional Fundamental Diagram (BFD) which relates the pedestrian fluxes to both the co- and counter-moving pedestrian densities. This Bi-directional Macroscopic (BM) model using the BFD estimated from the data quantitatively reproduces the dynamical clustering patterns observed in the experiments. Finally, we use the BM model to examine the outcome of a corridor segregation strategy and demonstrate the need for a real-time crowd prediction system. (Received August 07, 2013)

1092-92-154 **Richard C Schugart***, richard.schugart@wku.edu, and **Donna Daulton**, **K Renee Fister**, **Tennnesse Tucker Joyce**, **Ben Howard**, **Sashwati Roy** and **Chandan K Sen**. *Using optimal control theory to identify optimal treatment protocols with oxygen therapy for the treatment of a bacterial infection in a wound.* Preliminary report.

A reduced mathematical model was developed for the treatment of a bacterial infection in a wound using oxygen therapy. Optimal control theory was employed to aid in the identification of optimal treatment protocols for hyperbaric and topical oxygen. The model formulation and preliminary results using optimal control will be presented, while future directions will be discussed. (Received August 07, 2013)

1092-92-252 **Matthew Oremland*** (moremlan@vt.edu). *A Framework for Solving Optimization Problems for Agent-Based Models.*

Agent-based models (ABMs) are a class of computer simulation model in which agents interact with each other and their environment according to local update rules. While ABMs are a powerful tool, they are often computationally intensive and suffer from a lack of mathematically analytical tools. We present a framework for solving optimization problems with ABMs by constructing a system of equations that describe high-level behavior of the ABM.

The framework is illustrated by use with SugarScape, a well-known large-scale ABM. In SugarScape, agents patrol a virtual landscape in search of sugar. We investigate an optimization problem by periodically taxing agents for their sugar. Our goal is to determine tax schedules that minimize deaths and maximize the amount of sugar collected.

A system of difference equations is derived to describe the agents' movement, sugar accumulation, and population levels. Parameter estimation, symbolic regression, and heuristic methods are employed to refine the equations and to solve the optimization problem. Optimal tax schedules (as determined by the equations) are compared with those obtained by the ABM in order to determine the descriptive effectiveness of the proposed framework. (Received August 11, 2013)

1092-92-266 **Christina Lorenzo*** (clorenzo@math.purdue.edu). *Modeling the synergy between HSV-2 and HIV and potential impact of HSV-2 therapy.*

We developed a two-gender model to study the epidemiological synergy between HIV and HSV-2. The model describes the transmission dynamics of both pathogens under the influence of heterogeneous mixing between activity groups. We derive explicit expressions for the basic reproduction numbers of HSV-2 and HIV, as well as the invasion reproduction numbers, which are shown to determine the outcomes of the competitive dynamics between the two pathogens. The explicit formulas of these reproduction numbers are also used for a sensitivity/uncertainty analysis which can help identify the most influential parameters. Numerical simulations provide insights into the epidemiological synergy between HSV-2 and HIV. Specifically, we demonstrate the effects of treating individuals with HSV-2 on HIV control and explore the influence of sexual structure on the disease prevalence and control. This is a joint work with Zhilan Feng, Zhipeng Qiu, Zi Sang, and John Glasser. (Received August 12, 2013)

1092-92-284 **Sarah M. Emery*** (sarah.emery@louisville.edu), Biology Dept., 139 Life Sciences Bldg., University of Louisville, Louisville, KY 40292, and **S. Luke Flory**, **Keith Clay**, **Joseph R. Robb** and **Brian Winters**. *Demographic responses of the invasive annual grass Microstegium vimineum to prescribed fires and herbicide.*

Management of invasive plant species often includes prescribed fire and herbicides, and evaluation of these techniques should include whole-population responses of targeted plants. In this study, we evaluated how the timing and frequency of prescribed fire and herbicide application affected population growth of the invasive annual grass Microstegium vimineum using periodic matrix population models. We found that spring fires were effective at reducing population growth rates during the year of treatment but there was no effect of burning on M. vimineum populations the following year. Similarly, fall prescribed fires were effective at reducing seed production, as well as numbers of seedlings and adults following fires, but had no long-term effect on population growth rates. Post-emergent herbicide alone was the only treatment that reduced M. vimineum population growth beyond one year. Seedbank survival had the highest life-stage elasticity across all treatments, indicating that novel management methods specifically designed to exhaust seedbanks for three or more years may be needed to prevent M. vimineum population resurgence after cessation of treatments. (Received August 12, 2013)

1092-92-288 **Kimberly I. Meyer** (meyer.kimberly@gmail.com), Department of Mathematics, University of Louisville, Louisville, KY 40292, and **Bingtuan Li*** (bing.li@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292. *A Spatial Model of Plants with an Age-Structured Seed Bank and Juvenile Stage.*

We formulate an integro-difference model to predict the growth and spatial spread of a plant population with an age-structured seed bank and juvenile cohort. We allow the seeds in the bank to be of any age producing a system of infinitely many equations. We assume that juvenile plants mature into adults at a particular age. The production of new seeds can be density-dependent and so the function describing this growth is allowed to

be non-monotone. The functions describing the seed bank and juvenile plants are linear. We show that when the system has a positive equilibrium, there is a spreading speed that can be computed using model parameters and that this spreading speed can be characterized as the slowest speed of a class of traveling wave solutions. The spreading speed results are obtained through linearization and comparison to an analogous finite system, while the existence of traveling wave solutions is shown by using an asymptotic fixed point theorem. We conduct numerical simulations of a truncated version of this model. These simulations show that traveling wave solutions may exhibit different patterns of fluctuations including periodic oscillations and chaotic tails. (Received August 12, 2013)

1092-92-302 **Janet A Best*** (jbest@math.ohio-state.edu), **Michael C Reed** and **H F Nijhout**. *Unexpected effects of levodopa therapy for Parksinson's disease.*

Parkinson's disease has been traditionally thought of as a dopaminergic disease in which cells of the substantia nigra pars compacta (SNc) die. However, accumulating evidence implies an important role for the serotonergic system in Parkinson's disease in general and in physiological responses to levodopa therapy, the first line of treatment. We use a mathematical model to investigate the consequences of levodopa therapy on the serotonergic system and on the pulsatile release of dopamine (DA) from dopaminergic and serotonergic terminals in the striatum. (Received August 12, 2013)

1092-92-310 **Danielle Burton** and **Shandelle M Henson*** (henson@andrews.edu). *Bifurcation of synchronous ovulation cycles in colonial birds.*

Spontaneous oscillator synchrony has been documented in many physical and biological systems, including estrous/menstrual synchrony in rats and humans. In previous work we showed that ovulation synchrony occurs in two species of colonial birds and that the level of synchrony increases with colony density. Here we use a simple proof-of-concept model to study the bifurcation of synchronous cycles as a function of colony density. (Received August 13, 2013)

1092-92-313 **Ali Gharouni*** (v3d66@unb.ca), 418 Tilley Hall, Department of Mathematics, University of New Brunswick, Fredericton, New Brunsw E3B 5A3, Canada, and **Myriam Barbeau**, **Andrea Locke**, **Lin Wang** and **James Watmough**. *An Integrodifference Model for Biological Invasion of European Green Crab (Carcinus maenas).*

We present a discrete-time model for biological invasion of European Green Crab (Carcinus maenas) in the Canadian Maritimes that couples matrix population models for population growth with integrodifference equations for dispersal. We calculate the population's asymptotic invasion speed and carry out the sensitivity analysis of the invasion speed with respect to changes in demographic and dispersal parameters. This is an ongoing project. (Received August 12, 2013)

1092-92-317 **Sharon Anne Bewick*** (sharon_bewick@hotmail.com), Department of Biology, University of Maryland, College Park, MD 20742, **Bingtuan Li** (bing.li@louisville.edu), Department of Mathematics, University of Louisville, Louisville, KY 40292, and **William F. Fagan** (bfagan@umd.edu), Department of Biology, University of Maryland, College Park, MD 20742. *Critical Patch Size Problems for a Changing World.*

We consider a stage-structured population model consisting of mobile adult insects and sessile (or nearly so) juveniles. In contrast to previous stage-structured models, we assume that adult insects breed continuously over a window of time corresponding to the adult lifespan. Consequently, juvenile recruitment depends on the length of time available for reproduction. This, in turn, is a function of the length of the adult lifespan as well as the timing of resource availability (e.g. nectar or host plants necessary for reproduction). Assuming that larvae can only survive within a predefined patch (e.g. where host plants are found), but that adults can survive anywhere on the landscape, we derive an expression for the critical patch size necessary to support a viable insect population. Because the timing of insect emergence relative to resource emergence affects the level of juvenile recruitment, we find that the critical patch size is a function of the mismatch between insect and resource phenology. Implications with respect to species conservation in the face of global change are discussed. (Received August 12, 2013)

1092-92-345 **Katia Vogt Geisse*** (kvogtgei@math.purdue.edu), Purdue University, Department of Mathematics, 150 N University Street, West Lafayette, IN 47907, and **Calistus Ngonghala**. *Investigating the effects of the vaccine RTS,S on malaria prevalence.* Preliminary report.

Malaria is a vector-borne infectious disease caused by parasites of the genus *Plasmodium* and transmitted from human to human by female *Anopheles* mosquitoes. Malaria is a major international health problem, especially

in the tropical and subtropical regions of the world. Current malaria control measures include the use of long-lasting insecticidal nets, indoor residual spraying, intermittent preventive treatment, early diagnosis and treatment with anti-malaria drugs, etc. Although these interventions have proven to be effective in reducing malaria prevalence in endemic areas over the past decade, they are still inadequate in fully containing malaria. Hence, there is an urgent need for a vaccine to complement these control strategies. The RTS,S vaccine, which is currently under phase 3 trial, is a promising vaccine for the malaria disease. Before introducing a vaccine into the population it is necessary to understand the impact of the vaccine on disease burden and how social factors may affect disease dynamics. We present a mathematical model that explores the impact of vaccine introduction on malaria dynamics. (Received August 13, 2013)

1092-92-348 **Rolf J Ryham*** (rryham@fordham.edu), **Fredric S Cohen** (fredric_cohen@rush.edu), **Robert Eisenberg** (beisenb@rush.edu), **Thomas Klotz** (tklotz@fordham.edu) and **Lihan Yao** (lihan.yao@gmail.com). *Non-Spontaneous Deformation of Bilayers under Surface Director Energies.* Preliminary report.

Membrane fusion is a biological process where two bilayers merge and form a connection between two formerly separate membrane compartments. Fusing membranes undergo a sequence of topological transitions and each of these transitions are believed to involve an energy barrier. A goal in membrane and mathematical biology is to calculate minimal energies involved with these deformations. To model the first transition–stalk formation– a surface-director model was developed using the generalized Helfrich elastic bending energy. Paths of least energy were calculated and allowed us to determine the energy barrier of between parallel and partially fused membranes. We compare the shape of least energy stalks to the those shapes derived from recent diffraction images. (Received August 13, 2013)

1092-92-351 **Antonio Mastroberardino*** (axm62@psu.edu), **Yuanji Cheng**, **Ahmed Abdelrazec** and **Hao Liu**. *Mathematical Modeling of the HIV/AIDS Epidemic in Cuba.* Preliminary report.

In this talk, I will present a nonlinear mathematical model for the transmission dynamics of HIV/Aids in Cuba. Due to Cuba's highly successful national prevention program, we assume that the only mode of transmission is through contact with people who do not know that they are HIV positive. We find the equilibria of the governing nonlinear system, perform a linear stability analysis, and then determine the threshold for global stability. We conclude with an application of optimal control as a demonstration of the effectiveness of the Cuban prevention program. (Received August 13, 2013)

1092-92-383 **Shigui Ruan*** (ruan@math.miami.edu), Department of Mathematics, University of Miami, Coral Gables, FL 33124-4250. *Traveling Waves in Epidemic Models.*

In this talk, we first review some classical epidemic models, such as Ross-Macdonald model, Kermack-McKendrik model, Kendall model, Diekmann-Thieme model, etc. Then the existence of traveling waves in some epidemic models described by reaction-diffusion systems will be demonstrated. Some specific problems, such as the transmission of rabies, will be modeled and studied. (Received August 14, 2013)

93 ► *Systems theory; control*

1092-93-149 **Rachel Leander*** (rachel.leander@mtsu.edu), **Suzanne Lenhart** and **Vladimir Protopopescu**. *Optimal control of continuous systems with impulse controls.*

Impulse control problems, in which a continuously evolving state is modified by discrete control actions, have applications in epidemiology, medicine, and ecology. In this paper we present a simple method for solving impulse control problems for systems of differential equations. In particular, we show how impulse control problems can be reformulated and solved as discrete optimal control problems. The method is illustrated with two examples. (Received August 07, 2013)

1092-93-220 **Judy Day*** (judyday@utk.edu), **Seddik Djouadi**, **Wassim Bara** and **Greg Zitelli**. *Modeling, State Estimation and Control of Complex Immune Responses.*

This talk will provide a historical overview and summarize recent strides in the endeavor to capture the rich, complex dynamics of the acute inflammatory response and effectively apply control strategies to correct dysfunctional responses. From ordinary differential equations (ODE) models containing many interacting variables to small abstract ODE representations of the inflammatory response to infection, substantial strides have been made to gain insight into this complex process through the modeling process. Inherent in these efforts is the goal of translating the insights from these models toward useful and real-world application. Toward achieving that

goal, we also present recent work on the application of control methodologies on an ODE model of inflammation with the object of directing inflammatory response trajectories of a virtual patient population to a healthy resolution. (Received August 10, 2013)

1092-93-287 **Erik M Ferragut*** (efn@ornl.gov), **Jason Laska**, **Alex Melin** and **Seddik M Djouadi**. *Graph-Based Analysis of Cyber-Physical System Resiliency.* Preliminary report.

Although cyber-physical security has become an important area of research, rigorous definitions of resilience have yet to be standardized, and the related control system analytics are still scarce. A linear control system can be described for time $t \geq 0$ by the matrix equation $\dot{x}(t) = Ax(t) + Bu(t)$ with $x(t)$ the system state, A the $n \times n$ system dynamics matrix, $u(t)$ the control input, and B the $n \times k$ control matrix. In a control-signal loss scenario, columns of B are eliminated by an attacker.

We define the control resiliency of the system, r_d, to be the vector of the number of sets of columns of size d whose removal renders the system uncontrollable. We propose measuring resilience with a lexicographic ordering on r_d. By using an independently derived characterization of controllability, we easily relate each column of B to the collection of eigenvalues made controllable by it, so that computation of r_d reduces to a graph-related enumeration problem. We then show that (1) complete enumeration of r_d, being equivalent to set covering, is NP-complete, but (2) the lexicographically most significant part of r_d can be computed in linear time. (A similar analysis applies to observability resilience to sensor loss.) (Received August 13, 2013)

94 ► Information and communication, circuits

1092-94-18 **Jay A. Wood*** (jay.wood@wmich.edu), Department of Mathematics, Western Michigan University, 1903 W. Michigan Ave., Kalamazoo, MI 49008-5248. *Exotic Automorphisms of Additive Codes.* Preliminary report.

Because of the failure of the extension property for Hamming weight in the context of $GF(q)$-additive codes, it is possible for there to exist additive Hamming isometries of an additive code that are not monomial. We give examples of such 'exotic' automorphisms and show how they can be constructed. (Received June 14, 2013)

1092-94-89 **Ricardo Alfaro*** (ralfaro@umflint.edu), Mathematics Department, University of Michigan-Flint, Flint, MI 48502, and **Karimah Dhul-Qarnayn** (kdhulqar@umflint.edu). *The "build-up" construction for self-dual codes over $\mathbb{F}_q[u]/ < u^t >$.*

Given a self-dual code over $\mathbb{F}_q[u]/ < u^t >$ we present a method to obtain explicitly new self-dual codes of larger length. Conversely, we also prove that, with the appropriate assumptions on length and number of generators, every self-dual code over $\mathbb{F}_q[u]/ < u^t >$ can be obtained in this manner. We use this construction to produce several optimal self-dual codes over the base field in a manner that generalizes the Lee weight. This construction is based on the "build-up" constructions presented by Han, Lee and Lee, and by Lee and Kim in 2012. (Received July 31, 2013)

1092-94-123 **Rainer Steinwandt*** (rsteinwa@fau.edu), Department of Mathematical Sciences, 777 Glades Road, Boca Raton, FL 33431. *Applying Shor's algorithm to the discrete logarithm problem on binary elliptic curves.*

One of the main motivations for post-quantum cryptography is Shor's quantum algorithm to compute discrete logarithms efficiently. This talk discusses the complexity of realizing a discrete logarithm computation on a binary elliptic curve as a quantum circuit. The main focus is on the gate complexity (especially the number of so-called T-gates) and the circuit depth needed to realize the pertinent group arithmetic.

(This talk does not assume familiarity with quantum computing.) (Received August 05, 2013)

1092-94-127 **jintai ding*** (jintai.ding@gmail.com) and **Chengdong Tao** (chengdongtao2010@gmail.com). *Simple Matrix Scheme for Encryption.*

There are many attempts to build asymmetric pubic key encryption schemes based on multivariate polynomials of degree two over a finite field. However, most of them are insecure. The common defect comes from the fact that certain quadratic forms associated with their central maps have low rank, which makes them vulnerable to the MinRank attack. We propose a new simple and efficient multivariate pubic key encryption scheme based on matrix multiplication, which does not have such a low rank property. The new scheme will be called Simple Matrix Scheme or ABC in short. We also propose some parameters for practical and secure implementation. (Received August 06, 2013)

1092-94-131 **Andrew Klapper*** (klapper@cs.uky.edu), Department of Computer Science, 307 Marksbury, 329 Rose Street, University of Kentucky, Lexington, KY 40506-0633, and **Claude Carlet** and **Mark Goresky** (goresky@ias.edu), School of Math, Institute for Advanced Study, Princeton, NJ 08540. *Arithmetic Walsh Transforms.*

Modern symmetric key cryptosystems are based on primitives such as pseudorandom sequence generators and highly nonlinear Boolean functions. Analysis is commonly by algebraic structures (polynomials, power series, linearly recurring sequences, etc.) based on $\mathbb{F}_2$.

Since '93 we've studied related structures based on with-carry algebra, e.g. feedback with carry shift registers and generalizations. I will describe recent results on a with-carry algebraic structure based on Boolean functions ($f : \mathbb{F}_2^n \to \mathbb{F}_2$). This structure makes it possible to define the arithmetic Walsh transform (AWT), a with carry analog of the Walsh-Hadamard transform. We have computed the AWT of affine functions and some quadratic functions. We have found the expected AWT of a Boolean function f in terms of its global properties. We have an AWT analog of Parseval's identity. This will allow us to define with-carry analogs of such cryptographic concepts as bentness and correlation immunity. We have also found an analog of the Poisson summation formula. This formula expresses certain weighted linear combinations of arithmetic Walsh coefficients in terms of f. This allows us to characterize certain cryptographic properties of f in terms of the AWT. (Received August 06, 2013)

1092-94-181 **Roxana Smarandache*** (rsmarand@nd.edu), University of Notre Dame, Notre Dame, IN 46556. *Pseudocodewords obtained from permanents and Bethe-permanents.*

It was recently conjectured that a vector with components equal to the Bethe permanent of certain submatrices of a parity-check matrix is a pseudocodeword. In this talk we look at certain cases for which this is true and investigate the families of pseudocodewords obtained. (Received August 08, 2013)

1092-94-193 **Finley Freibert*** (freiberf@ohiodominican.edu). *Equivalency classes of binary nonsingular square matrices related to a generalization of self-dual codes.*

Complementary information set codes (or CIS codes) are a generalization of self-dual codes defined by Carlet, Gaborit, Kim, and Sole in "A new class of codes for Boolean masking of cryptographic computations." A CIS code is a binary $[2n, n]$ code which has two disjoint information sets. We will discuss a classification method for CIS codes and the results of this method for CIS codes of length 14 and 16. (Received August 09, 2013)

1092-94-299 **Marcelo Firer** and **Judy L Walker*** (judy.walker@unl.edu), Department of Mathematics, University of Nebraska – Lincoln, Lincoln, NE 68588-0130. *Master Metrics on Binary Channels.*

A metric d on $\mathbb{F}_2^n$ is said to be a *master metric* for the channel $W : \mathbb{F}_2^n \to \mathbb{F}_2^n$ if nearest neighbor decoding with respect to d is equivalent, for all codes $C \subset \mathbb{F}_2^n$, to maximum likelihood decoding. It is well-known that the Hamming metric is a master metric for the binary symmetric channel (for any length n). In this talk, we investigate two fundamental questions: (1) For what binary channels does there exist a master metric? and (2) For what metrics d does there exist a channel W so that d is a master metric on W? (Received August 12, 2013)

1092-94-355 **Elizabeth Weaver*** (elizweav@ius.edu) and **Heide Gluesing-Luerssen**. *Recovering the Factors of a Product Trellis.*

Trellises are graphical representations of codes that are useful when decoding with the Viterbi algorithm, a graph search process similar to Dijkstra's algorithm. While there are many ways of creating such graphs, we will focus on the product construction. This method combines smaller trellises representing subcodes of the desired code by using a direct product to obtain a trellis representing the desired code itself. In this talk, we will present an algorithm which recovers the factors of a given product trellis and show that while such a set of factors may not be unique, all such sets will generate isomorphic trellises. (Received August 13, 2013)

1092-94-370 **Michael E O'Sullivan*** (mosullivan@mail.sdsu.edu), 5800 Campanile, San Diego State University, San Diego, CA 92182. *On Subfield-Subcodes of Algebraic-Geometry Codes.* Preliminary report.

I will present recent work on construction and decoding of subfield-subcodes from algebraic curves. (Received August 13, 2013)

1092-94-376 **Yuqing Chen*** (yuqing.chen@wright.edu), 3640 Colonel Glenn Hwy, Dayton, OH 45435.
A trace representation of perfect Golay codes and their duals. Preliminary report.

In this talk we use Assmus and Mattson's idea of representing linear codes by using linear functionals to give a trace representation of perfect Golay codes and their duals. This approach can also be used to represent linear codes over finite rings. (Received August 13, 2013)

97 ► Mathematics education

1092-97-109 **Priscilla S. Bremser*** (bremser@middlebury.edu), Department of Mathematics, 14 Old Chapel Road, Middlebury, VT 05753. *Doing Mathematics With Teachers at the Vermont Mathematics Initiative.* Preliminary report.

The Vermont Mathematics Initiative is a three-year master's degree program designed to "train teachers to be K-8 mathematics leaders in their schools and districts." Instructional teams at the VMI include both mathematicians and experienced classroom teachers. In this talk, we will discuss the collaborative instruction model for the twelve content courses and describe the other components of the program. Priscilla Bremser has been a VMI instructor since 2007. (Received August 04, 2013)

1092-97-132 **Michael Mays*** (mays@math.wvu.edu). *The Mathematics Teacher Education Partnership.*

The Mathematics Teacher Education Partnership (MTE-Partnership), an initiative of the Science and Mathematics Teacher Imperative of the Association of Public and Land-grant Universities, is a partnership of institutions of higher education and K-12 schools, districts, and other organizations working collaboratively to redesign secondary mathematics teacher preparation programs.

Its goal is to transform the preparation of secondary mathematics teachers to ensure teacher candidates can promote mathematical excellence in their future students, leading to college and career readiness as described in the Common Core State Standards for Mathematics (CCSS-M) and other documents.

The MTE-Partnership has developed a set of guiding principles describing a shared vision to be explored and refined by the MTE-Partnership and others involved in preparing secondary mathematics teachers, and is implementing the principles in projects organized around Research Action Clusters built using the Networked Improvement Communities model promoted by the Carnegie Foundation for the Advancement of Teaching. (Received August 06, 2013)

1092-97-140 **Art Duval*** (artduval@math.utep.edu). *Equivalence relations in mathematics, K–16+.* Preliminary report.

Equivalence relations show up at all levels in mathematics from kindergarten to graduate school: regrouping in addition and subtraction; equivalent fractions; equivalent algebraic expressions and equations; vectors; modular arithmetic; row reduction in matrices; cardinality; etc. One reason students may have difficulties with these topics is the subtle difference between "equivalent" and "equal" in these settings. In spite of the centrality of equivalence relations to understanding so many math topics, we don't explicitly talk about this to students, even to math majors and prospective math teachers, until late in their education, if at all.

I will tie together the common mathematical threads that underlie the various uses of equivalence relations in these diverse settings. My goals are both to encourage you to use these ideas in your own classroom, and also to motivate you to find similar underlying mathematical ideas that run up and down the curriculum. (Received August 06, 2013)

1092-97-179 **Elise Lockwood*** (elise314@gmail.com). *Fostering Collaborations and Developing Instructor Support Materials for an Inquiry-Oriented Abstract Algebra Curriculum.*

In recent years, inquiry-oriented mathematics curricula have become increasingly prevalent, gaining attention among policy-makers and enjoying, in some cases, widespread implementation. At the undergraduate level, there is a need to involve mathematicians in efforts to design and implement such curricula. In the Teaching Abstract Algebra for Understanding project, we sought to scale up a group theory curriculum that was developed through a series of design experiments and refined through iterations of classroom trials. This process, which involved mathematicians, motivated us to design Instructor Support Materials (ISMs) to support teachers in successfully implementing the curriculum. These ISMs have taken the form of an interactive website that provides instructors with resources to help teachers implement the curriculum effectively and faithfully. In this presentation, we describe the process of designing the curriculum and the ISMs, discussing examples from the research phases of our work that contributed to the design of the materials. Our findings provide a resource for other researchers

who seek to develop similar support materials and who seek to develop similar kinds of collaborations between mathematicians and mathematics education researchers. (Received August 08, 2013)

1092-97-211 **Ruthmae Sears*** (ruthmaesears@usf.edu), University of South Florida, Department of Secondary Education, 4202 E. Fowler Ave., EDU105, Tampa, FL 33620, and **Gladis Kersaint** (kersaint@usf.edu), University of South Florida, Department of Secondary Education, 4202 E. Fowler Ave., EDU105, Tampa, FL 33620. *Cultivating Partnerships between Mathematicians & Mathematics Educators.* Preliminary report.

This session will describe efforts at the University of South Florida to productively engage mathematicians as partners in teacher education and professional development. A historical perspective is provided illustrate how the partnerships were cultivated. In addition, we describe partnership efforts in which we have engaged. (Received August 13, 2013)

1092-97-217 **Daniel L McGee*** (mcgeed4@nku.edu), Kentucky Center for Mathematocs, MEP-475, Northern Kentucky University, Highland Heights, KY 41099. *Using Collaboration to Fulfill Needs: An Opportunistic Approach to Teacher Preparation.*

The presentation will begin by describing a fully opportunistic collaboration conducted at the University of Puerto Rico (UPR). Several math professors were interested in flipped classrooms however excessive class sizes due to budget cuts discouraged them. Meanwhile, math educators wished to provide direct experience with innovative pedagogy to pre-service teachers but found that the dynamics of practice teaching at most local schools did not permit it. Using pre-service teachers as teacher's aides in flipped classrooms with various administrative incentives for all parties involved provided a solution. The implementation of the CCSSI in Kentucky has presented new opportunities for collaboration with administrators and teachers seeking an optimal implementation. The presentation will continue with an overview of various successful collaborations associated with the CCSSI, organized by the Kentucky Center for Mathematics, that use this same "work imbedded", "collaborations to fulfill needs" approach. It will conclude with a "nuts and bolts" perspective on how these collaborations were organized and made effective. (Received August 11, 2013)

1092-97-232 **Diana White*** (diana.white@ucdenver.edu), 2919 E. 107th Ct., Northglenn, CO 80233. *Incorporating Popular Books into the Teaching of the History of Mathematics.*

There are a myriad of books related to mathematics and the history of mathematics written for a non-specialist audience. Generally written in a lively, enthusiastic style, can these books be leveraged in the teaching of mathematics? In this talk, the speaker shares how she has done just that in teaching the history of mathematics, providing an overview of the assignment rationale, details, outcomes, and student responses. Additionally, ideas for how this assignment could be adapted to other courses will be provided. (Received August 10, 2013)

1092-97-238 **Glenn Stevens*** (ghs@math.bu.edu) and **Al Cuoco**. *The Focus on Mathematics community and professional school of mathematics.*

At the recent Association of Teachers of Mathematics in New England's Summer Mathematics Institute, Brendon Ferullo, a mathematics teacher at Framingham MA High School, and Steve Rosenberg, a mathematician at BU, led a workshop entitled "Comparing High School Lessons that Encourage Mathematical Practice with Those That Do Not." This kind of collaboration has been a centerpiece of a community of mathematical practice that has been evolving for over two decades in the Boston area. One goal of this community is to close the gap between school mathematics and mathematics as a scientific discipline, by creating a culture in which practicing mathematicians and secondary mathematics teachers work together to improve both high school and university mathematics education. This talk will describe the community and its philosophy, outline some of its programs in teacher preparation and professional development that address the recommendations of MET-II, and discuss some ideas for a new phase of the work—a professional graduate school, developed in collaboration with expert mathematics teachers. (Received August 10, 2013)

1092-97-250 **W James Lewis*** (jlewis@math.unl.edu), 203 Avery Hall, Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. *Teaching Teachers Mathematics: Nebraska's Story.* Preliminary report.

What mathematics should teachers know and how should they come to know that mathematics? The Mathematical Education of Teachers II argues that the mathematical knowledge needed for teaching differs from that of other professions and that teachers need mathematics courses that develop a solid understanding of the mathematics they will teach. The publication also urges greater involvement of mathematicians in teacher education. We will report on efforts at the University of Nebraska-Lincoln to create mathematics courses for teachers and to

work in partnership with mathematics educators to educate mathematics teachers able to educate K-12 students who graduate college and career ready. (Received August 11, 2013)

1092-97-274 **Jennifer A Eli*** (jeli@math.arizona.edu), 617 N. Santa Rita Ave, Tucson, AZ 85721.
Developing a Collaborative Model for Mentoring Secondary Mathematics Student Teachers.
The student teaching practicum is arguably the most influential part of a pre-service teacher (PST) preparation program. Currently, a triad collaboration model, consisting of the PST, a mentoring in-service teacher, and a university supervisor (a mathematics educator), is widely used to support PSTs. Under this traditional triad model, perspectives of university mathematicians are often absent during student teaching practicum, despite the importance of such individuals in secondary teacher preparation programs prior to student teaching. Furthermore, cultural and institutional barriers frequently separate mathematics education faculty and mathematics faculty. Thus, faculty members' vision of PSTs' needs and experiences are restricted, and cross-disciplinary knowledge development is inhibited. Connections among mathematicians, mathematics educators, and practicing secondary teachers must be forged and strengthened, if teacher preparation programs are to prepare students to utilize their mathematical knowledge for teaching in meaningful ways. In this session, I will discuss the development of an innovative tetrad model that seeks to break down barriers and support cross-cultural work in the service of teacher preparation. (Received August 12, 2013)

1092-97-286 **Christie A. Perry*** (c.perry@moreheadstate.edu), 150 University Blvd., Morehead, KY 40351, **Vivian F. Cyrus** (v.cyrus@moreheadstate.edu), 150 University Blvd., Morehead, KY 40351, and **Mike Dobranski** (m.dobranski@moreheadstate.edu), 150 University Blvd., Morehead, KY 40351. *MET II: Progress at Morehead State University.* Preliminary report.
Presenters from the Department of Mathematics, Computer Science, and Physics will share their ongoing progress in implementing the recommedations given in the CBMS report: The Mathematical Education of Teachers II. (Received August 12, 2013)

1092-97-316 **Casey R Monday*** (casey_monday@mail.msj.edu), 5701 Delhi Road, Department of Mathematics, Cincinnati, OH 45233-1670. *Using MET-II to Develop a Math Problem Solving Course for Future Middle Grades Educators.* Preliminary report.
The development of mathematics courses for educators is often considered daunting by mathematicians who are not already involved in teacher education. The MET-II serves as an exceptional guide for developing such courses in that it: educates mathematics faculty on the importance of their involvement in teacher education; suggests, in an organized way, how to develop teacher education courses; supplements the CCSSM nicely by speaking directly to mathematicians on how to use the document. This talk will focus on how the MET-II guided the creation, implementation, reflection and revision of a problem solving course for future middle grades educators at the University of Kentucky. I will briefly discuss how together, the mathematics and the mathematics education departments prepared me for my own career as a mathematician as well as a teacher educator. (Received August 12, 2013)

1092-97-321 **Amanda Katharine Serenevy*** (amanda@riverbendmath.org), 1021 Queensboro, Mishawaka, IN 46544. *Pedagogical Content Knowledge Needed to Transition to the Common Core.*
Since 2006, I have been inccreasingly involved in helping current and future teachers, mostly in north-central Indiana, to master the pedagogical content knowledge they need. During this session, I will share several specific examples of pedagogical content knowledge needed by most current and future teachers as they transition to the Common Core State Standards. These include methods for scaffolding number sense and critical thinking through the teaching of computational skills, stages needed to transition students from pre-algebraic to algebraic thinking, and conceptual understanding of fractions. I will also share some changes I made to the math courses for future elementary teachers which have been successful in helping future teachers to improve their pedagogical content knowledge. (Received August 12, 2013)

1092-97-349 **Paul Zorn*** (zorn@stolaf.edu). *Mathematics, Mathematics Education, and the MAA.*
Boundaries between mathematics and mathematics education are, and should be, indistinct. Part of the MAA's mission statement makes this unity explicit: "The mission . . . is to advance the mathematical sciences, especially at the collegiate level, by supporting effective mathematical education at all levels,supporting research and scholarship, providing professionaldevelopment, influencing public policy, and promoting public appreciation and understanding of mathematics." I'll outline several strategies and initiatives through which the MAA broadly advances mathematical education at all levels—and has done so for a century. These include MAA and joint committees, Board representation of high school teachers, a special interest group on school–college

articulation, grant-supported activities, and more. The talk will focus especially on MAA's planned 2015 CUPM Curriculum Guide and the recent INGenIOuS project (joint with AMS, ASA, and SIAM) on mathematical workforce development. (Received August 13, 2013)

1092-97-382 **Zvezdelina E Stankova*** (stankova@mills.edu), 5000 MacArthur Blvd, Department of Mathematics & Computer Science, Mills College, Oakland, CA 94613. *The Math Circles are of Eastern European origin; but are they a U.S. phenomenon nowadays?*

When in 1998 the Berkeley Math Circle (BMC) started, I knew of only two other circle in the US: in Boston and San Jose. Each of these three original math circle were tightly connected with a university. Nowadays, one can find hundreds of math circles in the US through the National Association of Math Circles and the Math Circles for Teachers and Students Association. Still, the majority of them do depend on university resources. What made math circles so important back in Eastern Europe has been transformed and incorporated over the last 15-20 years into the challenging educational landscape of the U.S. In spring '98, after a successful math circle workshop at MSRI for SF Bay Area teachers a poll was taken to see how many teachers were ready to start a math circle at their school. The hands raised were ... 0. How many hands would be raised today? From the 50 instructors who will deliver the 100 sessions for 5-12th graders at the BMC in 2013-2014, 20 are visiting researchers, 20 are local university faculty and students, 6 work in the industry, and only 3 are high school teachers. Can we, as mathematicians, use the scarce time but infinite enthusiasm and intellectual power of math faculty to increase the number of teachers ready to start their own math circles? (Received August 14, 2013)

1092-97-387 **Diana White*** (diana.white@ucdenver.edu). *Entry Points and Challenges for Mathematicians in Mathematics Education.*

There are numerous formal documents recommending increased participation by mathematicians in mathematics education. Where does an interested mathematician start? Are some of entry points more accessible than others? What background knowledge is needed? What challenges are there? What support is their to overcome them? In this talk, we explore these and related questions. (Received August 14, 2013)

00 ► General

1093-00-80 **Traian A Pirvu*** (tpirvu@math.mcmaster.ca), 1280 Main St W, Hamilton, Canada, and **Ivar Ekeland** and **Oumar Mbodji**. *Time Consistent Portfolio Management.*

Abstract. This paper considers the portfolio management problem for an investor with finite time horizon who is allowed to consume and take out life insurance. Natural assumptions,such as differrent discount rates for consumption and life insurance lead to time inconsistency. This situation can also arise when the investor is in fact a group, the members of which have differrent utilities and/or differrent discount rates. As a consequence, the optimal strategies are not implementable. We focus on hyperbolic discounting, which has received much attention lately, especially in the area of behavioural finance. We consider the resulting problem as a leader-follower game between successive selves, each of whom can commit for an in finitesimally small amount of time. We then define policies as subgame perfect equilibrium strategies. Policies are characterized by an integral equation which is shown to have a solution in the case of CRRA utilities. (Received July 31, 2013)

1093-00-219 **Jane Friedman*** (janef@sandiego.edu). *Hierarchies in Voting Games and Partitions.* Preliminary report.

A large number of methods of measuring power in voting games are known to be ordinally equivalent. This gives rise to the notion of a hierarchy of players. This talk will interpret results about voting hierarchies as results about integer partitions. (Received August 14, 2013)

1093-00-319 **Evelyn Kamaria Thomas*** (ekthomas@umbc.edu), Mathematics and Psychology Building, Room 410, 1000 Hilltop Circle, Baltimore, MD 21250, **Katharine Gurski** (kgurski@howard.edu), Howard University, 203 Academic Support Building B, Washington, DC 20059, and **Kathleen Hoffman** (khoffman@math.umbc.edu), Mathematics and Psychology Building, Room 410, 1000 Hilltop Circle, Baltimore, MD 21250. *Analysis of SI Models with Multiple Interacting Populations using Subpopulations with Forcing Terms.* Preliminary report.

As a system of differential equations describing an epidemiological system becomes large with multiple connections between subpopulations, the expressions for reproductive numbers and endemic equilibria become algebraically complicated, which makes drawing conclusions based on biological parameters difficult. We present a new method which deconstructs the larger system into smaller subsystems, captures the bridges between the smaller systems as external forces, and bounds the reproductive numbers of the full system in terms of reproductive numbers of the smaller systems, which are algebraically tractable. This method also allows us to analyze the size of the endemic equilibria. (Received August 19, 2013)

01 ► History and biography

1093-01-20 **Alan Tucker*** (alan.tucker@stonybrook.edu), Applied Math Dept, Stony Brook University, Stony Brook, NY 11794-3600. *The History of the Undergraduate Program in Mathematics in the United States.*

The undergraduate program in mathematics in America has had a punctuated evolution. The Mathematical Association of American was organized in 1915 at the end of a period of dramatic rethinking of American education at all levels, one product of which was the introduction of academic majors in higher education. The mathematics major was static in its first 40 years, followed by great changes from 1955 to 1975, and then a period of relative stability to the present. (Received June 05, 2013)

1093-01-21 **Amy Ackerberg-Hastings*** (aackerbe@verizon.net). *American Innovation in Mathematical Instruments.* Preliminary report.

Patent models and other references to patents and inventions are found throughout the mathematics collections at the Smithsonian's National Museum of American History (NMAH). Scholars have explored specific examples of mathematical innovation related to these objects; for instance, see Peggy A. Kidwell, "Computing Devices, Mathematics Education and Mathematics: Sexton's Omnimetre in Its Time," *Historia Mathematica* 36 (2009):

395–404. In 2013, NMAH unveiled a showcase on "Invention and the Patent Model," while in 2014 the Arts & Industries Building will reopen with an "Innovation Pavilion" developed in partnership with the U.S. Patent and Trademark Office and in 2015 the renovated west wing of NMAH will include exhibitions on *Places of Invention* and *American Enterprise*, both exploring innovations in all aspects of American life. It is thus an opportune time to consider broader themes of mathematical innovation documented by the mathematics collections, such as the nature of improvements and inventors and the wider influence of innovation. The talk will reflect on these and other themes by drawing on examples of protractors, slide rules, scale rules, dividers and compasses, and planimeters. (Received June 07, 2013)

1093-01-64 **Steve Batterson*** (sb@mathcs.emory.edu). *American Mathematics 1890 to 1913: From Approximate Nullity to the Verge of Parity with Europe.* Preliminary report.

Oswald Veblen wrote of Henry Fine: "Fine was one of the group of men who carried American mathematics forward from a state of approximate nullity to one verging on parity with European nations." Veblen did not specify any time frame for this advance. However, in his 1913 tour of Europe, Veblen concluded that America's best mathematicians were competitive with those at Göttingen, excepting David Hilbert. This was the year that George D. Birkhoff published his seminal proof of Poincaré's Geometric Theorem. The mathematics departments at Harvard, Chicago, and Princeton then were turning out high level research and graduate students.

While American mathematics did have a few successes spread through the nineteenth century, in 1890 its standing was low and its prospects were bleak. Then, in consecutive years, William Fogg Osgood and Maxime Bôcher were appointed to faculty positions at Harvard, and E. H. Moore was selected to lead the subject at the University of Chicago. What they accomplished individually, together, and with others set a new course for American mathematics.

In this talk I will defend its title and discuss the transformation. (Received July 25, 2013)

1093-01-104 **David Lindsay Roberts*** (robertsdl@aol.com). *The Role of Psychology in Mid 20th Century Reform in American Mathematics Education.* Preliminary report.

Ever since E. L. Thorndike's early 20th century experiments undermining the notion of "transfer of training," American mathematicians and mathematics educators have often felt the need to appeal to or dispute contemporaneous psychological theories when proposing changes to the pedagogy or curriculum of mathematics. Psychologists have also been appealed to in constructing testing regimes to evaluate students and curricula. This talk will describe and assess some of this interplay between psychology and mathematics education, with particular emphasis on the New Math reforms of the 1950s and 1960s. (Received August 05, 2013)

1093-01-111 **Peggy Aldrich Kidwell*** (kidwellp@si.edu), MRC 671, NMAH, Smithsonian Institution, P.O. Box 37012, Washington, DC 20013-7012. *Mathematical Recreations and Machines - Nim, Tic-Tac-Toe, and the Advent of the Digital Computer.* Preliminary report.

The introduction of reliable and relatively inexpensive electrical relays in the 1940s, aided by improvements in electronic circuitry in the course of the twentieth century, made it possible to build a wide array of game-playing machines. Some devices played only a specific games. Others were general purpose computers. The latter were far too expensive to be used solely for playing games. However, interest in intelligence and machine learning, combined with a need to offer public demonstrations of computers, encouraged a range of games. Machine versions of two games, Nim and tic-tac-toe, illustrate this new approach to mathematical recreations. (Received August 06, 2013)

1093-01-112 **Patti W Hunter*** (phunter@westmont.edu), Department of Mathematics, Westmont College, 955 La Paz Road, Santa Barbara, CA 93108. *Funding Science in the Cold War: Persuading the Ford Foundation.* Preliminary report.

Support for science was an important element of American philanthropy in the first half of the twentieth century. Carnegie and Rockefeller had included science in their grant-making, and had especially been interested in promoting internationalism in science. When the Ford Foundation joined the ranks of the big funders at mid-century, it emphasized practical aspects of improving human welfare and avoided science as a funding area, even occasionally making explicit efforts to indicate that the Foundation was not interested in supporting science for its own sake. Occasionally, however, scientists were able to secure funds from Ford by aligning their scientific interests with the Foundation's commitments. Several historians in the past two decades have examined the Ford Foundation's contributions to science in Europe, and have shown that strengthening American interests in the Cold War context was foundational to its activities in this area. Here, I describe and analyze some of Ford's contributions to mathematics and statistics in two countries, Turkey and Egypt, and show that in the context

of developing countries as well, scientists were able to connect their disciplinary interests with Ford's Cold War concerns and obtain funding for their work. (Received August 06, 2013)

1093-01-119 **Walter J. Meyer*** (meyer1@adelphi.edu), Dept. of Mathematics and Computer Science, Adelphi University, Garden City, NY 11530. *The Cajori Two Project: Initial Results.* Preliminary report.

For some years now, a group of us have been assembling a digital database of American college mathematics curricula throughout the 20th century. This database, extracted from college catalogs, covers 20 campuses at 10 year intervals from 1905 to 2005. Software has been written for analysis and display, including a website for on-line interaction. This talk will outline what we did in more detail and present some initial results about the growing curricular diversity of the 20th century. (Received August 06, 2013)

1093-01-130 **Stephanie Dick*** (sadick@fas.harvard.edu), 1 Oxford St., Science Center 371, Department of History of Science, Harvard University, Cambridge, MA 02138. *Reproving Principia: Automated Theorem Proving and the Materials of Mathematics.*

Mathematics is traditionally characterized as a highly abstract craft of the human mind. In fact, it has a very rich material dimension consisting of many tools - calculators, physical models, written symbol systems, etc. - that have equipped the heads and hands of mathematicians through history. The advent of digital computing created many new possibilities for the material representation and exploration of mathematics.

This talk explores an early interaction between mathematics and the media of digital computing - the development of an theorem-proving program called the Logic Theorist (LT). It was developed in the mid-1950s at the RAND Corporation. The LT was designed to prove theorems from Whitehead and Russell's 1910 logical treatise, Principia Mathematica. In Principia, logical propositions and proofs occupy one medium in particular: paper. The architects of the LT instead had to develop ways of representing and manipulating the objects of logic in the digital media of the Johnniac mainframe computer. Logical expressions, for example, had to be reformalized for input by punched card, storage in magnetic core and drum memory, and manipulation by computer operations. This talk explores the history of the LT as a case in this material history of mathematical representation. (Received August 08, 2013)

1093-01-131 **Joseph W. Dauben*** (jdauben@att.net), Department of History, Herbert H. Lehman College, CUNY, 250 Bedford Blvd. Part West, Bronx, NY 10468. *The History of Chinese Mathematics in America.* Preliminary report.

Among the first to take notice of the history of mathematics in ancient China in the U.S. was D.E. Smith at Teacher's College, Columbia University. He drew not only on correspondence with colleagues in both China and Japan, but upon what materials had been published by various European sources as well. How did Smith assess the significance of mathematics in China, and how well-informed did his assessments turn out to be? Another who tried to do justice to Chinese mathematics at about the same time was George Sarton, and it is instructive to contrast the approach he took to the subject with that Smith popularized in his various writings as well. (Received August 08, 2013)

1093-01-140 **Karen V. H. Parshall*** (khp3k@virginia.edu), Departments of History and Mathematics, University of Virginia, P. O. Box 400137, Charlottesville, VA 22904. *Mathematics and the Politics of Race: The Case of William Claytor (Ph.D., University of Pennsylvania, 1933).*

William Claytor (1908-1967) entered the graduate program in mathematics at the University of Pennsylvania in 1930 after spending one year in the newly inaugurated doctoral program at Howard University. A student of J. R. Kline who was himself a student of R. L. Moore, Claytor embraced the point set topology that was then quickly becoming an American area of expertise thanks to the active research program and effective mentorship of Moore and his mathematical "family." By 1933, Claytor had earned his Ph.D. for what Kline praised as "a very fine thesis ... perhaps the best that I have ever had done under my supervision" and began the process of trying to turn that promising beginning into a productive career as a research mathematician. This talk will trace the efforts of Claytor and his supporters as it explores the politics of race that "colored" American academia in the 1930s. (Received August 09, 2013)

1093-01-158 **Charlotte K. Simmons*** (cksimmons@uco.edu), College of Mathematics and Science, 100 N University Drive, Box 177, Edmond, OK 73034. *Gőttingen is Here.* Preliminary report.

As many as 144 German-speaking mathematicians have been listed who were forced to leave their positions at German institutions following the 1933 Law for the Restoration of the Professional Civil Service. The "great migration of the 1930's" is said to have shifted the center of the mathematical world from Germany to the United States. Numbered among these emigrants is Richard Courant, who was "absolutely inexhaustible"

and relentlessly pursued his dream of building an institute for advanced training in mathematics at New York University for nearly two decades. By 1958, the Courant Institute, which began as a suite of rooms in a girls' dormitory, was described as the "national capital of applied mathematical analysis." In this talk, we will discuss Courant's efforts to bring his experience in Gőttingen to bear upon the state of science in America, as well as how he and other immigrants impacted mathematics in America during this important chapter in our history. (Received August 11, 2013)

1093-01-267 **Brittany Shields*** (bshields@sas.upenn.edu). *Mathematics and Cultural Exchange: New York University's Courant Institute of Mathematical Sciences' Participation in International Conferences and Visits.*

Following his mathematical training in Göttingen under David Hilbert, Richard Courant served as the director of the world-renown Göttingen Mathematical Institute in the 1920s. Following his dismissal from the university in 1933, Courant eventually came to the United States where he founded the (later: Courant) Institute of Mathematical Sciences at New York University. Over the following decades, Courant and other members of the NYU mathematics institute participated in numerous international conferences, visited mathematical institutes abroad and hosted international visitors on NYU's campus. Courant kept close notes of his experiences aboard, including his visits to post-war Germany and as a delegate of the National Academy of Sciences to Soviet Novosibirsk. This paper will examine Courant's records of these moments of cultural exchange, paying close attention to the ways in which mathematics functions as a catalyst to such exchanges. (Received August 18, 2013)

1093-01-270 **Della Dumbaugh*** (ddumbaugh@richmond.edu), Dept. of Mathematics and Computer Science, University of Richmo, VA 23173. *Sustaining the Community: Publications and Public Spaces.* Preliminary report.

The "common interest" of mathematics in the last quarter of the nineteenth century contributed to the emergence of an American mathematical community. What "standards and traditions" evolved as mathematicians strengthened this community in the opening decades of the twentieth century? Using the private exchanges of Leonard Dickson and Oswald Veblen, this talk explores some of the issues and events that shaped this phase of growth in the American mathematical community. (Received August 18, 2013)

1093-01-331 **Deborah A. Kent***, Department of Mathematics and CS, 2505 University Avenue, Des Moines, IA 50311. *The Analyst: Mathematical publishing "on the boarders of civilization," 1873-1883.* Preliminary report.

The beginning of *The American Journal of Mathematics* in 1876 introduced a new model of institutionally funded mathematical research journals in the United States. Prior to that, early nineteenth century efforts to produce mathematical periodicals in the U.S. hinged on editorial efforts and financial backing from a few dedicated individuals. This talk will focus on *The Analyst*, the longest-running predecessor of *The American Journal* edited by Joel E. Hendricks. (Received August 19, 2013)

05 ► Combinatorics

1093-05-14 **Zsófia Kereskényiné Balogh*** (zsofibalogh1987@gmail.com) and **Gábor Nyul**. *Stirling numbers and Bell numbers for graphs.*

Let G be a simple graph. A partition of $V(G)$ is called independent if each block is an independent vertex set. Then the Stirling number of the second kind $\left\{ {G \atop k} \right\}$ and the Bell number B_G for the graph G is defined to be the number of independent partitions into k subsets and the number of all independent partitions, respectively. In our talk we study the properties of these numbers.

We determine Stirling numbers of the second kind and Bell numbers for several well-known graphs. Applying the general properties for a special graph, we have an alternative way to achieve the so-called r-Stirling numbers of the second kind and r-Bell numbers. (Received May 12, 2013)

1093-05-17 **Xi Chen** and **Bruce E Sagan*** (sagan@math.msu.edu), Department of Mathematics, Michigan State University, East Lansing, MI 48824. *On the fractal nature of the Fibonomial triangle.* Preliminary report.

It is well known that Pascal's triangle exhibits fractal behavior when reduced modulo a prime. We show that the triangle of Fibonomial coefficients has a similar nature modulo two. Specifically, for any $m \geq 0$, the subtriangle consisting of the first $3 \cdot 2^m$ rows is duplicated on the left and right sides of the next $3 \cdot 2^m$ rows, with an inverted

triangle of zeros in between. We give three proofs of this fact. The first uses a combinatorial interpretation of the Fibonomials due to Sagan and Savage. The second employs an analogue of Lucas' congruence for the parity of binomial coefficients. The final one is inductive. We also use induction to show that the Fibonomial triangle has a similar structure modulo three. We end with some open questions. (Received June 03, 2013)

1093-05-22 **George E. Andrews*** (gea1@psu.edu), Dept. of Math., 306 McAllister Bldg., The Pennsylvania State University, University Park,, PA 16802. *q-Fibonacci numbers and MacMahon's "almost" proof of the Rogers-Ramanujan identities.* Preliminary report.

In his book on Ramanujan, Hardy tells the incredible story of the discovery of the Rogers-Ramanujan identities. P.A. MacMahon plays a substantial role in this tale. In particular, he devoted an entire chapter in his book, Combinatory Analysis, to these identities where they are presented as unproven conjectures. Neither MacMahon nor Hardy realized that L.J.Rogers had proved them in 1894 in a forgotten paper. In this talk we shall examine some neglected aspects of MacMahon's chapter. We find that he not only developed q-analogs of the Fibonacci numbers, but also wrote down (without realizing its implications) a natural algorithm which when fully implemented provides an independent proof of the Rogers-Ramanujan identities. (Received June 08, 2013)

1093-05-27 **Jeffrey B. Remmel*** (jremmel@ucsd.edu), Department of Mathematics, Univerisity of Califonia, San Diego, La Jolla, CA 92093-0112. *Quadrant Marked Mesh Patterns.* Preliminary report.

If $\sigma = \sigma_1 \dots \sigma_n$ is a permutation in the symmetric group S_n, we say that σ_i matches the quadrant marked mesh pattern $MMP(a, b, c, d)$ if there are at least a elements of σ to the right of σ_i which are larger than σ_i, at least b points to the left of σ_i which are larger than σ_i, at least c elements of σ to the left of σ_i which are smaller than σ_i, at least d points to the right of σ_i which are smaller than σ_i. Let $mmp^{(a,b,c,d)}(\sigma)$ denote the number of σ_i in σ that match $MMP(a, b, c, d)$. The study of the distribution of quadrant marked mesh patterns in permutations was introduced by S. Kitaev and Remmel who also studied the distribution of quadrant marked mesh patterns in alternating permutations. Kitaev, Remmel, and Tiefenbruck studied the distribution of quadrant marked mesh patterns in 132-avoiding permutations. In this talk, we will survey such results as well as talk about new results on joint distributions of such statistics. (Received June 14, 2013)

1093-05-31 **Elizabeth Drellich*** (drellich@math.umass.edu), Department of Mathematics and Statistics, University of Massachusetts, Amherst, MA 01003. *A Giambelli Formula for Peterson Varieties.*

Peterson Varieties are the best understood type of regular nilpotent Hessenberg varieties. A Giambelli formula expresses an arbitrary Schubert class as a product of generators of the cohomology ring. This talk will give a surprisingly uniform Giambelli formula for Peterson Schubert classes in all Lie types. (Received June 22, 2013)

1093-05-41 **Alexander Halperin*** (adh208@lehigh.edu), 14 E Packer Avenue, Department of Mathematics, Bethlehem, PA 18015, and **Colton Magnant**, 1332 Southern Drive, Department of Mathematical Sciences, P.O. Box 8093, Statesboro, GA 30460. *H-linked graphs with prescribed lengths.*

Given a multigraph H, a graph G is *H-linked* if every injective map $f : V(H) \longrightarrow V(G)$ can be extended into an H-subdivision in G. Given a multigraph H and an integer sequence $\mathcal{D} = \{d_{ij,s} \mid (v_iv_j, s) \in E(H), d_{ij,s} \geq 2\}$, a graph G is *$(H, \mathcal{D}, e)$-linked* if every injective map $f_1 : V(H) \longrightarrow V(G)$ can be extended into an H-subdivision (f_1, f_2) in G such that each path $f_2(v_iv_j, s)$ has length within e of $d_{ij,s}$. If $e = 0$, then we say G is *$(H, \mathcal{D})$-linked*. We establish a sharp minimum degree condition for a large graph G to be $(H, \mathcal{D}, 1)$-linked. Additionally, we establish a sharp minimum degree condition for a large graph G to be $(H, \mathcal{D})$-linked. (Received July 08, 2013)

1093-05-44 **Adriano M. Garsia*** (garsia@math.ucsd.edu), 4695 Mt Armet Dr, San Diego, CA CA 92117. *The two sides of the extended Shuffle Con jecture.* Preliminary report.

Eugene Gorsky and Andrei Negut have recently put the finishing touches to what may be viewed as the symmetric function side of the general m,n-Shuffle conjecture. Earlier, Tatsuyuki Hikita gave a beautiful construction of the combinatorial side as a weighted enumeration of m,n-Parking Functions. All these developments are gravid with challenging Combinatorial problems. In this talk I will report on my findings in an effort to translate some of the contents of these remarkable publications in a language that is more accessible to the general combinatorial audience. In particular I have made an effort to state the resulting m,n-Shuffle Conjecture using notation that is as close as possible to the statement of the original Shuffle Conjecture. (Received July 11, 2013)

1093-05-70 **Kagan Kursungoz*** (kursungoz@sabanciuniv.edu), Sabanci Univ. MDBF, Orta Mh. Universite Cd. No 27, Orhanli Tuzla, 34956 Istanbul, Turkey. *q-Multinomial Coefficients in the Context of Rogers-Ramanujan Identities.* Preliminary report.

The first Rogers-Ramanujan identity states that the number of partitions of a positive integer n into distinct and non-consecutive parts equals the number of partitions of n into parts that are 1 or 4 modulo 5. The condition of having distinct and non consecutive parts is equivalent to having parts with pairwise differences at least two. Schur's partition theorem involves partitions in which the pairwise difference of parts is at least three; however, there is an extra condition on parts which are divisible by three. Without that extra condition, there can be no nice partition identity (Lehmer). We will release the extra condition and discuss a way to construct a generating function involving center (or middle) q-multinomial coefficients. (Received July 28, 2013)

1093-05-145 **Ruth E Davidson***, Box 8205, North Carolina State University, Raleigh, NC 27695-8205, and **Seth Sullivant**. *Distance-based phylogenetic methods near a polytomy.*

A phylogenetic tree models the common evolutionary history of a group of species. A tree metric is a distance function on a set of species realized by a tree with edge weights. Distance-based phylogenetic algorithms attempt to solve the NP-hard least-squares phylogeny problem by mapping an arbitrary dissimilarity map representing biological data to a tree metric. The set of all dissimilarity maps is a Euclidean space properly containing the space of all tree metrics as a polyhedral fan. Outputs of distance-based tree reconstruction algorithms such as UPGMA and Neighbor-Joining are points in the maximal cones in the fan. Tree metrics with polytomies, or internal vertices of degree higher than three, lie at the intersections of maximal cones. A phylogenetic algorithm divides the space of all dissimilarity maps into regions based upon which combinatorial tree is reconstructed by the algorithm. We use polyhedral geometry to compare the local nature of the subdivisions induced by least-squares phylogeny, UPGMA, and Neighbor-Joining. Our results suggest that in some circumstances, UPGMA and Neighbor-Joining poorly match least-squares phylogeny when the true tree has a polytomy. (Received August 09, 2013)

1093-05-176 **Francois Bergeron*** (bergeron.francois@uqam.ca), Dept. of Mathematics, UQAM, C.P. 8888, Succ. Centre-Ville, Montreal, Quebec H3C 3P8, Canada. *Recent Developments in Rational Combinatorics.*

There has been a lot of recent developments in the interaction between the combinatorics of generalized Dyck paths, and parking functions, in a rectangle; linking thes discret objects to several subjects such as the elliptic Hall algebra, the shuffle algebra, rational Cherednik algebras, etc. Part of this story involves interesting operators on symmetric functions. We will describe how to construct new such operators that (conjecturally) furnish the bigraded Frobenius characteristic of rectangular parking function modules for all pairs of integers. (Received August 13, 2013)

1093-05-246 **Daniel Parry*** (dan.t.parry@gmail.com), NJ. *Elementary Properties of Concave Compositions.* Preliminary report.

A concave composition of n is a sum of nonegative integers

$$\sum_{i=0}^{L} \lambda_i^- + c + \sum_{i=0}^{R} \lambda_i^+ = n$$

with $\lambda_1^- \geq \lambda_2^- \geq \cdots \geq \lambda_L^- > c < \lambda_1^+ \leq \lambda_2^+ \leq \cdots \leq \lambda_R^+$. Concave compositions are connected to the study of mock theta functions as well as self avoiding random walks. In a recent paper by Andrews, Rhoades, and Zwegers, questions were posed about the statistical properties of a concave composition and its likely shape.

This talk will aim to discuss the properties of the length, perimeter, and tilt of a typical concave composition as well as describe its likely shape. We hope to convince the audience that while concave compositions are new, from a statistical standpoint they are no different than pairs of integer partitions roughly of the same size which are placed next to each other. (Received August 16, 2013)

1093-05-249 **Kassie Archer*** (kassie.r.archer.gr@dartmouth.edu), 6188 Kemeny Hall, Hanover, NH 03755. *Descents of λ-unimodal cyclic permutations.*

Let $\lambda = (\lambda_1, \ldots, \lambda_k)$ be a composition of n. A λ-unimodal permutation π is a concatenation of k unimodal segments of lengths λ_i for all $1 \leq i \leq k$. For example, $\pi = 149652387$ is a $(6,3)$-unimodal permutation because it is concatenation of a unimodal segments 149652 and 387.

I will present an identity conjectured by Roichman and Adin about the descent set of λ-unimodal cycles, the proof of which involves a relationship between these permutations and words. Additionally, I will discuss some consequences of the identity from representation theory. (Received August 16, 2013)

1093-05-271 **Christopher A Francisco**, Stillwater, OK 74078, **Jeffrey Mermin**, Stillwater, OK 74078, and **Jay Schweig*** (jay.schweig@okstate.edu), Stillwater, OK 74078. *Borel ideals, pointed pseudo-triangulations, and Catalan numbers.* Preliminary report.

In an earlier work, we showed that the Betti numbers of certain Borel ideals correspond to the number of pseudo-triangulations of certain point configurations. Here, we explain this relationship with an explicit bijection involving binary trees, and discuss how an the sequence resulting from the application of an invertible transformation to Catalan's triangle can be used in other counting applications. (Received August 18, 2013)

1093-05-277 **Nantel Bergeron*** (bergeron@yorku.ca), **C Benedetti**, **N. Thiem** and **M. Aguiar**. *Categorification of Combinatorial Hopf Algebras, symmetric functions in noncommutative variables.*

The space of symmetric functions (in commutative variables) plays a central role in mathematics and representations theory. It can be understood as the Grothendick group of the category of the symmetric groups modules. Further Categorification of this space was established by understanding the functors corresponding to the endomorphisms of the space of symmetric functions.

I will be interested in the space of symmetric functions in noncommutative variables. I will show it could be understood as the Grothendick group of the category of upper triangular groups over finite fields-modules.

This is part of a general quest to categorify certain family of combinatorial Hopf algebras. (Received August 18, 2013)

1093-05-310 **Anna Puskas*** (apuskas@math.columbia.edu). *Metaplectic Demazure and Demazure-Lusztig operators.*

There are two different approaches to constructing p-adic metaplectic Whittaker functions. One approach, due to Chinta and Offen for GL_r and to McNamara in general, represents the spherical Whittaker function in terms of a sum over a Weyl group. The second approach, by Brubaker, Bump and Friedberg and separately by McNamara, expresses it as a sum over a highest weight crystal. The goal is to establish a direct connection between these two approaches. By such a direct connection, one hopes to extend the crystal description from type A to greater generality. Demazure and Demazure-Lusztig operators appear in relevant formulas in the non-metaplectic setting: the Demazure Character formula, Tokuyama's theorem and the work of Brubaker, Bump and Licata in describing Iwahori-Whittaker functions. This talk constitutes a first step towards this goal. We define metaplectic analogues of Demazure and Demazure-Lusztig operators and present two character formulas involving the operators for the long word. Some work in progress, aiming to find similar formulas for metaplectic Iwahori-Whittaker functions will also be mentioned. This is joint work with Gautam Chinta and Paul E Gunnells. (Received August 19, 2013)

1093-05-343 **Jennifer Morse*** (morsej@math.drexel.edu), 3141 Chestnut Street, Philadelphia, PA 19104. *k-Schur functions and Gromov-Witten invariants for flag manifolds.*

We show how to identify the set of 3-point Gromov-Witten invariants for flag manifolds and the WZW fusion rules as coefficients in a product of k-Schur functions. Using symmetric function combinatorics, we describe a defining set of invariants. Time permitting, we show how this approach gives a t-parameter family of representatives for the Schubert classes of cohomology of the affine Grassmannian that is connected to Macdonald symmetric functions. (Received August 20, 2013)

1093-05-356 **Hasan Coskun*** (hasan.coskun@tamuc.edu), Department of Mathematics, 2600 S Neal St, Commerce, TX 75429. *Multiple Bracket, Lah Number and Stirling Number Identities.*

The author has constructed remarkable multiple analogues of several families of combinatorial special numbers in a recent article, including the bracket symbol, and Stirling numbers of the first and second kind. A new definition for the Lah numbers is given, and certain summation identities and related properties of these multiple numbers are constructed in the present paper. (Received August 20, 2013)

1093-05-358 **Avinash J. Dalal*** (adalal@math.drexel.edu), Avinash J. Dalal, Department of Mathematics, Korman Center 206, 33rd and Market Streets, Philadelphia, PA 19104. *On atom expansions of Macdonald polynomials.* Preliminary report.

A long-standing open problem is to find a combinatorial interpretation for the coefficients in the Schur expansion for Macdonald polynomials

$$H_\mu[X;q,t] = \sum_\lambda K_{\lambda\mu}(q,t)s_\lambda.$$

The Kostka-Foulkes polynomials, $K_{\lambda\mu}(0,t)$, appear in many contexts such as Hall-Littlewood polynomials, affine tensor product multiplicities and they encode dimensions of certain bigraded S_n-modules.

In their study of Macdonald polynomials, Lapointe, Lascoux and Morse found computational evidence for a family of new bases $\{A_\mu^{(k)}(x;t)\}_{\mu_1 \leq k}$ for subspaces of the ring of symmetric functions. Most relevant to the work was the empirical study of $\{A_\mu^{(k)}(x;t)\}_{\mu_1 \leq k}$ leading ties to representation theory and conjectures that affine Schubert calculus is strongly linked to the theory of Macdonald polynomials.

To this end, we introduce one parameter families of symmetric functions that transition positively with Hall-Littlewood and Macdonald's P-functions and specialize to certain Schubert representatives in affine Schubert calculus. Our work relies on a notion of translation that presents a surprising connection between chains in the strong and weak order poset on the affine Weyl group $\tilde{A}_{n-1}$. (Received August 20, 2013)

1093-05-375 **Justin Z Schroeder*** (jzschroeder@gmail.com). *Maximal graphs with a distinguishing partition.* Preliminary report.

A *distinguishing partition* for an action of a group Γ on a set X is a partition of X that is preserved by no nontrivial element of Γ. As a special case, a distinguishing partition of a graph is a partition of the vertex set that is preserved by no nontrivial automorphism. Not all graphs admit a distinguishing partition; for example, the complete graph K_n for $n \geq 2$ does not admit a distinguishing partition, so a natural goal is to determine the minimum number of edges that must be removed from a complete graph on n vertices in order for the remaining graph to admit a distinguishing partition. In this talk, we show that this number is $\lceil \frac{n-1}{3} \rceil$. (Received August 20, 2013)

1093-05-380 **Julianna Tymoczko*** (jtymoczko@smith.edu), Department of Mathematics and Statistics, Smith College, 44 College Lane, Northampton, MA 01063. *The Robinson-Schensted algorithm and web bases.*

We describe joint work with Matthew Housley (Brigham Young University) and Heather Russell (Washington College) that compares two natural bases for the irreducible representation of the symmetric group associated to the partition [n,n,n]. The first basis is the web basis, associated to Kuperberg's combinatorial description of the spider category. The second is the left cell basis for Kazhdan-Lusztig's left cells. We consider the images of these bases under two classical combinatorial maps: the Robinson-Schensted algorithm and Khovanov-Kuperberg's bijection. We show that these maps preserve Vogan's generalized tau-invariant, which refines the data of the inversion set of a permutations. However, the two bases are not equivalent, in the sense that these classical combinatorial maps are not equivariant with respect to the permutation group. (Received August 20, 2013)

11 ► Number theory

1093-11-1 **Barry Mazur***, Department of Mathematics, Harvard University, 1 Oxford Street, Cambridge, MA 02138. *Arithmetic statistics: elliptic curves and other mathematical objects.*

Arithmetic statistics: elliptic curves and other mathematical objects

Barry Mazur

Abstract for the Erdös Memorial Lecture—Saturday, October 12, 2013

Paul Erdös would surely be delighted by the current interest in the statistics of diophantine phenomena both in terms of what has been recently proved—e.g., by the marvelous work of Manjul Bhargava and his associates—and in terms of the rich assortment of important conjectures that pave the way to future work. This talk will focus on elliptic curves, Markov processes related to their arithmetic, and some 'minimalist' conjectures regarding their rational points. (Received August 16, 2013)

1093-11-7 **Yilmaz Simsek*** (ysimsek@akdeniz.edu.tr), Akdeniz University, Science Faculty, Department of Mathematics, 07058 Antalya-Turkey, Turkey. *Remarks on special numbers and their applications.* Preliminary report.

In this paper we study on the special numbers (Eulerian Numbers, Bernoulli Numbers, Stirling Numbers). We give their generating functions. By using these functions, we derive some partial differential equations and functional equations. By using these equations, we investigate many fundamental properties of these numbers. We also give recent studies on these numbers. (Received February 19, 2013)

1093-11-29 **Wissam Raji*** (wr07@aub.edu.lb), 320 Bliss Hall, Riad Solh Street, Beirut, Lebanon, and **Ahmad El Guindy**. *Unimodularity of roots of period polynomials of Hecke eigenforms.*

We prove that all the roots of the full period function of any Hecke eigenform are on the unit circle —z—=1. (Received June 21, 2013)

1093-11-30 **Jeffery Breeding*** (jbreeding@fordham.edu), Fordham University, 441 East Fordham Road, Bronx, NY 10458. *Jacquet modules and dimensions of spaces of fixed vectors.*

Consider the connected reductive algebraic group $G = \mathrm{GSp}(4, F)$ defined over a non-archimedean local field F of characteristic zero with ring of integers $\mathfrak{o}$ and maximal ideal $\mathfrak{p}$ such that $\mathfrak{o}/\mathfrak{p}$ is a finite field with q elements. Let (π, V) be an admissible representation of G. In this talk, we discuss how to use Jacquet modules to compute the dimension of the space of $\Gamma(\mathfrak{p})$-fixed vectors of π, where $\Gamma(\mathfrak{p})$ is the principal congruence subgroup of G of level $\mathfrak{p}$. (Received June 21, 2013)

1093-11-38 **Abdelmejid Bayad** and **Matthias Beck*** (mattbeck@sfsu.edu). *Relations for Barnes Zeta Functions.* Preliminary report.

The *Barnes ζ-function* is

$$\zeta_n(z, x; a_1, \ldots, a_n) := \sum_{(m_1,\ldots,m_n)\in \mathbf{Z}^n_{\geq 0}} \frac{1}{(x + m_1a_1 + \cdots + m_na_n)^z}$$

defined for $\Re(x) > 0$ and $\Re(z) > n$ and continued meromorphically to $\mathbf{C}$. We exhibit relations between this function, its special evaluations (analogues of Bernoulli polynomials), the Hurwitz ζ-function, and Fourier-Dedekind sums. Our results can be interpreted as bridging between Euler-type identities for Bernoulli numbers and reciprocity theorems for Dedekind-type sums. (Received July 01, 2013)

1093-11-100 **Jongryul Lim*** (ihswbs@postech.ac.kr). *A characterization of Jacobi cusp forms of certain types.*

A characterization of elliptic cusp forms of even integral weight $k \geq 2$ on a congruence subgroup $\Gamma_0(N)$ with $N \geq 1$ was given with regard to the growth conditions of their Fourier coefficients. In this paper we give a characterization of Jacobi cusp forms of weight k and index m on $\Gamma_0(N)$ with $(2m, N) = 1$ by investigating the structure of Jacobi Eisenstein space and computing the Fourier coefficients of the Jacobi Eisenstein series. (Received August 05, 2013)

1093-11-134 **Cormac O'Sullivan***, Dept of Math, CP 315, 2155 University Ave, Bronx, NY 10453. *Asymptotics for the partial fraction decomposition of the restricted partition generating function.*

Let $p_N(n)$ denote the number of partitions of n into at most N parts. These restricted partitions have generating function

$$\sum_{n=0}^{\infty} p_N(n)q^n = \prod_{j=1}^{N} \frac{1}{1-q^j}$$

with partial fraction decomposition

$$\prod_{j=1}^{N} \frac{1}{1-q^j} = \sum_{\substack{0\leqslant h<k\leqslant N\\(h,k)=1}} \sum_{\ell=1}^{\lfloor N/k\rfloor} \frac{C_{hk\ell}(N)}{(q - e^{2\pi ih/k})^\ell}.$$

The limit of the coefficients $C_{hk\ell}(N)$ as $N \to \infty$ has been the subject of conjectures of Rademacher (1973) and more recently Sills and Zeilberger (2013). In this talk we describe the latest results on the behavior of $C_{hk\ell}(N)$ for large N and connections with the dilogarithm function. (Received August 08, 2013)

1093-11-135 **Pavel Guerzhoy*** (pavel@math.hawaii.edu), 2565 McCarthy Mall, Keller Hall, Department of Mathematics, University of Hawaii at Manoa, Honolulu, HI 96822. *On Zagier's adele.* Preliminary report.

Don Zagier suggested a natural construction, which associates a real number and p-adic numbers for all primes p to the cusp form $g = \Delta$ of weight $k = 12$. He claimed that these quantities constitute a rational adele. A proof of this claim depends on the fact that the space of cusp forms is one-dimensional; only finitely many such cases for the full modular group are known.

We discuss the proof of a similar statement when g is a weight $k = 2$ primitive form with rational integer Fourier coefficients; there are infinitely many such forms g. The proof depends on a version of Hodge decomposition for the formal group law of the rational elliptic curve associated with g. (Received August 08, 2013)

1093-11-137 **David W. Farmer*** (farmer@aimath.org), **Sally Koutsoliotas** and **Stefan Lemurell**. *Coefficients of modular forms start out negative.*

Modular forms of small weight and small level do not exist. As the weight or the level increases, the "first" cusp forms which appear are very likely to have a negative second Fourier coefficient. A similar phenomenon occurs in higher rank. We use L-functions to provide a simple explanation. (Received August 08, 2013)

1093-11-139 **Wen-Ching Winnie Li*** (wli@math.psu.edu), Department of Mathematics, Penn State University, University Park, PA 16802. *Atkin and Swinnerton-Dyer congruences for noncongruence modular forms Preliminary report.* Preliminary report.

Unlike their congruence counterpart, the arithmetic for noncongruence modular forms remains mysterious. A main reason is the lack of efficient Hecke operators. Absent of tools, the progress on noncongruence modular forms has been guided by numerical examples. The first systematic study of the subject was due to Atkin and Swinnerton-Dyer, who made an amazing observation that at good primes, the space of weight k cusp forms for a given noncongruence subgroup has a basis whose Fourier coefficients satisfy 3-term congruence relations, called ASD congruences, analogous to the 3-term recursive relation satisfied by a Hecke eigenform. In this talk we shall review the development and discuss the state-of-the-art of the ASD congruences. (Received August 08, 2013)

1093-11-141 **Takumi Noda*** (takumi@ge.ce.nihon-u.ac.jp), 1 Nakagawara, Tokusada, Tamuramachi, Koriyama, Fukushima 963-8642, Japan. *A transformation formula for a certain kind of Eisenstein series in aerodynamic interference calculations.*

In 1949, F. Olver established a transformation formula which converts a certain slowly convergent series into a rapidly convergent and easily computable form. The original (double) series occurs in aerodynamic interference calculations, and its numerical estimates have some practical importance. In this talk, we revisit this double series from the point of view of analytic number theory, and show the transformation property as a corollary of the Fourier-type expansion of a certain kind of non-holomorphic Eisenstein series by employing Mellin-Barnes integral transformations. (Received August 09, 2013)

1093-11-144 **Amanda Folsom*** (amanda.folsom@yale.edu), Yale University Mathematics Department, P.O. Box 208283, New Haven, CT 06520-8283, **Ken Ono** (ono@mathcs.emory.edu), Emory University, and **Robert C. Rhoades** (rob.rhoades@gmail.com), Stanford University/CCR. *q-series and quantum modular forms.*

We revisit Ramanujan's last letter to Hardy, and prove one of his remaining conjectures as a special case of a more general result. Quantum modular forms, defined by Zagier, as well as Dyson's combinatorial rank function, the Andrews-Garvan crank function, and mock theta functions, all play key roles. Along these lines, we also show that the Rogers-Fine false theta functions, functions that have not been well understood within the theory of modular forms, specialize to quantum modular forms. This is joint work with K. Ono (Emory U.) and R.C. Rhoades (Stanford U./CCR). (Received August 09, 2013)

1093-11-146 **Philippe Demontigny*** (ppd1@williams.edu), 5 Litton Road, Flemington, NJ 08822, and **Thao T Do**. *A Generalization of Fibonacci Far-Difference Representations and Gaussian Behavior.*

A natural generalization of base B expansions is Zeckendorf's Theorem, which states that every integer can be uniquely written as a sum of non-consecutive Fibonacci numbers $\{F_n\}$, with $F_1 = 1, F_2 = 2$. If instead we allow the coefficients in the decomposition to be zero or ± 1, the resulting expression is known as the far-difference representation. Alpert proved that a far-difference representation exists and is unique under certain restraints, specifically that two adjacent summands of the same sign must be at least 4 indices apart and those of opposite signs must be at least 3 indices apart.

We prove that a far-difference representation can be created using sets of Skipponacci numbers, which are generated by recurrence relations of the form $S_{n+1} = S_n + S_{n-k}$ for $k \geq 0$. Now every integer can be written uniquely as a sum of the $\pm S_n$'s such that every two terms of the same sign differ in index by at least $2k+2$, and every two terms of opposite signs differ in index by at least $k+2$. Additionally, we prove that the number of positive and negative terms converges to a Gaussian. The proof uses recursion to obtain the generating function for having a fixed number of summands, which we prove converges to the generating function of the Gaussian. (Received August 09, 2013)

1093-11-148 **Bruce C Berndt** and **Armin Straub*** (arminstraub@mpim-bonn.mpg.de), Max Planck Institute for Mathematics, Vivatsgasse 7, 53111 Bonn, Germany. *On a secant Dirichlet series and Eichler integrals of Eisenstein series.*

This talk is motivated by the secant Dirichlet series $\psi_s(\tau) = \sum_{n=1}^{\infty} \frac{\sec(\pi n \tau)}{n^s}$, recently introduced and studied by Lalín, Rodrigue and Rogers as a variation of results of Ramanujan. We review some of its properties, which include a modular functional equation when s is even, and demonstrate that the values $\psi_{2m}(\sqrt{r})$, with $r > 0$ rational, are rational multiples of π^{2m}.

These properties are then put into the context of Eichler integrals of general Eisenstein series. In particular, we determine the period polynomials of such Eichler integrals and indicate that they appear to give rise to unimodular polynomials, an observation which complements recent results on zeros of period polynomials of cusp forms by Conrey, Farmer and Imamoglu. (Received August 10, 2013)

1093-11-162 **Lucien Szpiro**, **Michael Tepper*** (mlt16@psu.edu) and **Phillip Williams**. *Semi-stable reduction implies minimality of the resultant.*

For a dynamical system on $\mathbb{P}^n$ over a number field or a function field, we show that semi-stable reduction implies the minimality of the resultant. We use this to show that every such dynamical system over a number field admits a globally minimal presentation. (Received August 12, 2013)

1093-11-169 **Jeffrey C. Lagarias*** (lagarias@umich.edu), Dept. of Michigan, University of Michigan, 530 Church Street, Ann Arbor, MI 48109-1043, and **Robert Rhoades**. *Polyharmonic Maass forms on PSL(2, Z).*

An m-polyharmonic Maass form of weight k on the full modular group PSL(2, Z) is a real analytic weight k modular form annihilated by the m-th power of the hyperbolic Laplacian. This talk reports on the question of the finite dimensionality of the vector space of such functions having moderate growth at the cusp, and on finding forms giving bases for such spaces. This is work in progress. (Received August 12, 2013)

1093-11-205 **Daniel P. Wisniewski*** (daniel.wisniewski@desales.edu), Department of Mathematics/Computer Science, DeSales University, 2755 Station Avenue, Center Valley, PA 18034, and **Helen G. Grundman** (grundman@brynmawr.edu), Department of Mathematics, Bryn Mawr College, 101 N. Merion Avenue, Bryn Mawr, PA 19010. *Tetranomial Thue Equations.*

We consider the particular problem of bounding the number of solutions $(p, q) \in \mathbf{Z}^2$, with $|pq| \geq 2$, to the *tetranomial* Thue equation, $|F(x, y)| = 1$, where

$$F(x, y) = ax^n + rx^m y^{n-m} - sx^k y^{n-k} + ty^n,$$

with $n > m > k > 0$, $a, r, s, t \in \mathbf{Z} - \{0\}$, such that

$$\left|\frac{an}{rm}\right| > (1-\varepsilon)^{-1} \quad \text{and} \quad \left|\frac{tn}{s(n-k)}\right| > (1-\varepsilon)^{-1},$$

with $\sqrt{\frac{4(n-1)}{n2^n}} \leq \varepsilon < 1$.

In this talk, I will present our results consisting of upper bounds on the number of solutions for $n \geq 6$ and specific values of ε. I will then summarize the methods we used to prove bounds for $n \geq 9$. (Received August 14, 2013)

1093-11-206 **Eva G Goedhart*** (egoedhart@brynmawr.edu) and **Helen G Grundman**. *The complete solution of $NX^2 + 2^L 3^M = Y^N$.*

Let $N > 1$ be an integer and consider the Diophantine equation

$$NX^2 + 2^L 3^M = Y^N.$$

We have proven that this equation has no solutions with $L, M, X, Y \in \mathbb{Z}^+$ and $\gcd(NX, Y) = 1$. Our proof incorporates a variety of standard methods including the use of defective Lehmer pairs and class number arguments.

In this talk, I will discuss these methods along with earlier results, then present our proof. (Received August 14, 2013)

1093-11-207 **Karol Koziol*** (karol@math.columbia.edu), Columbia University Department of Mathematics, Room 509, MC 4406, 2990 Broadway, New York, NY 10027. *Towards a Langlands correspondence for Hecke modules of* SL_n *in characteristic p.* Preliminary report.

We show how to realize the pro-p-Iwahori-Hecke algebra of SL_n as a subalgebra of the pro-p-Iwahori-Hecke algebra of GL_n. Using the interplay between these two algebras, we deduce a numerical Langlands correspondence between "packets" of Hecke modules and mod-p projective Galois representations. (Received August 14, 2013)

1093-11-212 **Austin Daughton*** (adaughto@temple.edu). *Dirichlet Series with Functional Equations and General Singularities.*

The correspondence between Dirichlet series with certain nice properties and automorphic forms has been a longstanding facet of analytic number theory. Initiated by Riemann to prove that the zeta function satisfies a functional equation, a full correspondence between 'nice' Dirichlet series and modular forms was given by Hecke in 1936. Since then, there has been a lot of interest in generalizing Hecke's result in many directions (to different levels, higher order groups, different functional equations, nonholomorphic forms, automorphic integrals, etc.). In this talk, I will discuss a generalization to Dirichlet series with the classical functional equation but whose singularities are allowed to be very general and give an application to a problem closely related to Hamburger's Theorem. (Received August 14, 2013)

1093-11-215 **Victor H Moll*** (vhm@math.tulane.edu), Department of Mathematics, Tulane University, New Orleans, LA LA 70118. *A special sequence of rational numbers.*

A sequence of numbers appearing in the evaluation of a definite integral are described. Several properties including combinatorial interpretation and arithmetical properties will be presented. (Received August 14, 2013)

1093-11-233 **Djordje Milićević*** (dmilicevic@brynmawr.edu), Bryn Mawr College, Department of Mathematics, 101 North Merion Avenue, Bryn Mawr, PA 19010. *p-adic analytic twists and strong subconvexity (joint work with Valentin Blomer).*

One of the principal questions about L-functions are the so-called subconvex estimates on the size of their critical values, deeply arithmetic both in proofs and in the often spectacular consequences. For a fixed cuspidal (holomorphic or Maaß) newform f, we prove a subconvexity bound $L(f\otimes\chi, 1/2+it) \ll_{p,t} q^{1/3+\epsilon}$ for the twisted L-function of f with a Dirichlet character χ of prime power conductor $q = p^n$ (with an explicit polynomial dependence on p and t). The Weyl subconvexity exponent achieved is the strongest available in any family of L-functions of degree higher than one. Our results, which showcase the structural relationship between p-adic analysis and the depth aspect, are obtained by exhibiting strong cancellation between the Hecke eigenvalues of f and the values of χ, which act as twists by exponentials with a p-adically analytic phase. Among the tools, we develop a general result on p-adic approximation by rationals (a p-adic counterpart to Farey dissection) and a p-adic version of van der Corput's method for exponential sums. (Received August 16, 2013)

1093-11-239 **Daniel Birmajer** (abirmaj6@naz.edu), **Juan B Gil** (jgil@psu.edu) and **Michael D Weiner*** (mdw8@psu.edu). *Explicit formulas for roots of polynomials with coefficients in the ring of p-adic integers.* Preliminary report.

We prove two versions of Hensel's lemma that give explicit formulas for the roots of any polynomial with coefficients in the ring of p-adic integers. Our formulas are given in terms of partial Bell polynomials and rely on the inversion formula of Lagrange. For illustration purposes, we examine the special cases of quadratic and cubic polynomials, and discuss the roots of unity leading to a formula for the so-called Teichmuller lifts. (Received August 16, 2013)

1093-11-248 **Helen G. Grundman** and **Laura L. Hall-Seelig*** (hallseeligl@merrimack.edu). *Simultaneous Solutions to a Pair of Diophantine Equations.*

Focusing on algebraic integers in fields of degree at most four over $\mathbb{Q}$, we consider the problem of finding all simultaneous solutions to the pair of equations

$$xyz = 1 \qquad \text{and} \qquad x + y + z = k$$

for various values of $k \in \mathbb{Z}$. Adapting the methods used by Andrew Bremner for the case where $k = 1$, we translate the problem to one of finding points on a related elliptic curve, E_k, and solve the problem completely for all k for which the Mordell-Weil group of E_k is finite. (Received August 16, 2013)

1093-11-264 **Karen Taylor*** (karen.taylor@bcc.cuny.edu) and **Cormac O'Sullivan** (sullivancormaco@gmail.com). *Hyperbolic Fourier Coefficients of Modular Forms.* Preliminary report.

The number theoretic properties of (parabolic) Fourier coefficients of modular forms is vast. Petersson (1941) showed, in addition to parabolic expansions, that modular forms have elliptic and hyperbolic exansions. This is a preliminary report on explicit formulae for hyperbolic fourier coefficients of modular forms. (Received August 18, 2013)

1093-11-278 **Karl E Mahlburg*** (mahlburg@math.lsu.edu), Lockett Hall, Baton Rouge, LA 70803, and **Kathrin Bringmann**. *Schur's partition theorem and mixed mock modular forms.*

I will discuss families of partitions with gap conditions that were introduced by Schur and Andrews, and describe their intrinsic connections to combinatorial q-series and automorphic forms. The generating functions for these families naturally lead to fundamental identities for theta functions and Hickerson's universal mock theta function. This provides a very general answer to a conjecture of Andrews, in which he predicted the modularity of the generating function for Schur's partitions. As a final application, we prove the striking result that the universal mock theta function can be expressed as a conditional probability in a certain natural probability space with an infinite sequence of independent events. (Received August 18, 2013)

1093-11-283 **Nikolaos Diamantis***, School of Mathematical Sciences, University of Nottingham, Nottingham, NG7 2RD, United Kingdom, and **Roelof Bruggeman**. *Shifted convolutions and second-order automorphic forms.*

We discuss a method of spectrally decomposing a certain type of shifted convolutions which is based on the "completion" of a second-order Eisenstein series into a square-integrable Γ-invariant function. This second-order Eisenstein series naturally parametrizes the shifted convolution in question. (Joint work with R. Bruggeman) (Received August 19, 2013)

1093-11-340 **Abdul-Nasser El-Kassar*** (abdulnasser.kassar@lau.edu.lb), Lebanese American University, P.O. Box 13-5053, Beirut, 1102 2801, Lebanon, and **Therrar El-Kadri**. *Finite Commutative Rings Having a Boolean kth Group of Units.*

Let $(R, +, .)$ be a finite commutative ring with identity and let $(U(R), .)$ be its group of units. El-Kassar and Chehade [Math. Balkanica 20 (2006), no. 3-4, 275–286; MR2269732 (2007g:16048)] showed that $U(R)$ supports a ring structure $(U(R), ., *)$ isomorphic to a ring $R^1 = \mathbf{Z}_{n_1} \oplus \mathbf{Z}_{n_2} \oplus ... \oplus \mathbf{Z}_{n_i}$. The second group of units of the ring R, denoted by $U^2(R)$, is defined to be $U(U(R))$. The operations of $U^2(R)$ are described using the isomorphism $U^2(R) \cong U(R^1)$. The kth group of units of the ring R is defined iteratively by $U^k(R) = U(U^{k-1}(R))$. Since $U^k(R)$ eventually becomes a Boolean ring, we define the class of R, denoted by $C(R)$, to be the positive integer k such that $U^k(R)$ is Boolean. In this paper, we consider the problem of determining all rings R having $C(R) = k$, where k is a fixed positive integer. In particular, we show that the class of all rings $\mathbf{Z}_n$ with $C(\mathbf{Z}_n) = k$ is determined in terms of the divisors of certain integer B_k. Algorithms for finding B_k are developed. (Received August 20, 2013)

1093-11-355 **Diego Marques** and **Jonathan Sondow*** (jsondow@alumni.princeton.edu). *The Schanuel Subset Conjecture implies the Gelfond Power Tower Conjecture.*

We introduce the *Schanuel Subset Conjecture* (SSC). It states that, if the complex numbers $\alpha_1, ..., \alpha_n$ are linearly independent over $\mathbb{Q}$, and if the set $\{\alpha_1, ..., \alpha_n, e^{\alpha_1}, ..., e^{\alpha_n}\}$ is $\overline{\mathbb{Q}}$-dependent on a subset $\{\beta_1, ..., \beta_n\}$, then $\beta_1, ..., \beta_n$ are algebraically independent.

It is easily shown that *Schanuel's Conjecture implies SSC*. Are the two conjectures in fact equivalent?

In a 1934 announcement in *Comptes Rendus*, Gelfond stated a vast generalization of the Gelfond-Schneider Theorem, but he never published a proof. A special case, which we call the *Gelfond Power Tower Conjecture*, asserts that, if $z = e^{\omega}$ or $z = \alpha$, where $\omega \neq 0$ and α are algebraic numbers with α irrational, then the power towers $z^z, z^{z^z}, z^{z^{z^z}}, \ldots$ are algebraically independent.

Our main result is that, *if the Schanuel Subset Conjecture is true, then the Gelfond Power Tower Conjecture is also true.*

An e-print is available at http://arxiv.org/abs/1212.6931. (Received August 21, 2013)

13 ► Commutative rings and algebras

1093-13-61 **Lawrence Ein** and **Daniel Erman*** (derman@math.wisc.edu), Van Vleck Hall, University of Wisconsin, Madison, WI 53706-1325, and **Robert Lazarsfeld**. *Syzygies of high degree Veronese subrings.* Preliminary report.

In 2012, Ein and Lazarsfeld gave an asymptotic description of the Betti tables of high degree Veronese subrings. We will discuss a new generalization of that result that admits a greatly simplified proof. (Received July 25, 2013)

1093-13-66 **Luca Chiantini** and **Juan C. Migliore*** (migliore.1@nd.edu). *Almost maximal growth.* Preliminary report.

Let Z be a finite set of reduced points in projective space. Let R/I_Z be its coordinate ring, and let A be an artinian reduction by a general linear form. In an old paper with A. Bigatti and A.V. Geramita, I described geometric consequences that arise when the Hilbert function of A has maximal growth in some degree, according to Macaulay's bound. The consequences were in terms of many points of Z lying on a variety of some sort, depending on the growth, and a description of this subset of points. This directly generalized a result of Davis, that handled the case where the points lay in a projective plane. In current work in progress with L. Chiantini, we give similar consequences when the growth of the Hilbert function of A is not maximal, but "almost maximal." (Received July 26, 2013)

1093-13-102 **Michael Gekhtman*** (mgekhtma@nd.edu), Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. *Cluster structures on Poisson-Lie groups.*

I will describe a recent progress in constructing cluster structures compatible with non-standard Poisson-Lie structures in SL(n). This is a joint project with M. Shapiro and A. Vainshtein. (Received August 05, 2013)

1093-13-118 **David Cook II*** (dcook8@nd.edu), Department of Mathematics, 255 Hurley Building, University of Notre Dame, Notre Dame, IN 46556-4618. *Monomial ideals with persistent associated primes.*

We introduce the uniform face ideal of a simplicial complex with respect to a given ordered proper vertex colouring. This ideal is a monomial ideal which is generally not squarefree. If the colouring satisfies a certain nesting property, we describe the associated primes, which we show to be persistent. (Received August 06, 2013)

1093-13-165 **Uwe Nagel** and **Augustine O'Keefe*** (abok222@uky.edu). *Cellular resolutions of some artinian level monomial ideals.*

Nagel and Reiner showed that a mixed subdivision of the dilated simplicial complex $d\Delta_n$ supports a minimal cellular resolution of the d^{th} power of the maximal ideal in the ring $k[x_1, \ldots, x_n]$. In this talk we give a procedure on $d\Delta_n$ resulting in a cell complex supporting a minimal free resolution of $\mathfrak{m}^d + \langle x_1^{a_1}, \ldots, x_n^{a_n} \rangle$. (Received August 13, 2013)

1093-13-177 **Tai Huy Ha** and **Kuei-Nuan Lin*** (klin@smith.edu). *Normality of Polytopes Arising from Hypergraphs.* Preliminary report.

This is joint work with Tai Ha. Let H be a finite hypergraph and I be a square-free monomial ideal of K[A] corresponding to H where K is a field and A is an alphabet set. Let K[H] be the subalgebra of K[A] generated by monomial generators of I. We are going to find a combinatorial criterion of the normality of K[H]. (Received August 13, 2013)

1093-13-209 **Vinh An Pham*** (vapnnc@mail.missouri.edu), Mathematics Department, University of Missouri-Columbia, Columbia, MO 65211. *Ramification of Local Rings along Valuations.*

Consider the standard setting of ramification theory of valuations, say, K^*/K is a finite extension of algebraic function fields over some ground field k, ν^* is a k-valuation of K^* with its restriction ν on K, R and S are algebraic local rings which are contained in K and K^* respectively and are dominated by ν^*. Similar to the familiar associated graded ring assigned to an ideal filtration in a commutative ring, we also have the associated graded ring of a valuation (denoted by $gr_\nu(R)$ and $gr_{\nu^*}(S)$ in our settings), suggested and used by Tessier in his work on resolution of singularities. For function fields of algebraic surfaces over algebraically closed fields k of characteristic zero, Ghezzi, Ha and Kashcheyeva have shown that under finite sequences of quadratic transforms along ν^*, $gr_{\nu^*}(S)$ is eventually finitely generated over $gr_\nu(R)$. Our main result is to generalize this to the case of arbitrary ground field of characteristic zero. This is a joint work with Steven Dale Cutkosky. (Received August 15, 2013)

1093-13-213 **Christine Berkesch*** (cberkesc@umn.edu), School of Mathematics, University of Minnesota, Minneapolis, MN 55455, and **Daniel Erman** and **Manoj Kummini**. *Extremal Betti tables.*

We discuss extremal Betti tables of resolutions in three different contexts. We begin over the graded polynomial ring, where extremal Betti tables correspond to pure resolutions and can be realized via so-called tensor complexes. We then contrast this behavior with that of extremal Betti tables over regular local rings and over a bigraded ring. (Received August 14, 2013)

1093-13-223 **Thanh Quang Vu*** (vqthanh@math.berkeley.edu). *Periodicity of Betti numbers of monomial curves.*

Let K be an arbitrary field. Let $\mathbf{a} = (a_1 < ... < a_n)$ be a sequence of positive integers. Let $C(\mathbf{a})$ be the affine monomial curve in $\mathbb{A}^n$ parametrized by $t \to (t^{a_1}, ..., t^{a_n})$. Let $I(\mathbf{a})$ be the defining ideal of $C(\mathbf{a})$ in $K[x_1, ..., x_n]$. For each positive integer j, let $\mathbf{a} + j$ be the sequence $(a_1 + j, ..., a_n + j)$. In this talk, we present a proof of the conjecture of Herzog and Srinivasan saying that the betti numbers of $I(\mathbf{a} + j)$ are eventually periodic in j with period $a_n - a_1$. When j is large enough, we describe the betti table for the closure of $C(\mathbf{a}+j)$ in $\mathbb{P}^n$. (Received August 15, 2013)

1093-13-225 **Louiza Fouli** and **Susan Morey*** (morey@txstate.edu), Department of Mathematics, Texas State University, 601 University Drive, San Marcos, TX 78666. *Depths of Powers of Edge Ideals of Graphs.*

There is a one-to-one correspondence between square-free monomial ideals generated in degree two and graphs given by associating to any graph G the ideal $I(G)$ whose generators correspond to the edges of G. We will use the relationship between a graph and its edge ideal to give lower bounds on the depths of such ideals. We will also show how similar bounds can sometimes be obtained for the depths (or equivalently the projective dimensions) of powers of these ideals. (Received August 15, 2013)

1093-13-244 **Daniel Birmajer*** (abirmaj6@naz.edu), 4245 East Avenue, Rochester, NY 14618, and **Juan Gil** (jgil@psu.edu) and **Michael D Weiner** (mdw8@psu.edu). *Factorization of Power Series over the Integers.* Preliminary report.

We investigate the arithmetic properties of the ring of formal power series with integer coefficients and give an explicit factorization for certain reducible polynomials whose constant term is of the form p^w with p prime and $w > 1$. Our formulas are given in terms of partial Bell polynomials and rely on the inversion formula of Lagrange. (Received August 16, 2013)

1093-13-284 **H. Charalambous*** (hara@math.auth.gr), Department of Mathematics, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece, and **A. Thoma** and **M. Vladoiu**. *Markov Bases of Lattice Ideals.*

Let $L \subset \mathbb{Z}^n$ be a lattice, $\Bbbk$ a field, $R = \Bbbk[x_1, \ldots, x_n]$ and $I_L = \langle x^u - x^v : \ u - v \in L \rangle$ the corresponding lattice ideal. We partition the set of monomials of R into *fibers*: x^u, x^v are in the same fiber if $u - v \in L$. We generalize the fiber graph construction, from the case where the intersection of L with $\mathbb{N}^n$ is $\mathbf{0}$ and thus all fibers are finite, to all lattices. We use the fiber graphs to characterize minimal generating sets of I_L of minimal cardinality and to give invariants for these generating sets. As an application we characterize all binomial complete intersection lattice ideals. (Received August 19, 2013)

1093-13-336 **Thomas Kahle**, **Ezra Miller*** (ezra@math.duke.edu) and **Christopher O'Neill**. *Binomial irreducible decomposition.* Preliminary report.

This talk presents a response to Problem 7.5 in the paper *Binomial ideals*, by Eisenbud and Sturmfels: "Does every binomial ideal have an irreducible decomposition into binomial ideals? Find a combinatorial characterization of irreducible binomial ideals." (Received August 20, 2013)

1093-13-359 **Tài Hà** and **Russ Woodroofe***, PO Box MA, Mississippi State, MS 39759. *An absence of leaves in regularity.*

Let G be a graph, and $I(G)$ the associated edge ideal. It is not difficult to show that there is a vertex v such that $\operatorname{reg} I(G) \leq \operatorname{reg} I(G \setminus N[v]) + 1$. In recent joint work with Tài Hà, we have shown that this vertex v can be chosen to avoid vertices of degree 1 ("leaves"). As a corollary, we get a new packing-type upper bound for the regularity of the edge ideal of a graph. (Received August 20, 2013)

14 ► Algebraic geometry

1093-14-2 **Patrick Gerald Brosnan*** (pbrosnan@umd.edu), Department of Mathematics, University of Maryland, College Park, MD 20742-4015. *Normal functions.*

Normal functions are certain sections of torus bundles introduced by Poincare in 1910. They are interesting partially because they are geometric objects, which can be associated to cohomology classes. Lefschetz used this idea in 1924 to prove his (1,1) Theorem, which is the Hodge conjecture for surfaces. Unfortunately, while the normal functions considered by Lefschetz were essentially algebro-geometric objects, normal functions on higher dimensional varieties are complex-analytic, but not usually algebraic. I will explain this and work by several authors (including Schnell, Kato-Nakayama-Usui, Pearlstein and myself) which shows that normal functions arising in nature do behave in some ways like algebro-geometric objects. For example, the zero locus of such a function is algebraic. I will also explain an approach to the Hodge conjecture due to Green and Griffiths, which is based on normal functions. (Received June 26, 2013)

1093-14-25 **Dawei Chen*** (dawei.chen@bc.edu), 266 Carney Hall, Department of Mathematics, Boston College, Chestnut Hill, MA 02467, and **Izzet Coskun** (coskunizzet@gmail.com), 851 S. Morgan St, MSCS, University of Illinois at Chicago, Chicago, IL 60607. *Extremal effective divisors on moduli space of curves.* Preliminary report.

The cone of effective divisors plays a central role in the study of birational geometry of a variety X. In this talk I will give an introduction to this subject and report some recent progress on the case when X is the moduli space of curves with marked points in low genus. This is joint work with Izzet Coskun. (Received June 13, 2013)

1093-14-28 **Tolga Karayayla*** (tkarayay@metu.edu.tr), Department of Mathematics, Middle East Technical University, Univ. Mah. Dumlupinar Bulv. No:1, 06800 Ankara, Turkey. *Automorphism Groups of Rational Elliptic Surfaces with Section and Constant J-Map.*

I will present the second leg of the classification project for the automorphism groups of rational elliptic surfaces (RES) with section which concerns those RES with constant J-Map. In the first leg of this study, it was shown that the group $Aut(B)$ of regular automorphisms (biholomorphic maps) of a relatively minimal RES B over the field $\mathbb{C}$ is the semi-direct product $MW(B) \rtimes Aut_\sigma(B)$ of its Mordell-Weil group $MW(B)$ (the group of sections) and the subgroup $Aut_\sigma(B)$ of the automorphisms preserving the zero section of the surface. $MW(B)$ has been classified by Oguiso and Shioda with respect to the configuration of singular fibers on B. $Aut_\sigma(B)$ was classified for RES with non-constant J-Map in the first leg of this study. In this talk I will discuss the results in the constant J-Map case. RES with constant J-Map have richer automorphism groups. While $Aut_\sigma(B)$ has size at most 24 in the non-constant J-Map case, it can have size 144 or can even be infinite depending on the configuration of singular fibers on B if the J-Map is constant. One reason for having more symmetry in that second case is the existence of automorphisms which act as complex multiplication of order 3,4 or 6 on every smooth elliptic curve fiber of the surface. (Received June 17, 2013)

1093-14-33 **Amanda Knecht*** (amanda.knecht@villanova.edu), Villanova Mathematics and Statistics, St Augustine Ctr Rm 305, 800 Lancaster Avenue, Villanova, PA 19085. *Degree of Unirationality for del Pezzo Surfaces over Finite Fields.*

We address the question of the degree of unirational parameterizations of degree four and degree three del Pezzo surfaces. Specifically we show that degree four del Pezzo surfaces over finite fields admit degree two parameterizations and minimal cubic surfaces admit parameterizations of degree 6. It is an open question whether or not minimal cubic surfaces over finite fields can admit degree 3 or 4 parameterizations. (Received June 27, 2013)

1093-14-36 **Radu Laza*** (rlaza@math.sunysb.edu), Department of Mathematics, Stony Brook University, Stony Brook, NY 11794. *The KSBA compactification for the moduli space of degree two K3 pairs.*

A classical (and still open) problem in algebraic geometry is the search for a geometric compactification for the moduli of polarized K3 surfaces (X,L). If one considers instead K3 pairs (X,H) with H a divisor in the linear system —L—, the resulting moduli space has a natural geometric compactification given by the general MMP framework (pioneered by Kollar, Shepherd-Barron, and Alexeev). In this talk, I will discuss the existence of a good compactification for the moduli of K3 pairs in all degrees, and then discuss in detail the degree 2 case. (Received June 30, 2013)

1093-14-48 **Pablo Solis*** (pablo@math.berkeley.edu), 2404 Fulton St, Apartment 103, Berkeley, CA 94704. *Embeddings of Loop groups and G-bundles on nodal curves.* Preliminary report.

A well studied space in algebraic geometry and conformal field theory is the moduli space of semi stable vector bundles (or more generally, principal G-bundles) on a fixed smooth projective curve. For degeneration arguments it is of interest to understand the moduli space when the curve is allowed to develop nodes, unfortunately in this case the moduli space becomes non compact and more difficult to work with. In this talk I'll explain how a certain group LG called the loop group can be used to study such moduli problems. In particular using a compactification of the loop group I show how one can compactify the moduli space of G-bundles on a nodal curve. (Received July 15, 2013)

1093-14-60 **John Lesieutre*** (johnl@math.mit.edu). *Counterexamples to some positivity questions.*

I will explain the failure of several "positivity"-type properties of divisors: nefness is not an open condition in families; the diminished base locus of a divisor is not always a closed set; Zariski decompositions do not necessarily exist in dimension three; and asymptotic multiplicity invariants are not always finite, in the relative setting. (Received August 06, 2013)

1093-14-63 **Patricio I Gallardo*** (pgallardo@math.sunysb.edu), Mathematics Department Stony Brook University, 100 Nicolls Rd, Stony Brook, NY 11794-3651. *On the moduli space of quintic surfaces.*

By drawing an analogy with the moduli space of curves of genus three. We describe the role of geometric invariant theory and birational geometry in the compactification of the moduli space of smooth quintic surfaces. In particular, we discuss the interplay between non log canonical singularities and boundary divisors. (Received July 25, 2013)

1093-14-67 **Adam Coffman***, IPFW Dept. of Math. Sci., 2101 E. Coliseum Blvd., Fort Wayne, IN. *Rational functions on real or complex weighted projective spaces.*

On a complex weighted projective space, there are always enough rational functions of the form $f_{jk}(z) = [z_j^a : z_k^b]$ so that their product $(\ldots, f_{jk}, \ldots)$ is one-to-one on an open set. We consider the problem of how many such functions are needed, and how the real case is different. (Received July 26, 2013)

1093-14-84 **Anand Deopurkar*** (anandrd@math.columbia.edu), **Maksym Fedorchuk** and **David Swinarski**. *GIT Stability of First Syzygies of Canonical Curves.*

The GIT quotients arising from the generators of the ideals of (pluri)canonically embedded curves are expected to yield certain log canonical models of M_g. As a way to reach the canonical model, one can also consider the quotients arising from the syzygies. As a first step towards this goal, we prove that if g is odd, then the first of these quotients is non-empty, that is, the first syzygies of general canonical curves of odd genus are GIT-stable. (Received August 01, 2013)

1093-14-147 **Qile Chen*** (q_chen@math.columbia.edu), Rm 628, MC 4421, 2990 Broadway, New York, NY 10027. *Logarithmic Gromov-Witten theory.*

I will introduce the theory of stable logarithmic maps, which gives a nice compactification of the space of stable maps to varieties with log smooth boundaries, or to log smooth degenerations. These include a large class of interesting cases, for example target varieties with boundaries given by normal crossings divisors, or normal crossings degenerations. One of the major purposes of this theory is to study the behavior of Gromov-Witten invariants under log smooth degenerations. (Received August 10, 2013)

1093-14-170 **Matthew Ballard*** (matthewrobertballard@gmail.com), **Dragos Deliu**, **David Favero**, **M. Umut Isik** and **Ludmil Katzarkov**. *Homological Projective Duality for higher Veronese embeddings.*

Homological Protective Duality is notion introduced by Kuznetsov. As the name suggests it is closely tied to classical projective duality. In particular, it starts with an embedding of a variety X into projective space. The derived category of the homological protective dual is a semi orthogonal component of the derived category of the universal hyperplane section of X. By taking hyperplane sections and their duals, one obtains interesting comparisons between derived categories. In this talk, we will discuss the HPDs of the simplest projective embeddings: the Veronese embeddings. They arise as projective spaces equipped with sheaves of A-infinity algebras. (Received August 12, 2013)

1093-14-173 **Jeff Yelton*** (yelton@math.psu.edu). *Galois action on 2-adic Tate modules of hyperelliptic jacobians.*

The image of the action of Galois on ℓ-adic Tate modules of abelian varieties has been a topic of considerable study. A particularly interesting case is that of hyperelliptic jacobians for $\ell = 2$. Certain results such as Serre's celebrated "open image theorem" have shown that, under certain conditions, the image of Galois in the symplectic group of automorphisms of the Tate module is open of finite index. However, little is known about exactly how the Galois group acts on the field of definition of dyadic torsion of a given hyperelliptic jacobian. In this talk, I will give formulas for the field of definition of dyadic torsion of certain elliptic curves, as well as describe the structure of the Galois group of this field extension and how it acts on certain generators. If time permits, I will also discuss an analogous result for jacobians of hyperelliptic curves of genus 2. (Received August 13, 2013)

1093-14-234 **Zhaoting Wei*** (zhaotwei@indiana.edu), Indiana University, Department of Mathematics, 831 E 3rd Street, Bloomington, IN 47405. *Riemann-Roch Theorem and Duflo's Isomorphism Theorem.* Preliminary report.

For a smooth variety X, the *Atiyah Class* gives a map

$$\mathcal{T}_X[-1] \otimes \mathcal{T}_X[-1] \to \mathcal{T}_X[-1]$$

in the derived category $\mathcal{D}(X)$. This map makes $\mathcal{T}_X[-1]$ a Lie algebra object $\mathfrak{g}$ in $\mathcal{D}(X)$. Moreover, $\bigoplus_k \bigwedge^k \mathcal{T}_X[-k]$ correspond to $S(\mathfrak{g})$ and $p_{1*}(\mathrm{R}\mathcal{H}om_{X\times X}(\mathcal{O}_X, \mathcal{O}_X))$ gives the universal enveloping algebra $U(\mathfrak{g})$.

The HRK map

$$I_{\mathrm{HRK}} : \bigoplus_k \bigwedge^k \mathcal{T}_X[-k] \to p_{1*}(\mathrm{R}\mathcal{H}om_{X\times X}(\mathcal{O}_X, \mathcal{O}_X)).$$

fails to be an algebraic homomorphism. To make is compatible with the multiplication, we need to modify it with some certain power series of the Atiyah class, with coefficients coming from the Todd genus. This leads to the Riemann-Roch Theorem.

On the other hand in Lie theory we have the Duflo's isomorphism theorem

$$S(\mathfrak{g})^{\mathfrak{g}} \to Z(U(\mathfrak{g})),$$

which is analogous to the map in algebraic geometry.

I will explain the relation between these two theorems. Moreover, I will talk about how this idea leads to a generalization of Duflo's isomorphism theorem to *family algebras*. (Received August 16, 2013)

1093-14-269 **David Swinarski*** (dswinarski@fordham.edu), 113 W 60th St Room 813, New York, NY 10023, and **Maxim Arap**. *Graded Betti numbers of Beauville-Polishchuk rings.* Preliminary report.

The Chow ring of a Jacobian variety mod algebraic equivalence contains several natural geometric classes. We call the subring generated by these classes the Beauville-Polishchuk ring. van der Geer and Kouvidakis give a conjectural basis for the graded pieces of these rings. We prove their conjecture in some degrees and outline a strategy for the remaining cases. (Received August 18, 2013)

1093-14-305 **Mahir Bilen Can** (mcan@tulane.edu), **Roger Howe** (howe@math.yale.edu) and **Michael Joyce*** (mjoyce3@tulane.edu). *Unipotent Invariant Matrices.* Preliminary report.

We consider the twisted conjugation action of the complex general linear group GL_n on the space of $n \times n$ complex matrices given by $g \cdot A = gAg^t$. For a fixed unipotent element $u \in GL_n$, we describe the locus of matrices that are fixed by u; the answer is in terms of its Jordan type.

When the action is restricted to non-degenerate symmetric or skew-symmetric matrices, it can be interpreted as a natural GL_n-action on certain symmetric spaces. We consider the extended action on the wonderful embedding of these symmetric spaces and describe the fixed locus of a regular unipotent element (i.e. having just a single Jordan block). In that case, we find that the fixed locus has a cell decomposition which we use to determine the Betti numbers of the fixed locus. (Received August 19, 2013)

1093-14-349 **John Nathan Kirkpatrick Francis*** (jnkf@northwestern.edu). *Factorization homology and formal moduli.* Preliminary report.

After formulating the notion of a formal moduli problem of n-disk algebras, I'll show how they have the structure of observables in a quantum field theory. I'll describe how a natural algebraic duality on the moduli side interacts with a physical duality on the observable side. This is joint work with David Ayala. (Received August 20, 2013)

1093-14-367 **Giulia Sacca***, giulia.sacca@gmail.com, and **Enrico Arbarello**. *Singularities of moduli spaces of sheaves on K3 surfaces and Nakajima quivers varieties.* Preliminary report.

We establish the semistablity of Lazersfeld-Mukai bundles for some class of rank zero sheaves on a K3 surface and show that this implies the formality of the versal deformation space of these sheaves. As a consequence, we give examples of moduli spaces of rank zero sheaves on a K3 surface which, locally around their most singular points, are isomorphic to a quiver variety in the sense of Nakajima. The singularities of these moduli spaces arise from the choice of a specific polarization and admit natural symplectic resolutions. These correspond, via the above isomorphism, to natural symplectic resolutions of the quiver variety. (Received August 20, 2013)

1093-14-392 **Dmitry Vaintrob*** (mitkav@math.mit.edu), 239 Western Ave, Cambridge, MA 02139. *Regularity and local monodromy of the non-commutative Gauss-Manin connection.*

Given a topological fiber bundle $X \to B$, de Rham cohomology of the fibers with coefficients in the complex numbers forms a vector bundle over B. Nearby fibers of this vector bundle are identified via a flat connection called the *Gauss-Manin* connection. If, further, the fibration is a smooth map of complex algebraic varieties, the Gauss-Manin connection enjoys nice analytic properties which imply, among other things, that the monodromy around any embedding of a punctured unit disk into B has eigenvalues which are roots of unity. Proving this result is surprisingly tricky. The original proof uses Hironaka's resolution of singularities, and there is another proof by Nick Katz which uses characteristic-p methods.

I will present joint work with Vadim Vologodksy which generalises this result to the non-commutative world, where the fiber bundle of spaces is replaced by a family of categories. The proof goes through descent to characteristic p and uses some recent ideas of "noncommutative Hodge Theory" pioneered by Kaledin and Vologodsky. (Received August 21, 2013)

15 ► Linear and multilinear algebra; matrix theory

1093-15-89 **J Ding*** (jiudin@gmail.com), Department of Mathematics, University of Southern Mississippi, 118 College Dr., Box 5045, Hattiesburg, MS 39406, and **N Rhee** and **C Zhang**. *Solving the Yang-Baxter Matrix Equation.*

We present some new results on solutions of the Yang-Baxter matrix equation $AXA = XAX$, and the obtained solutions B are either commutative or non-commutative with the given matrix A. (Received August 02, 2013)

16 ► Associative rings and algebras

1093-16-40 **Chelsea Walton** and **Sarah Witherspoon*** (sjw@math.tamu.edu). *PBW deformations and Hopf algebra actions.* Preliminary report.

We give conditions for PBW deformations of smash products with Hopf algebras when the underlying algebra is Koszul, such as a polynomial or skew polynomial ring. Our results encompass many classes of examples of recent interest—symplectic reflection and Drinfeld Hecke algebras in positive characteristic (via actions of finite groups), infinitesimal Hecke algebras (via actions of Lie algebras), and quantized symplectic oscillator algebras (via actions of quantum groups)—as well as many new types of examples. (Received July 04, 2013)

1093-16-76 **James J Zhang***, Department of Mathematics, Box 354350, Seattle, WA 98195. *The discriminant controls automorphism group of noncommutative algebras.*

We use the discriminant to determine the automorphism group of some noncommutative algebras. This is joint work with Secil Ceken, John Palmieri and Yanhua Wang. (Received July 30, 2013)

1093-16-77 **David J Saltman*** (saltman@idaccr.org), 805 Bunn Dr, Princeton, NJ 08540, and **Louis Rowen**. *Tensor Products of Division Algebras.*

If F is an algebraically closed field and K/F and L/F are arbitrary field extensions, it is standard that $K \otimes_F L$ is a domain and thus has a field of fractions. Since the 1960's people have asked for a proof of the same fact when K, L are replaced by division algebras (I think most people assumed the result was true and just a proof was lacking). We will show this is very often true but also present a counterexample. For convenience we will focus on the case that the division algebras are $D_i/F(V_i)$ of prime degree and where the V_i are smooth F varieties of characteristic 0 (which we can achieve by desingularization). More specifically we will show two things. First of all, if either of the D_i ramify at any discrete valuation of $F(V_i)$ then $D_1 \otimes_F D_2$ is a (noncommutative) domain. Secondly we have an example there the V_i are elliptic curves and $D_1 \otimes_F D_2$ is NOT a domain. Along the way

we encounter two interesting issues. One is the curious properties of the FIELDS $F(V_1) \otimes_F F(V_2)$. The second is a splitting criterion in the case the V_i are curves. (Received July 31, 2013)

1093-16-81 **Susan J Sierra** (s.sierra@ed.ac.uk), University of Edinburgh, Edinburgh, EH9 3JZ, United Kingdom, and **Chelsea Walton*** (notlaw@math.mit.edu), Massachusetts Institute of Technology, Department of Mathematics, Cambridge, MA 02139. *The universal enveloping algebra of the Witt algebra is not noetherian.*

This talk is prompted by the long standing question of whether it is possible for the universal enveloping algebra of an infinite dimensional Lie algebra to be noetherian. To address this problem, we answer a 23-year-old question of Carolyn Dean and Lance Small; namely, we prove that the universal enveloping algebra of the Witt (or centerless Virasoro) algebra is not noetherian. To show this, we prove our main result: the universal enveloping algebra of the positive part of the Witt algebra is not noetherian.

As a consequence of our main result, we also show that the enveloping algebras of many other infinite dimensional Lie algebras are not noetherian. These Lie algebras include the Virasoro algebra and all infinite dimensional Z-graded simple Lie algebras of polynomial growth.

This is joint work with Susan J. Sierra. (Received August 01, 2013)

1093-16-87 **Linhong Wang*** (lwang@selu.edu), Department of Mathematics, SLU Box 10687, Southeastern Louisiana University, Hammond, LA 70402, and **Xingting Wang** (xingting@uw.edu), Department of Mathematics, University of Washington, Seattle, WA 98195. *Complete classification of pointed Hopf algebras of dimension p^2.* Preliminary report.

Let p be a prime. We complete the classification of pointed Hopf algebras of dimension p^2 over an algebraically closed field k. When char $k \neq p$, our result is the same as the well-known result for char $k = 0$. When char $k = p$, there are 14 types of pointed Hopf algebras of dimension p^2, including a unique noncommutative and noncocommutative type. (Received August 01, 2013)

1093-16-88 **Xingting Wang*** (xingting@uw.edu), Department of Mathematics, University of Washington, Seattle, WA 98105. *Finite-dimensional connected Hopf algebras.* Preliminary report.

Let H be a finite-dimensional connected Hopf algebra over an algebraically closed field $\mathbf{k}$ of characteristic $p > 0$. We provide the algebra structure of the associated graded Hopf algebra $\mathrm{gr}H$. Then, we study the case when H is generated by a Hopf subalgebra K and another element, and the case when H is cocommutative. When H is a restricted universal enveloping algebra, we give a specific basis for the second term of the Hochschild cohomology of the coalgebra H with coefficients in the trivial H-bicomodule $\mathbf{k}$. (Received August 01, 2013)

1093-16-94 **Naihuan Jing*** (jing@math.ncsu.edu), Dept of Mathematics, North Carolina State University, Raleigh, NC 27695. *Quantum Pfaffians and quantum matrices.*

The concept of a quantum Pfaffian is rigorously examined and refurbished using the new method of quantum deRham complexes. We derive a complete family of Plücker relations for the quantum linear transformations, and then use them to give an optional set of relations required for the quantum Pfaffian. We then give the complete relations between the quantum determinant and the quantum Phaffian and prove that any quantum determinant can be expressed as a quantum Pfaffian. The quantum hyper-Pfaffian is introduced at the modular case and we generalize several results to the hyper-case. This is joint work with Jian Zhang. (Received August 19, 2013)

1093-16-114 **Frauke M Bleher***, Department of Mathematics, University of Iowa, 14 MLH, Iowa City, IA 52242-1419, and **Ted Chinburg** and **Birge Huisgen-Zimmermann**. *Orbit closures and rational surfaces.* Preliminary report.

We study the Grassmannian of submodules C of a given dimension inside a finitely generated projective module P for a finite dimensional algebra Λ over an algebraically closed field k. The orbit of such a submodule C under the action of $\mathrm{Aut}_\Lambda(P)$ has been considered by a number of authors. We study the problem of bounding the geometry of the closure of this orbit in terms of representation theoretic data. We concentrate on the case when the orbit of C is an affine plane $\mathbb{A}^2_k$. We bound the geometry of the orbit closure of such a C, using "good blow ups" of relatively minimal smooth projective surfaces, such that the bounds only depend on k and $\dim_k(C)$. As a consequence we obtain that the Euler characteristic of the orbit closure of C is bounded above by a function depending on k and $\dim_k(C)$. (Received August 06, 2013)

1093-16-116 **Dmitri Nikshych*** (nikshych@math.unh.edu), University of New Hampshire, Department of Mathematics and Statistics, Durham, NH 03861, and **Brianna Riepel**. *Brauer-Picard groups of pointed fusion categories and categorical Lagrangian Grassmannians.*

Let C be a fusion category. The group of invertible C-bimodule categories is called the Brauer-Picard group of C and is denoted $BrPic(C)$. This notion extends the classical group of invertible bimodules over an algebra. The group $BrPic(C)$ is known to be isomorphic to the group of braided autoequivalences of the Drinfeld center of C.

In the case when C is the category of vector spaces graded by a finite group we analyze the action of $BrPic(C)$ on the set of Lagrangian subcategories of the Drinfeld center of C. Using this action we explicitly compute the Brauer-Picard groups of pointed fusion categories associated to several classical series of finite groups. (Received August 06, 2013)

1093-16-138 **Jessica A. Hamm*** (tuc07283@temple.edu) and **Martin Lorenz**. *Multiplicative Invariants of Root Lattices.*

The root systems of Lie theory give rise to some interesting lattices on which the associated Weyl group acts, notably the weight lattice and the root lattice. By a theorem of Bourbaki, the multiplicative invariant algebra of any weight lattice is known: it is a polynomial algebra. Multiplicative invariant algebras of root lattices, however, usually have a more complicated structure. In this talk we will discuss the multiplicative invariant algebras of the so-called classical root lattices under the action of their associated Weyl groups. (Received August 08, 2013)

1093-16-156 **Lance W. Small*** (lwsmall@ucsd.edu). *Old and New Answers and Problems in Affine Noetherian Rings.*

We shall discuss some recent progress on chain conditions in enveloping algebras of Lie algebras (Sierra – Walton) and some remaining problems in this area. Additionally, we shall consider the structure of certain infinite dimensional division algebras. (Received August 11, 2013)

1093-16-160 **Ellen E Kirkman*** (kirkman@wfu.edu), **Thomas Cassidy**, **Andrew Conner** and **W. Frank Moore**. *Twisted Matrix Factorizations.*

Let A be a connected graded, locally finite k-algebra, and let f be a homogeneous, regular, normal element of A with $af = f\sigma(a)$, for σ an automorphism of A. For a finitely generated graded left A-module M, let $M^{tw} := M^{\sigma}(-d)$, where d is the degree of f and M^{σ} is the associated Zhang twist of M. A *twisted left matrix factorization of f over A* is an ordered pair of maps of finitely generated graded free left A-modules $(\varphi : F \to G, \tau : G^{tw} \to F)$ such that $\varphi\tau = \lambda_f^G$ and $\tau\varphi^{tw} = \lambda_f^F$, where $\varphi^{tw} : F^{tw} \to G^{tw}$ is the map induced by φ, and $\lambda_f^M : M^{tw} \to M$ is the graded left A-module homomorphism given by left multiplication by f. We show that many of the properties of matrix factorizations in commutative regular local rings extend to the setting where A is a left noetherian Artin-Schelter regular ring of finite GK dimension, and we provide some examples of twisted matrix factorizations. (Received August 12, 2013)

1093-16-164 **Rajesh S Kulkarni*** (kulkarni@math.msu.edu), Department of Mathematics, Michigan State University, 619 Red Cedar Road, East Lansing, MI 48824, and **Aaron D Levin** (adlevin@math.msu.edu), Department of Mathematics, Michigan State University, 619 Red Cedar Road, East Lansing, MI 48824. *Relative Brauer groups of curves.* Preliminary report.

The relative Brauer group of function fields of curves has recently generated much interest. We will discuss historical interest in this circle of ideas followed by recent developments. We will then discuss our recent work, a consequence of which is that over a global field K, given a square-free integer ℓ and a finitely generated ℓ-torsion subgroup G of the Brauer group of K, we construct a smooth projective curve with minimal gonality whose relative Brauer group contains G. We will also discuss the relationship with representations of weighted Clifford algebras. (Received August 12, 2013)

1093-16-181 **Vasily A. Dolgushev*** (vald@temple.edu), 1805 N. Broad St., Wachman Hall Rm. 638, Philadelphia, PA 19122, and **Christopher Lee Rogers** and **Thomas H. Willwacher**. *A manifestation of the Grothendieck-Teichmueller group in geometry.*

Inspired by Grothendieck's lego-game, Vladimir Drinfeld introduced, in 1990, the Grothendieck-Teichmueller group GRT. This group has interesting links to the absolute Galois group of rationals, moduli of algebraic curves, solutions of the Kashiwara-Vergne problem, and theory of motives. My talk will be devoted to the manifestation of GRT in the extended moduli of algebraic varieties, which was conjectured by Maxim Kontsevich in 1999. My talk is based on the joint paper with Chris Rogers and Thomas Willwacher: http://arxiv.org/abs/1211.4230 (Received August 13, 2013)

1093-16-186 **Kenneth R Goodearl** (goodearl@math.ucsb.edu), Department of Mathematics, University of California, Santa Barbara, CA 93106, and **Milen T Yakimov*** (yakimov@math.lsu.edu), Department of Mathematics, Louisiana State University, Baton Rouge, LA 70803. *Quantum cluster algebra structures on CGL extentions.*

Cauchon-Goodearl-Letzter extensions form a very large, axiomatically defined class of algebras. We prove that each algebra in the class satisfying some mild conditions possesses a quantum cluster algebra structure. This result has many applications which include: 1. A proof of the Berenstein-Zelevinsky conjecture on quantum double Bruhat cells and 2. a construction of quantum cluster algebra structures on all quantum Schubert cell algebras extending the Geiss-Leclerc-Schroer result from the case of symmetric Kac-Moody algebras. (Received August 13, 2013)

1093-16-198 **Harm Derksen*** (hderksen@umich.edu). *Isomorphism Problems.*

Given two n-dimensional modules of a finite dimensional algebra, there are efficient known algorithms for testing whether they are isomorphic. These algorithms only require a polynomial number of arithmetic operations in the base field k. These algorithms can also be used for testing isomorphisms in arbitrary k-categories. For the Graph Isomorphism Problem, there is no known polynomial time algorithm. However, using certain k-categories associated to the Graph Isomorphism Problem one can distinguish many examples of non-isomorphic graphs in polynomial time. (Received August 13, 2013)

17 ► Nonassociative rings and algebras

1093-17-58 **Kailash C. Misra*** (misra@ncsu.edu), Department of Mathematics, North Carolina State University, Raleigh, NC 27695-8205. *Tensor Product Decomposition of $\widehat{\mathfrak{sl}}(n)$ Modules and identities.*

We decompose the $\widehat{\mathfrak{sl}}(n)$-module $V(\Lambda_0) \otimes V(\Lambda_i)$ using crystal bases and give generating function identities for the outer multiplicities. In the process we discover some seemingly new partition identities for $n = 3, 4$. This is based on some joint work with Evan Wilson. (Received July 23, 2013)

1093-17-128 **Jonathan Kujawa***, Dept. of Mathematics, University of Oklahoma, Norman, OK 73071. *Representations of the Lie Superalgebra gl(m,n).*

I will report on recent results and conjectures on the finite dimensional representations of the Lie superalgebra gl(m,n). In particular I will discuss intriguing geometric connections which are not yet well understood. This is ongoing work with Brian Boe and Dan Nakano. (Received August 08, 2013)

1093-17-168 **Alistair Savage***, Department of Mathematics & Statistics, University of Ottawa, 585 King Edward Ave, Ottawa, Ontario K1N 6N5, Canada, and **Oded Yacobi**. *Towers of algebras categorify the Heisenberg double.*

A tower of algebras is a graded algebra such that each graded piece is itself an algebra (with a different multiplication). Examples include the towers of group algebras of symmetric groups, Hecke algebras of type A, and nilcoxeter algebras. It is known that the Grothendieck groups of towers of algebras satisfying some natural conditions are Hopf algebras. We will discuss how certain induction and restriction functors on the category of modules over a tower of algebras categorify the so-called Heisenberg double of the Hopf algebra associated to that tower. In addition, we prove a Stone–von Neumann type theorem in this general setting. As special cases of our categorification theorem, we recover results of Geissinger and Zelevinsky (for the case of symmetric groups) and Khovanov (for the case of nilcoxeter algebras). For the tower of 0-Hecke algebras, we obtain a categorification of an algebra that we call the quasi-Heisenberg algebra. As an application of our Stone–von Neumann type theorem in this case, we obtain a new, representation theoretic, proof of the fact that the algebra of quasisymmetric functions is free as a module over the algebra of symmetric functions. (Received August 12, 2013)

1093-17-221 **Zhaobing Fan*** (zhaobing@buffalo.edu), 244 Mathematics Building, Buffalo, NY 14260, and **Yiqiang Li** (yiqiang@buffalo.edu), 244 Mathematics Building, Buffalo, NY 14260. *A geometric setting for quantum $\mathfrak{osp}(1|2)$.*

A geometric categorification is given for quotients of quantum $\mathfrak{osp}(1|2)$ and tensor products of its simple modules. The modified quantum $\mathfrak{osp}(1|2)$ is shown to be isomorphic to the modified quantum $\mathfrak{sl}(2)$. This is a joint work with Yiqiang Li. (Received August 15, 2013)

1093-17-247 **Zhaobing Fan** and **Yiqiang Li*** (yiqiang@buffalo.edu), 244 Mathematics Building, Buffalo, NY 14260. *Two-parameter quantum algebras, canonical bases and categorifications.*

I'll present a geometric construction (categorification) of two-parameter quantum algebras and discuss some applications. (Received August 16, 2013)

1093-17-274 **Tevian Dray*** (tevian@math.oregonstate.edu), Department of Mathematics, Oregon State University, Corvallis, OR 97331, **John Huerta** (jhuerta@math.ist.utl.pt), Centro de Análise Matemática, Geometria e Sistemas Dinâmicos, Instituto Superior Técnico, 1049-001 Lisboa, Portugal, **Joshua Kincaid** (kincajos@math.oregonstate.edu), Department of Physics, Oregon State University, Corvallis, OR 97331, **Corinne A. Manogue** (corinne@physics.oregonstate.edu), Department of Physics, Oregon State University, Corvallis, OR 97331, **Aaron Wangberg** (awangberg@winona.edu), Department of Mathematics & Statistics, Winona State University, Winona, MN 55987, and **Robert A. Wilson** (r.a.wilson@qmul.ac.uk), School of Mathematical Sciences, Queen Mary University of London, London, E1 4NS, United Kingdom. *Magic squares of Lie groups.*

The Tits-Freudenthal magic square yields a description of certain real forms of the exceptional Lie algebras in terms of a pair of (possibly split) division algebras. At the group level, the first two rows are well understood geometrically, with the minimal representations of F_4 and E_6 expressed in terms of the Albert algebra. In the third row, the minimal representation of E_7 consists of Freudenthal triples.

We present here several results at the group level, first summarizing previous work using Cartan decompositions involving all 5 real forms of E_6 to identify chains of real subgroups of the particular real form $SL(3,\mathbb{O})$, and a new description of Freudenthal triples in terms of "cubies", the components of an antisymmetric rank-3 representation of (generalized) symplectic groups, thus providing a unified, geometric interpretation of Freudenthal triples as a single object, and a new description of the minimal representation of E_7.

We then provide a complete description of the corresponding "2×2" magic square as $SU(2, \mathbb{K}' \otimes \mathbb{K})$, leading ultimately to a similar description of the Tits-Freudenthal magic square as $SU(3, \mathbb{K}' \otimes \mathbb{K})$, including a new description of the adjoint representation of E_8. (Received August 18, 2013)

1093-17-275 **Yi-Zhi Huang*** (yzhuang@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Vertex tensor categorifications.*

In 1994, Lepowsky and the speaker introduced a notion of vertex tensor category. One can then ask the following natural question of "vertex tensor categorification:" Given a commutative associative algebra, is it possible to construct a vertex tensor category such that its Grothendieck algebra is isomorphic to the given algebra? A reformulation of the results of Huang-Lepowsky and Huang-Lepowsky-Zhang gives positive answers to this question for many algebras arising as the fusion algebras of the conjectured examples of conformal field theories. In particular, the Kazhdan-Lusztig correspondence between quantum groups and affine Lie algebras can also be enhanced by using the main result of Huang-Lepowsky-Zhang to a result about vertex tensor categorifications. In this talk, I will discuss vertex tensor categories, the related results and some open problems in the representation theory of vertex operator algebras in terms of vertex tensor categorifications. (Received August 18, 2013)

1093-17-313 **Antun Milas*** (antun.milas@gmail.com), Albany, NY 12222. *ADE classification and the triplet vertex algebra.*

I will discuss representation theory, and the related combinatorics, of orbifold subalgebras of the triplet vertex algebra. The talk is based on a joint work with D. Adamovic and X. Lin. (Received August 19, 2013)

1093-17-324 **James Lepowsky*** (lepowsky@math.rutgers.edu). *The vertex-algebraic structure of principal subspaces as categorification.*

The classical Rogers-Ramanujan recursion (q-difference equation) relates the two Rogers-Ramanujan identities, and its solution gives the difference-two condition for partitions. In past work with S. Capparelli and A. Milas we in a certain sense "categorified" this recursion, and generalizations, by using intertwining operators in vertex operator algebra theory to construct exact sequences among the principal subspaces of standard $\widehat{sl(2)}$-modules. The exactness of the sequences lifts the recursions to a categorical setting revealing new vertex-algebraic structure, and the solution of the recursions now gives the graded dimensions ("characters") of the principal subspaces. In an ongoing program with C. Calinescu and Milas, we have sharpened those results and extended the new methods to further families of algebras and modules. We have been generalizing our methods to the subtler setting of twisted modules for vertex operator algebras. Recently, Calinescu, Milas and I have, in a "test case" of the new viewpoint, "categorified" (in the same sense) a classical recursion by constructing an exact sequence involving a twisted principal subspace, yielding its graded dimension as a consequence. (Received August 19, 2013)

1093-17-351 **Sara Madariaga*** (madariaga@math.usask.ca). *Gröbner-Shirshov bases for the non-symmetric operads of dendriform algebras and quadri-algebras.*

We show how to construct quadratic Gröbner-Shirshov bases for the free dendriform algebra and quadrialgebra, which implies the koszulness of these structures. We use the theory of operads and their representation as tree monomials. (Received August 20, 2013)

1093-17-352 **Robert H McRae*** (rhmcrae@math.rutgers.edu), Robert McRae, Department of Mathematics, Rutgers University, Hill Center, Busch Campus, Piscataway, NJ 08854. *Vertex algebraic structure in integral forms of standard affine Lie algebra modules.*

Integral forms of the universal enveloping algebras of affine Lie algebras have been constructed by Garland and others, allowing the construction of integral forms in standard modules for affine Lie algebras. We show that these integral forms have the structure of vertex algebras over $\mathbb{Z}$, and we give generating sets for this vertex algebraic structure. (Received August 20, 2013)

18 ► Category theory; homological algebra

1093-18-78 **Jacob R West*** (west@math.ucr.edu), Department of Mathematics, University of California, Riverside, 900 University Ave., Riverside, CA 92521. *Auslander-Reiten theory in stable* $(\infty, 1)$*-categories.*

Auslander-Reiten theory was introduced by M. Auslander and I. Reiten in the early 1970's as a tool for understanding representations of Artin algebras (and in particular, finite dimensional algebras). Of central interest are the so-called Auslander-Reiten sequences, which are (roughly speaking) minimal non-split short exact sequences. In this talk, we introduce an analogue of Auslander-Reiten theory in stable $(\infty, 1)$-categories. (Received July 31, 2013)

1093-18-117 **Brian Paljug*** (brian.paljug@temple.edu). *The action of derived automorphisms on infinity-morphisms, and an application to GRT-equivariance of Tamarkin's construction.*

Given two homotopy algebras and an infinity-morphism between them, it is natural to ask that, if we can modify the two homotopy algebras in some structured way, can we modify the infinity-morphism in some similar way, so as to preserve the new structures? In this talk we describe a situation in which the answer is yes, and indicate how it is possible. We will also give an application of these results, to show that Tamarkin's construction of formality morphisms is equivariant with respect to the action of the Grothendieck-Teichmuller group. (Received August 06, 2013)

1093-18-125 **Tom Lada*** (lada@math.ncsu.edu), Mathematics Department, Box 8205, North Carolina State University, Raleigh, NC 27695, and **Melissa Tolley**. *Derivations of Homotopy Algebras.*

We recall the definition of strong homotopy derivations of A_∞ algebras and introduce the corresponding definition for L_∞ algebras. We define the concept of strong homotopy inner derivations for both types of algebras and present explicit examples of them. (Received August 08, 2013)

1093-18-150 **Van C. Nguyen*** (vcnguyen@math.tamu.edu), Department of Mathematics, Mailstop 3368, Texas A&M University, College Station, TX 77843-3368. *Finite generation behaves differently in negative cohomology.*

While the usual cohomology rings of some finite dimensional Hopf algebras are known to be finitely generated, the same may not be true when we extend them to negative cohomology. In particular, we investigate this property for a finite dimensional symmetric Hopf algebra A over a field k. It turns out that if a module in a connected component of the stable Auslander-Reiten quiver associated to A has finitely generated Tate cohomology, then so does every module in that component. We apply some of these finite generation results on Tate cohomology to a non-trivial example. (Received August 10, 2013)

1093-18-232 **Owen Gwilliam***, 970 Evans Hall #3840, Department of Mathematics, UC Berkeley, Berkeley, CA 94720. *Determinant functors and factorization algebras.*

The Batalin-Vilkovisky formalism provides a homological approach to the quantization of field theories. The essential idea, however, is algebraic in nature, as we will explain, and it naturally provides a determinant-type functor. Motivated by this observation, we will construct, for any elliptic complex, a factorization algebra whose global sections on a closed manifold recovers the determinant line of the cohomology of elliptic complex. If

time remains, we will discuss how this relates to QFT constructions of the A-hat and Witten genus. (Received August 15, 2013)

19 ► K-theory

1093-19-52 **Clark Barwick*** (clarkbar@math.mit.edu), Department of Mathematics, 2-263, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02143. *The algebraic K-theory of higher categories.* Preliminary report.

The algebraic K-theory of the sphere spectrum $\mathbf{S}$ is a mysterious object that at once carries information about delicate questions of number theory and incredible information about high-dimensional manifolds. We discuss a program developed by Waldhausen and refined by Hopkins and Rognes to compute $K(\mathbf{S})$ using the chromatic tower. We extend these ideas to present a program to prove the Ausoni–Rognes Chromatic Red Shift Conjecture. (Received July 18, 2013)

20 ► Group theory and generalizations

1093-20-47 **Sang-hyun Kim** and **Thomas Koberda***, PO Box 208283, New Haven, CT 06520-8283. *Masur-Minsky style curve complex machinery for right-angled Artin groups.*

I will explain joint work with Sang-hyun Kim, in which we develop curve complex machinery for right-angled Artin groups. The central results are the acylindricity of the right-angled Artin group action on the analogue of the curve graph, and a bounded geodesic image theorem. From these results, we can deduce verbatim analogues of many theorems about mapping class groups in the context of right-angled Artin groups. (Received July 15, 2013)

1093-20-49 **Joseph Maher*** (joseph.maher@csi.cuny.edu), **Vaibhav Gadre** and **Giulio Tiozzo**. *Statistics for Teichmuller geodesics.*

We describe two ways of picking a geodesic "at random" in a space, one coming from the standard Lebesgue measure on the visual sphere, and the other coming from random walks. The spaces we're interested in are hyperbolic space and Teichmuller space, together with some discrete group action on the space. We investigate the growth rate of word length as you move along the geodesic, and we show these growth rates are different depending on how you choose the geodesic. (Received July 15, 2013)

1093-20-69 **Ted Chinburg*** (ted@math.upenn.edu) and **Matthew Stover** (mstover@temple.edu). *Non-commutative algebra and arithmetic groups.* Preliminary report.

This talk will be about using the arithmetic of divison algebras and Lefschetz theorems for surfaces to show that large arithmetic groups can sometimes be generated by small subgroups. The new result in the talk cuts down to 2 the number of Fuchsian curves needed to produce a divisor whose fundamental group has image of finite index in the arithmetic group in question. (Received July 28, 2013)

1093-20-109 **Jason Behrstock*** (jason.behrstock@lehman.cuny.edu) and **Cornelia Drutu**. *Polynomial divergence and thick groups.*

In a metric space the divergence of a pair of rays is a way to measure how quickly they separate from each other. Understanding what divergence rates are possible in the presence of non-positive curvature was raised as a question by Gromov and then refined by Gersten. We will describe a construction we gave, with Cornelia Drutu, of groups with several interesting properties, some of which shed light on the above question. (Received August 06, 2013)

1093-20-161 **Richard Peabody Kent*** (rkent@math.wisc.edu). *Congruence subgroup problems.*

It is a theorem of Bass, Lazard, and Serre, and, independently, Mennicke, that the special linear group $\mathrm{SL}(n,\mathbb{Z})$ enjoys the congruence subgroup property when n is at least 3. This property is most quickly described by saying that the profinite completion of the special linear group injects into the special linear group of the profinite completion of $\mathbb{Z}$. There is a natural analog of this property for mapping class groups of surfaces. Namely, one may ask if the profinite completion of the mapping class group embeds in the outer automorphism group of the profinite completion of the surface group. I'll discuss what's known about this problem, including a reduction to a question about centralizers. (Received August 12, 2013)

1093-20-254 **David Hill***, 1173 Raintree Dr, Charlottesville, VA 22901, and **Weqiang Wang**. *Categorification of Kac-Moody Superalgebras.*

We give a Khovanov-Lauda-Rouquier-type categorification of quantum Kac-Moody superalgebras with non-isotropic odd roots based on quiver Hecke superalgebras introduced by Kang-Kashiwara-Tsuchioka.

As a consequence, we obtain a canonically defined, bar invariant basis for the quantum group consisting of isomorphism classes of projective indecomposable modules. (Received August 17, 2013)

1093-20-282 **Hyungryul Baik*** (hb278@cornell.edu), 105 Malott Hall, Department of Mathematics, Cornell University, Ithaca, NY 14853. *Fuchsian Groups, Circularly Ordered Groups, and Dense Invariant Laminations on the Circle.*

We propose a program to study groups acting faithfully on S^1 in terms of number of pairwise transverse dense invariant laminations. The main motivation is Thurston's universal circle theory for tautly foliated 3-manifolds. We will characterize Fuchsian groups in this scheme. More precisely, we prove a group acting on S^1 is conjugate to a Fuchsian group if and only if it admits three very-full laminations with a variation of the transversality condition. (Received August 19, 2013)

1093-20-308 **Tim Susse*** (tsusse@gc.cuny.edu), Department of Mathematics, The Graudate Center, CUNY, 365 Fifth Ave., New York, NY 10016. *Stable Commutator Length and Knot Complements.*

Given a group G and an element g of it commutator subgroup the stable commutator length of g is the growth rate of the smallest number of commutators whose product is g^n. This quantity is closely related to the topology of surfaces with boundary in a topological space with fundamental group G.

When K is a torus knot and $G = \pi_1(S^3 \setminus K)$ (or, more generally, an amalgamated free product of two free abelian groups), I will describe a way to parameterize the surfaces with specified boundary as a finite-sided polyhedron. Consequently, stable commutator length is rational and computable in these groups, giving a topological solution to a conjecture of Calegari in this special case. (Received August 19, 2013)

1093-20-374 **Kasra Rafi*** (rafi@math.toronto.edu). *Thoughts about mapping class group and $Out(F_n)$.* Preliminary report.

We discuss analogies between the mapping class group and $\mathrm{Out}(F_n)$ and how some results in mapping class group translate to the $\mathrm{Out}(F_n)$ setting. (Received August 20, 2013)

22 ► Topological groups, Lie groups

1093-22-224 **Robert W Donley*** (rdonley@citytech.cuny.edu), Department of Mathematics, NYC College of Technology (CUNY), 300 Jay Street, New York City, NY 11201. *Schur Orthogonality Relations Revisited.* Preliminary report.

Schur orthogonality relations play a fundamental role in representation theory, in particular when studying square-integrable functions on a group with invariant measure. The traditional proof requires averaging on the group, but one may recast the result using tensor products and intertwining operators. We survey examples and applications where square-integrability does not apply. (Received August 15, 2013)

1093-22-280 **Lisa Carbone*** (carbonel@math.rutgers.edu), Department of Mathematics, Hill Center-Busch Campus, 110 Frelinghuysen Rd, Piscataway, NJ 08854. *Simply laced Lie algebras and Kac–Moody algebras with built–in structure constants.* Preliminary report.

Let $\mathfrak{g}$ be a Kac–Moody algebra. We define a Chevalley basis for $\mathfrak{g}$ so that the structure constants with respect to this basis are integers. When $\mathfrak{g}$ is simply laced, we prove the existence of a Chevalley basis that gives an easy formula for computing the structure constants for real root vectors whose sum is real. For symmetrizable and simply laced Kac–Moody algebras, this gives a complete description of the structure constants for their corresponding Kac–Moody Chevalley groups. This also gives an improvement of known 'fast methods' for determining structure constants of finite dimensional simply laced Lie algebras and their Chevalley groups. (Received August 18, 2013)

1093-22-286 **Mary Clair C Thompson*** (thompsmc@lafayette.edu), 202 Pardee Hall, Lafayette College, Easton, PA 18042, and **Tin-Yau Tam**. *Asymptotic Results in Noncompact Semisimple Lie Groups.*

Many well-known matrix results involve the convergence of specially constructed matrix sequences. For example, the QR algorithm and Rutishauser's LR algorithm are known to produce sequences that converge to a matrix with certain desirable properties.

This behavior is actually not special to matrix groups; we will discuss the extension of the Aluthge sequence and Rutishauser's LR algorithm to noncompact semisimple Lie groups, as well as conditions on the convergence of these sequences. (Received August 19, 2013)

1093-22-360 **Roger Howe**, Department of Mathematics, Yale University, 10 Hillhouse Ave, New Haven, CT 06520, and **Victor Protsak***, Department of Mathematics, SUNY Oswego, Oswego, NY 13126. *On branching and tensor product decomposition for G_2.*

Let G be a complex simple algebraic group of type G_2. We investigate branching from $Spin_7$ to G and the tensor product decomposition of finite-dimensional simple G-modules. The answers are formulated in terms of the lattice volumes of rational convex polytopes. (Received August 20, 2013)

28 ► Measure and integration

1093-28-62 **Ekaterina S Nathanson*** (ekaterina-nathanson@uiowa.edu) and **Palle E Jorgensen** (palle-jorgensen@uiowa.edu). *Definition of the Feynman path integral as a functional using the Henstock integration technique.* Preliminary report.

One of the key elements of the Feynman's formulation of non-relativistic quantum mechanics is a so-called Feynman path integral. It plays an important role in the theory but appears not as a well-defined object, but rather as a postulate based on intuition coming from physics. This is why it has been drawing attention of many mathematicians since the first publication of Feynman's work in 1948. The papers of Gelfand, Cameron, and Nelson are among the first attempts to supply Feynman's theory with mathematical rigor. They were followed by many others, but unfortunately not satisfactory. In the presentation I will introduce a new approach to define the Feynman's path integral. It is based on the theory developed by P. Muldowney. Muldowney uses the Henstock integration technique and nonabsolute integrability of Fresnel integral to obtain a representation of the Feynman's path integral as a functional. We will show how the new approach fixes the main problems in earlier attempts and what role the nonabsolute integrability of Fresnel integrals plays in establishing mathematical rigor supporting Feynman's intuitive derivations. (Received July 25, 2013)

30 ► Functions of a complex variable

1093-30-378 **Jeffrey F. Brock*** (jeff_brock@brown.edu). *Asymptotics of Weil-Petersson geodesics.* Preliminary report.

We give an overview of the important role of geometric group theory and coarse hyperbolicity in controlling the asymptotic geometry of Weil-Petersson geodesics in Teichmüller space. Such control, while persisting in low complexity, begins to unravel in the setting of the surfaces with complexity equal to that of the seven-holed sphere. In this talk I will elucidate the role of complexity, and describe particular features of geodesics that are suggestive of new approaches in the higher complexity setting. This talk will describe joint work with Howard Masur and Yair Minsky. (Received August 20, 2013)

31 ► Potential theory

1093-31-220 **Igor Cialenco*** (igor@math.iit.edu), Dep. of Applied Math, 10 West 32nd Str, Bld E1, Room 208, Chicago, IL 60616, and **Tomasz R. Bielecki**, **Samuel Drapeau** and **Martin Karliczek**. *Dynamic Assessment Indices.*

Measuring the performance and risk of a given cash flow is one of the fundamental question in finance, being crucially important for all market participants. For a given portfolio, trading strategy, company value, or any other random cash flow, as time passes and new information arrives, it is important to know "how acceptable" is the relevant future cash flow. Traditionally the industry benchmarks of measuring performance and risk are Sharpe Ratio, and Value at Risk, respectively. Dynamic Assessment Indices (DAI) are measures of performance

more general that both risk measures and performance measure. DAI is a function that takes as an input a process (a cash flow) and gives as an output another process (the performance or acceptability of that cash flow), which is quasiconcave, monotone and local (properties understood in the sense of L^0-module theory.) We will present the robust representation theorem of DAI. Next, we will show how the general theory is applied to stochastic processes, with special emphasis on dynamic consistency property. Also, we will show how such measures can be used for finding arbitrage free bid and ask prices of derivative securities in models of discrete time markets with transaction costs. (Received August 14, 2013)

32 ► Several complex variables and analytic spaces

1093-32-4 **Xiaojun Huang*** (huangx@math.rutgers.edu), Department of Mathematics, New Brunswick, NJ 08903. *Equivalence problems in several complex variables.*

A basic problem in Several Complex Variables, motivated from the classification of domains in a complex manifold, is to understand when two real submanifolds in a complex Euclidean space are holomorphically equivalent. There has been much work done along these lines (by Poincare, Cartan, Chern-Moser, etc.) when the manifolds have a certain uniform first order complex structure, called the CR structure. In the 60's, Bishop first considered various analytic and geometric properties for real submanifolds (called Bishop submanifolds now) with non-degenerate CR singularities. Bishop submanifolds, with a special type of CR singularities called elliptic CR singularities, have attracted a lot of special attention in the past 30 years due to their connection with many other problems and fields such as Complex Plateau Problems, Symplectic Geometry, and Classcial Dynamics. In the 80's, Moser-Webster solved the equivalence problem for Bishop surfaces with non-vanishing elliptic CR singularities. In 2009, in a joint work with W. Yin, we settled the equivalence problem for Bishop surfaces with vanishing elliptic CR singularities. In this talk, we will survey studies along these lines, as well as more recent development. (Received April 26, 2013)

1093-32-19 **Son Duong** (snduong@math.uci.edu), Department of Math., University of California, Irvine, CA 92697-3875, **Song-Ying Li*** (sli@math.uci.edu), Department of Mathematics, University of California, Irvine, CA 92697-3875, and **Xiaodong Wang** (xwang@math.msu.edu), Department of Math, Michigan State University, East Lancing, MI. *The sharp estimate on the first positive eigenvalue of Kohn-Laplacian.*

This is a joint work with Son Duong and Xiaodong Wang. We proved the Obta type theorem on a strictly pseudoconvex pseudo-hermitian CR manifolds for Kohn Laplacian. (Received June 03, 2013)

1093-32-46 **Sui-Chung Ng*** (scng@temple.edu), Rm 638 Wachman Hall, 1805 N. Broad. St., Philadelphia, PA 19122. *Holomorphic double fibration and flag domains on Grassmannians.*

The study of proper holomorphic mappings is a classical subject in Several Complex Variables. We will look at how holomorphic double fibration comes into play in this subject for flag domains on Grassmannians. In particular, we will see how the proper maps among generalized balls and those among Type-I bounded symmetric domains are related. (Received July 15, 2013)

1093-32-53 **John Erik Fornæss*** (fornaess@umich.edu), Trondheim, Norway. *Complex Dynamics with focus on the real part.* Preliminary report.

I will talk about joint work with Han Peters. We investigate complex dynamics of polynomials in one variable by focusing on the real parts of orbits. (Received July 20, 2013)

1093-32-57 **Emil J. Straube*** (straube@math.tamu.edu) and **Yunus E. Zeytuncu** (zeytuncu@math.tamu.edu). *Sobolev estimates for the complex Green operator on CR submanifolds of hypersurface type.*

Let M be a pseudoconvex, oriented, bounded and closed CR submanifold of $\mathbb{C}^n$ of hypersurface type. Our main result says that when a certain 1–form on M is exact on the null space of the Levi form, then the complex Green operator on M satisfies Sobolev estimates. This happens in particular when M admits a set of plurisubharmonic defining functions or when M is strictly pseudoconvex except for the points on a simply connected complex submanifold. These results are known when M is the boundary of a pseudoconvex domain in $\mathbb{C}^n$. In the general case, results from CR geometry play an important role. (Received July 22, 2013)

1093-32-59 **Željko Čučković** and **Sönmez Şahutoğlu*** (sonmez.sahutoglu@utoledo.edu), University of Toledo, Department of Mathematics and Statistics, 2801 W. Bancroft St., Toledo, OH 43606. *On Axler-Zheng theorem in $\mathbb{C}^n$.*

We prove a version of Axler-Zheng's Theorem on smooth bounded pseudoconvex domains in $\mathbb{C}^n$ on which the $\overline{\partial}$-Neumann operator is compact. (Received July 23, 2013)

1093-32-175 **Loredana Lanzani***, Department of Mathematical Sciences, 1, University of Arkansas, Fayetteville, AR 72701, and **Elias M. Stein**. *The Cauchy-Leray integral for domains with minimal smoothness.*

I will present joint work with E. M. Stein concerning the regularity in L^p of the Cauchy-Leray singular integral operator associated to a strongly $\mathbb{C}$-linearly convex domain in the n-dimensional Euclidean complex space $\mathbb{C}^n$, under minimal assumptions on the domain's boundary regularity. The Cauchy–Leray integral is the unique and natural operator with holomorphic kernel that most closely resembles the classical Cauchy integral from one complex variable (which corresponds to the case $n = 1$). Our assumptions on the domain's regularity are the weakest currently known (in the case of a planar domain these are akin to Lipschitz boundary). (Received August 13, 2013)

1093-32-197 **Shiferaw Berhanu** (berhanu@temple.edu), Deparment of Mathematics, TempleUniversity, Philadephia, PA 19122, and **Ming Xiao*** (xmg512@gmail.com), 110 Frelinghuysen Road, Piscataway, NJ. *A smooth version of reflection principle for mappings between CR manifolds.*

We will explain a smooth version of classical Schwarz principle for CR mappings between an abstract CR manifold and a generic CR manifold embedded in euclidean space proved in a new paper by S.Berhanu and M.Xiao. As a consequence of their results, they settled a conjecture of X.Huang raised in 1994. (Received August 13, 2013)

1093-32-229 **Albert Boggess*** (boggess@asu.edu), **Roman Dwilewicz** and **Zbigniew Slodkowski**. *Hartog's Theorems on Unbounded Domains in C^n.* Preliminary report.

We consider the question of when CR functions on the boundary of an unbounded domain in C^n extend to holomorphic functions in the interior. An easy necessary condition is that the domain not contain any complex variety of codimension one that is given as the zero set of a holomorphic function which is smooth up to the boundary. This condition is also sufficient in domains which are Reinhardt and "tube-like" along a complex fiber. We also prove a CR extension result which generalizes Bochner's tube-theorem to so-called "wide tubes" that "flare-out" at infinity at a prescribed rate of growth. (Received August 15, 2013)

1093-32-256 **Muhammed Ali ALAN*** (malan@syr.edu), Mathematics Department, 215 Carnegie Building, Syracuse University, Syracuse, NY 13244-1150, and **Nihat Gogus**. *Hardy Spaces on Hyperconvex Domains.*

In this talk we will recall Poletsky and Stessin's construction of Hardy Spaces on hyperconvex domains. We will give two characterizations of these spaces in the complex plane. The first characterization is in terms of their boundary values as a weighted subclass of L^p class with respect to the arclength measure on the boundary. The second one is in terms of having a harmonic majorant with a certain growth condition. We will give few properties of these spaces, give one of the first nontrivial example, and talk about some open problems. (Received August 17, 2013)

1093-32-273 **Yifei Pan*** (pan@ipfw.edu), 2101 E. Coliseum Blvd., Fort Wayne, IN 46805-1499. *On unique continuation of Cauchy-Riemann operator with L^2 potentials.*

In this talk, we prove a unique continuation theorem on Cauchy-Riemann operator with L^2 potential. Specifically, if $u(z)$, defined near the origin in the complex plane to C^n, and vanishing to infinite order there, satisfies $\bar{\partial}u/u \in L^2$, then u is identically zero. This result is sharp due to a counterexample of Mandache and If L^2 is replaced by L^q where $q > 2$, the result is due to S. Ivashkovich and V. Shevchishin. (Received August 18, 2013)

1093-32-291 **Marco M Peloso*** (peloso@uark.edu), Department of Mathematical Sciences, University of Arkansas, Fayetteville, AR 72701. *Bergman kernel and projection for the unbounded worm domain.*

This work is in collaboration with S. Krantz and C. Stoppato.

We wish to study the Bergman kernel and projection on the unbounded worm

$$\mathcal{W}_\infty = \left\{(z_1, z_2) \in \mathbf{C} \times \mathbf{C}^* : \left|z_1 - e^{i \log |z_2|^2}\right| < 1\right\},$$

where $\mathbf{C}^* = \mathbf{C} \setminus \{0\}$.

We show that the Bergman space of $\mathcal{W}_\infty$ is not trivial. In this work we study its Bergman kernel K and projection $\mathcal{P}_\infty$. We prove that $(z,w) \mapsto K(z,\overline{w})$ extends holomorphically near each point of the boundary except for the diagonal of $\partial\mathcal{W}_\infty \times \partial\mathcal{W}_\infty$ and for the critical set $(\mathcal{A} \times \mathcal{W}_\infty) \cup (\mathcal{W}_\infty \times \mathcal{A})$. We then find an expansion for K near the critical set which allows us to prove the following:

(1) For all $s > 0$, the Bergman projection $\mathcal{P}_\infty$ does not map the Sobolev space $W^s(\mathcal{W}_\infty)$ into itself.

(2) For $p \neq 2$, $\mathcal{P}_\infty$ does not map $L^p(\mathcal{W}_\infty)$ into itself.

(Received August 19, 2013)

1093-32-298 **Phillip S Harrington*** (psharrin@uark.edu), SCEN 301, 1 University of Arkansas, Fayetteville, AR 72701, and **Andrew Raich**. *Closed Range for the Cauchy-Riemann Complex on Unbounded Domains.* Preliminary report.

The Cauchy-Riemann complex is known to have closed range in L^2 for all bounded pseudoconvex domains by the classic result of Hörmander from 1965. However, if we remove the assumption of boundedness, then there are some surprising counterexamples which are smooth and strictly pseudoconvex. We can salvage the situation if we work in weighted L^2 spaces with carefully chosen weights (see, for example, work of Gansberger and Haslinger in 2010, as well as a recent preprint of Gansberger). However, if we wish to prove closed range in Sobolev spaces, as required by many applications, then we must develop a theory for weighted Sobolev spaces on unbounded domains. Many of the standard results for such spaces make implicit use of the assumption that the boundary of the domain is compact, and the need for unbounded weights further complicates the proofs, so great care is needed in the case of unbounded domains. In this talk I will outline some of the challenges in this approach and the progress we have made in overcoming them. (Received August 19, 2013)

1093-32-315 **Jennifer Halfpap*** (halfpap@mso.umt.edu). *A New Proof of the Sharp Degree Estimate for Proper Monomial Maps from $\mathbb{B}_2$ to $\mathbb{B}_N$.* Preliminary report.

Let $r\colon \mathbb{B}_n \to \mathbb{B}_N$ be a proper rational map between balls in complex Euclidean spaces of different dimensions. It is well-known to CR geometers that the degree of such a map is not artibtrary; it depends on the relationship between the domain and target dimensions. In 2003, D'Angelo, Kos, and Riehl established the sharp degree bound for proper monomial maps from $\mathbb{B}_2$ to $\mathbb{B}_N$. We give a new proof of this result using ideas from commutative algebra. (Received August 19, 2013)

1093-32-323 **Yuan Yuan***, 101 Lafayette Rd, Syracuse, NY 13204. *Geometry of local holomorphic maps.*

Local holomorphic isometries were systematically studied in 50's by Calabi and recently number theorists applied the local holomorphic maps between bounded symmetric domains to attack the problem in number theory, which also motivates our study of such problems. I will describe the main theorems on the global extension and the rigidity for local holomorphic isometries between Hermitian symmetric spaces and explain the relation with CR geometry, minimal rational curves and etc. (Received August 19, 2013)

1093-32-332 **Michael D Bolt*** (mbolt@calvin.edu), 1740 Knollcrest Circle SE, Calvin College, Grand Rapids, MI 49546-4403. *Möbius invariant structures for hypersurfaces and curves.*

For the group of linear fractional transformations acting on complex Euclidean space, we identify invariant geometric and analytic structures associated with a real hypersurface. In the first part of this talk, we use these structures to identify constant curvature Levi nondegenerate hypersurfaces for dimension two. We also discuss the nature of their duals. In the second part, we summarize how restricting to dimension one and extending to a generalized variable has led to a successful program of research by undergraduates. (Received August 19, 2013)

1093-32-342 **Dusty E Grundmeier*** (grundmer@umich.edu), 530 Church St, Dept. of Mathematics, Ann Arbor, MI 48103, and **Jiri Lebl** and **Liz Vivas**. *Mappings of Infinite Hyperquadrics.* Preliminary report.

In this talk I will consider mappings of infinite hyperquadrics in ℓ^2. Forstneric proved that there are compact, strictly pseudoconvex, real-analytic hypersurfaces that cannot be embedded into any finite dimensional sphere. On the other hand, Lempert showed that there is always such a mapping to the sphere in the infinite dimensional Hilbert space ℓ^2. I will discuss rigidity properties in this setting. (Received August 20, 2013)

1093-32-353 **Siqi Fu*** (sfu@camden.rutgers.edu). *Spectral stability of the $\bar{\partial}$-Neumann Laplacian.* Preliminary report.

In this talk, we present several preliminary results on stability of the spectrum of the d-bar-Neumann Laplacian as the geometric structure of the underlying domain changes. (Received August 20, 2013)

1093-32-357 **Peter Ebenfelt*** (pebenfelt@ucsd.edu), Department of Mathematics, La Jolla, CA 92093. *Partial rigidity of degenerate CR embeddings into spheres.*

We consider degenerate CR maps f of a strictly pseudoconvex hypersurface $M \subset \mathbb{C}^{n+1}$ into a sphere S in a higher dimensional complex space. The degeneracy of the mapping f will be characterized in terms of the ranks of the CR second fundamental form and its covariant derivatives. In 2004, the speaker, together with Huang and Zaitsev, established a rigidity result for CR embeddings f into spheres in low codimensions. A key step in the proof of this result was to show that degenerate maps are necessarily contained in a complex plane section of the target sphere (partial rigidity). In the 2004 paper, it was shown that if the total rank d of the second fundamental form and all of its covariant derivatives is $< n$ (n is the CR dimension of M), then $f(M)$ is contained in a complex plane of dimension $n+d+1$. When the total rank d exceeds n, it is no longer true, in general, that $f(M)$ is contained in a complex plane of dimension $n+d+1$. In this talk, we shall show that when the ranks of the second fundamental form and its covariant derivatives exceed n, then partial rigidity may still persist, but there is a "defect" k that arises from the ranks exceeding n such that $f(M)$ is only contained in a complex plane of dimension $n+d+k+1$. (Received August 20, 2013)

1093-32-365 **Claudio Meneses-Torres*** (claudio@math.sunysb.edu), Mathematics Department, Stony Brook University, Stony Brook, NY 11794, and **Leon Takhtajan**. *WZNW action and Kähler potentials on the moduli space of parabolic bundles over $\mathbb{P}^1$ *preliminary report*.* Preliminary report.

The moduli problem of stable parabolic bundles over the Riemann sphere can be interpreted from a complex analytic perspective. This allows us to introduce canonical complex coordinates on the moduli space (analogous to the Bers' coordinates on Teichmüller spaces) and a suitable analog of uniformization. The identification of the tangent space at a point with a certain space of automorphic forms leads to the introduction of the parabolic Narasimhan-Atiyah-Bott metric on the Moduli space, which is analogous to the Weil-Petersson metric.

Secondly, for each stable parabolic bundle, a regularized WZNW action functional is defined on the space of singular Hermitian metrics with prescribed asymptotics at a finite set of points in the sphere. We prove that these functionals evaluated at their extrema give rise to a function on the moduli space that is a Kähler potential for the parabolic Narasimhan-Atiyah-Bott metric over the restriction to a certain analytic open subset. (Received August 20, 2013)

1093-32-368 **Michael J Tinker*** (mtinker@uark.edu), 915 N Lindell Ave, Apt #1, Fayetteville, AR 72701. *Heat kernel estimates for Schrödinger operators with reverse Hölder potentials.*

Given $\bar{D} = \bar{\partial} + \tau P_{\bar{z}}$ on $L^2(\mathbb{C})$, $\tau > 0$, and D its formal adjoint, the heat kernel associated to $\bar{D}D$ has been studied by Christ when ΔP is a doubling measure and later by Raich when P is a subharmonic, nonharmonic polynomial. Both were motivated by a connection to the three-dimensional CR manifold $M \subset \mathbb{C}^2$ defined by $\Im(w) = P(z)$; after M is identified with $\mathbb{C} \times \mathbb{R}$, $\bar{\partial}_b$ on M goes over to $\bar{D}$ under a Fourier transform in the real direction. We begin in this setting with $P(x, y) = P(x)$, where $P \in C^2(\mathbb{R})$ satisfies a reverse Hölder condition. Now a Fourier transform in the y-direction is also possible; we obtain upper bounds on the heat kernel associated to $\widehat{\bar{D}}\widehat{D}$ by improving known results for Schrödinger operators. (Received August 20, 2013)

34 ► Ordinary differential equations

1093-34-97 **Hui Wang*** (huiwang@math.rutgers.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854. *A semilinear singular Sturm-Liouville equation involving measure data.*

We consider a semilinear singular Sturm-Liouville equation involving measure data. More precisely, it is a second order ODE on the interval (-1,1) in the divergence form, with the leading coefficient taking zero value at the origin, with a power nonlinearity and with a bounded Radon measure as the right-hand side. We answer the questions of the existence, nonexistence, uniqueness, and non-uniqueness of the solution(s). We also classify the isolated singularity at 0. (Received August 03, 2013)

1093-34-321 **Yixin Guo*** (yixin@math.drexel.edu), 3141 Chestnut st, Department of Mathematics, Drexel University, Philadelphia, PA 19104, and **Dennis Yang** (gyang@math.drexel.edu), 3141 Chestnut st., Department of Mathematics, Drexel University, Philadelphia, PA 19104. *Standing patterns in a neural field model with non-saturating gains.*

We study a neural network in the form of integro-differential euqation with a nonsaturating gain. The network consistes of a single layer neurons synaptically coupled by lateral inhibition. Using a specific connectivity function, we project the infinite dimensional equation to a finite order system of ordinary diferential equations. By analyzing the invariant manifolds for the corresponding reversible, conservative ODE system, we establish the existence of the Smale horseshoe for an open set of parameters. Consequently, there are countably many symmetric and asymmetric multi-bump standing pulses as well as spatially chaotic stationary solutions. Furthermore, the robustness of the Smale horseshoe implies that all of these solutions persist for nonsaturating piecewise-linear gain functions with small gains and also for smooth gain functions that are "close" to the Heaviside or piecewise-linear case. (Received August 19, 2013)

35 ► *Partial differential equations*

1093-35-3 **Robert Strain*** (strain@math.upenn.edu), Department of Mathematics, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104. *On the Boltzmann equation without angular cut-off.*

In this lecture we will explain several recent results surrounding global stability problem for the Boltzmann equation 1872 with the physically important collision kernels derived by Maxwell 1867 for the full range of inverse power intermolecular potentials, $r^{-(p-1)}$ with $p > 2$ and more generally. This is a problem which had remained open for quite a long time.

Specifically, we now have global solutions that are perturbations of the Maxwellian equilibrium states, and which decay rapidly in time to equilibrium. This proof is facilitated by our new sharp geometric understanding of the diffusive nature of the non cut-off collision operator.

Furthemore, since the work of Ukai-Asano in 1982, it has been a longstanding open problem to determine the optimal large time decay rates for the soft potential Boltzmann equation in the whole space, with or without the angular cut-off assumption. We prove that our solutions converge to the global Maxwellian with the optimal large-time decay rates. We furthermore prove the optimal decay rates for the high k-th order derivatives.

This Erdos lecture will include a great deal of lot of historical background and anecdotes.

Much of this is joint work with P. Gressman, other results are joint with V. Sohinger. (Received August 20, 2013)

1093-35-23 **Agostino Capponi*** (agcappo@gmail.com) and **Christoph Frei** (cfrei@ualberta.ca). *Multitask Principal-Agent Problems with Accident Prevention.*

We introduce a new continuous-time multitask principal-agent model in which the agent allocates his resources on two tasks: effort and accident prevention. We provide an explicit characterization of the contract sensitivities, along with the hidden effort and prevention actions applied by the agent. Our model is rich enough to capture contractual environments where the principal can protect the firm against excessive accident losses, promote, replace, and fire the agent. We analyze how such decisions depend on the interplay between risk aversion, strength of task interaction, as well as opportunity costs of the agent. (Received June 09, 2013)

1093-35-34 **Paul M. N. Feehan*** (feehan@rci.rutgers.edu), Department of Mathematics, Rutgers, The State University of New Jersey, 110 Frelinghuysen Road, Piscataway, NJ 08854. *A classical Perron method for existence of smooth solutions to boundary value and obstacle problems for degenerate-elliptic operators via holomorphic maps.*

We prove existence and uniqueness of solutions to boundary value problems and obstacle problems for degenerate elliptic and parabolic, linear, second-order partial differential operators with partial Dirichlet boundary conditions using new a version of the Perron method. These existence and uniqueness results have applications to questions regarding the existence and uniqueness of solutions to European and American-style option pricing problems for an asset price process modeled by a degenerate diffusion (such as the Heston process). (Received June 28, 2013)

1093-35-42 **Mihaela Cristina Drignei*** (mdrignei@pitt.edu), Division of Physical and Comp. Sciences, University of Pittsburgh at Bradford, Bradford, PA 16701. *A numerical method for solving a Goursat-Cauchy boundary value problem.*

In this talk we discuss a method to construct numerically the solution-pair of a second order hyperbolic partial differential equation when two types of boundary conditions on a triangular domain are imposed. One set of boundary conditions refer to one set of the triangle's boundaries (we call them Goursat type), and the other set of boundary conditions both refer to the third boundary of the triangle (we call them Cauchy type). To solve numerically this boundary value problem we make a change of dependent variables and place a mesh on the triangular domain with lines that are the characteristic curves of the hyperbolic PDE. Then we shall integrate along the characteristic curves of the hyperbolic PDE in such a way that numerical values of the solution-pair will be produced at mesh nodes located on vertical lines. The calculations will proceed from the vertical boundary of the domain going backwards to the origin of the coordinate system, from one vertical line to another. The trapezoidal formula will be used for numerical integration. Numerical examples will be provided. (Received July 09, 2013)

1093-35-54 **Seung Hyun Kim*** (skim2014@csw.org), 45 Georgian Road, Weston, MA 02493. *An effective transform method for the computation of the free boundary in an one-phase Stefan problem.* Preliminary report.

In this paper, we present an effective computation method for the free boundary in an one-phase Stefan problem by changing the curvy domain to a rectangular domain. The numerical result obtained by our method with a quadratic equation for the free boundary is compared with the exact solution. With the same method, we suggest the solution for a nonlinear Stefan problem. (Received July 21, 2013)

1093-35-74 **Camelia A Pop*** (cpop@math.upenn.edu), Department of Mathematics, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104-6395, **Charles L Epstein** (cle@math.upenn.edu), Department of Mathematics, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104-6395, and **Arshak Petrosyan** (arshak@math.purdue.edu), Department of Mathematics, Purdue University, West Lafayett, IN 47907. *Regularity results for the factional Laplacian with drift.*

We study the elliptic obstacle problem defined by the fractional Laplacian with drift in the subcritical regime. With the aid of a new monotonicity formula, we establish the optimal regularity of solutions, and the Lipschitz regularity of the free boundary in neighborhoods of regular points. In the supercritical regime, the symbol associated to the operator defined by the fractional Laplacian with drift is no longer elliptic, because the drift is of higher order than the diffusion component. In this case, we establish the local regularity in Sobolev spaces of solutions to the linear equation defined by the fractional Laplacian with drift. This is joint work with Charles Epstein and Arshak Petrosyan. (Received July 30, 2013)

1093-35-90 **Arash Fahim*** (fahim@math.fsu.edu), 1017 Academic Way, Room 208, Tallahassee, FL 32306. *Monte Carlo Schemes for nonlinear PDE's.*

Monte Carlo methods provide faster evaluation of financial derivatives in higher dimensions comparing to other methods, e.g. finite element. Moreover, they are both available in Markovian and non-Markovian models. In some Markovian models, the PDE for the price of the derivative is nonlinear and the classical Feynman-Kac formula does not work. We review some of the Monte Carlo schemes for semi-linear (mildly nonlinear) PDEs, and present the methodology for fully nonlinear PDEs. Then, we briefly sketch the convergence techniques for a general Monte Carlo scheme and present the components of error analysis. Finally, we conclude the talk with some numerical examples. (Received August 02, 2013)

1093-35-98 **Luca Capogna*** (lcapogna@wpi.edu), Department of Mathematical Sciences, Stratton Hall,Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609. *Regularity and structure of sub-Riemannian isometries.*

In a recent joint paper with Enrico LeDonne (University of Jyvaskyla, Finland) we study the regularity and the structure of the group of isometries (i.e. distance preserving homeomorphisms) between two sub-Riemannian manifolds.

Our main results are the following: (1) Every isometry is smooth in the region where the sub-Riemannian structure is equiregular; (2) The group of isometries of a equiregular sub-Riemannian manifold is a finite dimensional Lie group. We also give sufficient conditions for sub-Riemannan isometries to be Riemannian isometries for some Riemannian extension of the sub-Riemannian metric.

Our work extends to the sub-Riemannian context a famous theorem of Myers-Steenrod (1939). Our proof is based on an argument inspired to the harmonic coordinates approach to the Riemannian problem due to

M. Taylor (2006) and is reminiscent of the morphism property for quasiconformal mappings. The proof uses ideas and techniques from analysis in metric spaces, geometric function theory, differential geometry and PDE. (Received August 04, 2013)

1093-35-99 **Anna L Mazzucato*** (alm24@psu.edu) and **Victor Nistor**. *Green-function methods for pricing of options.*

We discuss a recently developed method to derive approximate pricing kernels for options in closed form. This method relies on dilations, Taylor expansions, and time-ordered series. It leads to explicit formulas for pricing European options in one space dimension. In higher dimensions, it reduces the problem to numerical integration. (Received August 04, 2013)

1093-35-108 **Ivan Blank**, Department of Mathematics, Kansas State University, Manhattan, KS 66506, and **Zheng Hao*** (haozheng@math.ksu.edu), Department of Mathematics, Kansas State University, Manhattan, KS 66506. *The Obstacle Problem for Elliptic Operators in Divergence Form.*

Recently, Blank and Teka developed some of the theory for elliptic operators in nondivergence form with coefficients in VMO. We describe how we have shown similar results for the divergence form version of the obstacle problem with coefficients in VMO, including existence, uniqueness, nondegeneracy, optimal regularity, and measure stability. In fact, we now even have a stronger version of Caffarelli's regularity theory than Blank and Teka proved, as we can show that the free boundary is a Reifenberg Vanishing set near regular points. This talk is based on joint work with Blank. (Received August 06, 2013)

1093-35-121 **David M. Ambrose*** (ambrose@math.drexel.edu), Department of Mathematics, Drexel University, Philadelphia, PA 19104, and **Shari Moskow**, Department of Mathematics, Drexel University. *Scattering of electromagnetic waves by thin, high-contrast dielectrics.*

We study the scattered electric field from a thin, high-contrast dielectric volume. The space occupied by the scatterer is the Cartesian product of a bounded, two-dimensional region with a finite interval; that is, the scatterer is cylindrical, and of finite volume. The electric field is a solution of the time-harmonic Maxwell equations. We will discuss three theorems. In the first theorem, we establish an integral representation for the electric field which accounts for the jumps in the index of refraction which occur at the object boundary. This integral representation includes a surface integral over the boundary of the object. In our second theorem, we find an explicit formula for the limit as the thickness of the scatterer vanishes for the operator associated to this surface integral. In our third theorem, we demonstrate that under some uniform regularity assumptions, the normal trace of the electric field on the object boundary goes to zero as the thickness of the object goes to zero simultaneously as the contrast goes to infinity. (Received August 07, 2013)

1093-35-142 **Fathi M Allan*** (f.allan@uaeu.ac.ae), Department of Mathematical Sciences, United Arab Emirates University, Al AIn, United Arab Emirates. *Heat transfer characteristics of nano fluid flow over a stationary flat plate under wall suction/blowing.*

The flow properties and heat transfer characteristics of water base-copper nano-fluid flow over a stationary at plate under wall suction/blowing is considered. A similarity transformation is employed to transform the Naveir-Stokes equations and the energy equations into a set of nonlinear ordinary differential equations. A detailed study of the effects of the two parameters, nanoparticle volume fraction and wall suction, on the different physical properties of the flow is carried out.

The variation of the velocity profile, the temperature profile, the hydraulic and thermal boundary layer thickness, the local skin friction coefficient and the local Nusselt number with the change of the nanoparticle volume fraction and wall suction is presented. The numerical results thus obtained show that the hydraulic boundary layer thickness decreases linearly as the wall suction factor increases. While it decreases nonlinearly as the nanoparticle volume fraction increases. It also indicates that the thermal boundary layer thickness is inversely proportional to the wall suction factor; meanwhile, it is directly proportional to the nanoparticle volume fraction. (Received August 09, 2013)

1093-35-149 **Wolfgang Reichel*** (wolfgang.reichel@kit.edu), Institute for Analysis, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany. *Characterization of balls by Coulomb/Newton-potentials and related stability questions.*

Consider the Newtonian potential of a body in $\mathbb{R}^3$. A result of L.E. Fraenkel says that if the body has constant density and if the potential of the body is constant on its boundary then necessarily the body is a ball. Similar

characterizations hold not only for the three-dimensional Newtonian potential but quite generally for Riesz-potentials of convex bounded domains in $\mathbb{R}^n$ and also for Coulomb potential concentrated on the boundary of a sufficiently regular n-dimensional body.

We also consider the stability of Fraenkel's result with respect to perturbations of the density. If the density is close to constant and if the potential is constant on the boundary of the body then we deduce that the body is almost a ball. In fact the proximity of the body to a ball can be quantified. (Received August 10, 2013)

1093-35-153 **Maya Chhetri*** (maya@uncg.edu), Department of Mathematics and Statistics, UNC Greensboro, Greensboro, NC 27410, and **Petr Girg**. *Existence of positive solutions for a class of superlinear semipositone systems.*

We consider an elliptic system of the form

$$\begin{aligned} -\Delta u &= \lambda\, f(x,v) \quad \text{in} \quad \Omega, \\ -\Delta v &= \lambda\, g(x,u) \quad \text{in} \quad \Omega, \\ u &= 0 = v \quad \text{on} \quad \partial\Omega\,, \end{aligned}$$

where $\lambda > 0$ is a parameter and Ω is a bounded domain in R^N with $C^{2,\alpha}$ boundary $\partial\Omega$. Here the nonlinearities $f, g : \Omega \times [0,\infty) \to R$ are Carathéodory functions that are superlinear at infinity and satisfy $f(x,0) < 0$ and $g(x,0) < 0$ almost everywhere in Ω. We prove that the system has a positive strong solution for λ small by using degree theory combined with re-scaling argument and a uniform L^∞ apriori bound of positive strong solutions to some Lane-Emden type of systems. (Received August 11, 2013)

1093-35-159 **Giovanni Cupini*** (giovanni.cupini@unibo.it), Dipartimento di Matematica, Università di Bologna, Piazza di Porta San Donato 5, 40126 Bologna, Italy. *L^p estimates for degenerate Ornstein-Uhlenbeck operators.*

In two joint papers with Bramanti, Lanconelli and Priola, global L^p estimates, $p > 1$, for hypoelliptic degenerate Ornstein-Uhlenbeck operators are proved, in absence of an underlying structure of homogeneous group. These estimates are the by-product of L^p estimates for the corresponding evolution operator. In our talk we will describe how abstract recent results for singular integrals in nonhomogeneous spaces enabled us to get the results. (Received August 12, 2013)

1093-35-167 **Nguyen T Nguyen*** (nnguyen@math.uchicago.edu). *The Dirichlet and regularity problems for second order elliptic operators with bounded, real, but not necessarily symmetric, coefficients.* Preliminary report.

In this paper, we consider the L^2 boundary value problems for the divergence form second order elliptic equation $\mathcal{L}u = -\mathrm{div}(A\nabla u) = 0$ in $\Omega \subset \mathbb{R}^d_+$, a bounded Lipschits domain, where the matrix A is assumed to be real but not necessarily symmetric. Assume that A is closed, in a Carleson measure sense, to an elliptic matrix that is continuous on the boundary $\partial\Omega$. In this setting, we show that the Dirichlet and regularity problems are solvable. We also provide similar positive answer in the system setting provided that the coefficients $A = (a^{rs}_{ij})$ satisfies the extra "symmetry" condition: $a^{rs}_{ij} + a^{rs}_{ji} = a^{sr}_{ij} + a^{sr}_{ji}$ and the Dirichlet problem is defined to include the square function estimate. (Received August 12, 2013)

1093-35-179 **Fabrice Baudoin***, 150 N. University Street, West Lafayette, IN 47906. *Bakry meets Villani.*

We study gradient bounds for solutions of degenerate Fokker-Planck equations, including as a special case, the celebrated kinetic Fokker-Planck equation. Our method generalizes to hypoelliptic operators the Bakry's approach and allows to recover and strengthen hypocoercive estimates obtained by Villani. (Received August 13, 2013)

1093-35-182 **Dean Baskin**, Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208-2730, **Andras Vasy***, Department of Mathematics, Stanford University, Building 380, 450 Serra Mall, Stanford, CA 94305-2125, and **Jared Wunsch**, Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208-2730. *Asymptotic behavior of waves on asymptotically Minkowski spaces.*

In this talk we consider a non-trapping n-dimensional Lorentzian manifold endowed with an end structure modeled on the radial compactification of Minkowski space. We find a full asymptotic expansion for tempered forward solutions of the wave equation in all asymptotic regimes. The rates of decay seen in the asymptotic expansion are related to the resonances of a natural asymptotically hyperbolic problem on the "northern cap" of the compactification. For small perturbations of Minkowski space this corresponds to resonances of small perturbations of actual hyperbolic space. The methods of this work are closely related to those employed by Hintz and Vasy in an analysis of semilinear wave equations on such spaces. (Received August 13, 2013)

1093-35-183 **Peter Hintz***, Department of Mathematics, Stanford University, Building 380, 450 Serra Mall, Stanford, CA 94305-2125, and **Andras Vasy**, Department of Mathematics, Stanford University, Building 380, 450 Serra Mall, Stanford, CA 94305-2125. *Semilinear wave equations on asymptotically de Sitter, Kerr-de Sitter and Minkowski spacetimes.*

In this talk I will discuss the small data solvability of suitable semilinear wave and Klein-Gordon equations on geometric classes of spaces, which include so-called asymptotically de Sitter and Kerr-de Sitter spaces, as well as asymptotically Minkowski spaces. These spaces allow general infinities, called conformal infinity in the asymptotically de Sitter setting; the Minkowski type setting is that of non-trapping Lorentzian scattering metrics introduced by Baskin, Vasy and Wunsch. Our results are obtained by showing the *global* Fredholm property, and indeed invertibility, of the underlying linear operator on suitable L^2-based function spaces, which also possess appropriate algebra or more complicated multiplicative properties. The linear framework is based on the b-analysis, in the sense of Melrose, introduced in this context by Vasy to describe the asymptotic behavior of solutions of linear equations. An interesting feature of the analysis is that *resonances*, namely poles of the inverse of the Mellin transformed b-normal operator, which are 'quantum' (not purely symbolic) objects, play an important role. (Received August 13, 2013)

1093-35-184 **Dean R. Baskin*** (dbaskin@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208. *Wave decay on conic manifolds.*

We consider manifolds with conic singularities that are isometric to $\mathbb{R}^n$ outside a compact set. Under natural geometric assumptions on the cone points, we prove the existence of a logarithmic resonance-free region for the cut-off resolvent. The estimate also applies to the exterior domains of non-trapping polygons via a doubling process.

The proof of the resolvent estimate relies on the propagation of singularities theorems of Melrose and Wunsch to establish a "very weak" Huygens' principle.

As applications of the estimate, we obtain an exponential local energy decay and a resonance wave expansion in odd dimensions, as well as a lossless local smoothing estimate for the Schroedinger equation.

This is joint work with Jared Wunsch. (Received August 13, 2013)

1093-35-190 **Xiaolong Han** (xiaolong.han@anu.edu.au), Mathematical Science Institute, The Australian National University, John Dedman Building 27, Union Lane, Canberra, ACT 0200, Australia, and **Melissa Tacy*** (mtacy@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208-2730. *High frequency single layer potential operators.*

The theory surrounding the classical single layer potential operator defined by its kernel

$$\Delta K_0 = \delta$$

is well understood. However the related high frequency single layer potential operator defined by

$$(\Delta + \lambda^2)K_\lambda = \delta$$

has been less thoroughly studied. This operator appears when reconstructing eigenfunctions from boundary data and therefore has applications to the numerical production of eigenfunctions. In this talk I will discuss L^2 estimates on this single layer potential operator seen as an operator from the boundary to the interior of a domain. This is joint work with Xiaolong Han. (Received August 13, 2013)

1093-35-195 **Marius Mitrea***, University of Missouri, Department of Mathematics, Columbia, MO 65211. *The oblique derivative problem without transversality.* Preliminary report.

The origin of the oblique derivative problem goes back to the work of H. Poincare on the theory of tides. Ever since this groundbreaking work, it has been of interest to consider this problem in an as general geometric measure theoretic setting as possible. In my talk, I will discuss the version of this problem without the familiar transversality condition typically imposed on the direction vector field used to formulate the boundary condition. (Received August 13, 2013)

1093-35-199 **Ling Xiao*** (lxiao8@jhu.edu). *Gradient Estimates and Lower Bound for The Blow-up Time of Star-shaped Mean Curvature Flow.*

In this talk, I will begin with some known results for mean curvature flow. Then, I will prove a gradient estimate for star-shaped mean curvature flow. As an application, I will give an estimate on the lower bound of the blow-up time. (Received August 13, 2013)

1093-35-211 **Shari Moskow*** (moskow@math.drexel.edu), 3141 Chestnut St, Philadelphia, PA 19104, and **Fioralba Cakoni**. *Asymptotic Expansions for Transmission Eigenvalues for Media with Small Inhomogeneities.*

We consider the transmission eigenvalue problem for an inhomogeneous medium containing a finite number of diametrically small inhomogeneities of different refractive index. We prove a convergence result for the transmission eigenvalues and eigenvectors corresponding to media with small homogeneities as the diameter of small inhomogeneities goes to zero. In addition we derive rigorously a formula for the perturbations in the real transmission eigenvalues caused by the presence of these small inhomogeneities. (Received August 14, 2013)

1093-35-236 **Tadele Mengesha*** (mengesha@math.psu.edu) and **Nguyen C Phuc** (pcnguyen@math.lsu.edu). *Quasilinear equations with general structure and divergence data over nonsmooth domains.*

A global estimate in the weighted Lorentz space is obtained for the gradient of solutions to quasilinear Dirichlet boundary value problems over a bounded nonsmooth domain. As a consequence of this, regularity estimates in Morrey, Lorentz-Morrey and Hölder spaces are also established. These results generalize various existing estimates for nonlinear equations. The nonlinearities have a general structure, are assumed to be elliptic and satisfy a uniform small mean oscillation. The boundary of the domain, on the other hand, may exhibit roughness but assumed to be sufficiently flat in the sense of Reifenberg. Our approach uses maximal function estimates and Vitali covering lemma, and also known regularity results of solutions to nonlinear homogeneous equations. As an application of the estimates an existence result for a quasilinear Riccati-type equations is established. This is a joint work with Nguyen C Phuc. (Received August 16, 2013)

1093-35-237 **Ermanno Lanconelli***, Dipartimento di Matematica, Piazza di Porta S. Donato, 5, Bologna, 40126. *On a Class of Fully Nonlinear PDEs from Complex Geometry.*

We present the state of the art, and some new regularity and symmetry results, for a class of fully non-linear PDEs stemming from Complex Geometry. The involved equations are related to the Levi form and to the pseudoconvexity, the way the usual fully nonlinear Elliptic equations are related to the Hessian form and to the convexity. (Received August 16, 2013)

1093-35-240 **Henok Mawi*** (henok.mawi@howard.edu). *A Free Boundary Problem for a Higher Order Elliptic Operator.*

Let Ω be a domain in $\mathbb{R}^n$ with $0 \in \partial\Omega$. Suppose in B, the unit ball in $\mathbb{R}^n$, u and Ω solve the following equation in the sense of distributions:

$$Lu = \chi_\Omega \text{ in } B$$
$$D^\alpha u = 0 \text{ for } |\alpha| \leq 3 \text{ in } B \setminus \Omega.$$

Here L is a homogeneous fourth order elliptic operator, for instance, the Bi- Laplacian, and χ_Ω denotes the characteristic function.

We analyze the regularity properties of u. (Received August 16, 2013)

1093-35-251 **Cythia V Flores*** (cynthia@math.ucsb.edu), Department of Mathematics, South Hall Room 6607, University of California, Santa Barbara, CA 93106-308. *Decay properties of the IVP for the Benjamin-Ono equation.*

In this talk we investigate unique continuation properties of solutions to the initial value problem associated to the Benjamin-Ono equation given by

$$\begin{cases} \partial_t u + \mathcal{H}\partial_x^2 u + u\partial_x u = 0, \quad x, t \in \mathbb{R} \\ u(x,0) = u_0(x) \end{cases} \tag{1}$$

with $\mathcal{H}$ denoting the Hilbert transform

$$\mathcal{H}f(x) = \frac{1}{\pi}\,\text{p.v.}(\frac{1}{x} * f)(x) = \frac{1}{\pi}\lim_{\epsilon\downarrow 0}\int_{\epsilon<|y|<\frac{1}{\epsilon}} \frac{f(x-y)}{y}dy$$
$$= -i\,(\text{sgn}(\xi)\,\widehat{f}(\xi))\check{}(x).$$

in weighted Sobolev spaces $Z_{s,r} = H^s(\mathbb{R}) \cap L^2(|x|^{2r}dx)$ for $s \in \mathbb{R}$, and $s \geq 1$, $s \geq r$. More precisely, we prove that the uniqueness property based on a decay requirement at three times can not be lowered to two times even by imposing stronger decay on the initial data. (Received August 16, 2013)

1093-35-255 **Daniela De Silva*** (desilva@math.columbia.edu), 2990 Broadway, New York, NY 10027. *The thin one-phase free boundary problem.*

We describe the regularity theory for the free boundary occurring in the thin one-phase problem. The thin one-phase problem is closely related to the classical Bernoulli free boundary problem (or one-phase problem). In the "thin" setting the free boundary occurs on a $n-1$-dimensional subspace and it is expected to have $n-2$ Hausdorff dimension. (Received August 17, 2013)

1093-35-262 **Alexander L Shklyarevsky*** (shklyarevs@aol.com), 2-39 27th Street, Fair Lawn, NJ 07410. *Analytical Approaches to Solution of PDEs and PIDEs and their Application to Physics and Mathematical Finance.*

The purpose of this presentation is to highlight new methods, directions and recent research in analytical methods of solution for partial differential equations, partial integro-differential equations and their application to physics and mathematical finance. We will overview the entire analytical domain but will focus more on certain methodologies and approaches.

I am interested to be included in the AMS special session SS 14A. (Received August 18, 2013)

1093-35-265 **John C Schotland***, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109. *Topological reduction of the inverse Born series.*

I will discuss a fast direct method to solve the inverse scattering problem for diffuse waves. Applications to optical tomography will be described. (Received August 18, 2013)

1093-35-266 **Fioralba Cakoni*** (cakoni@math.udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Boundary Integral Formulation of the Transmission Eigenvalue Problem for Maxwell's Equations.* Preliminary report.

The interior transmission problem arises in inverse scattering theory for inhomogeneous media. It is a boundary value problem for a coupled set of equations defined on the support of the scattering object and appears in the analysis and solution methods for the inverse medium problem. Of particular interest is the eigenvalue problem associated with this boundary value problem, referred to as the transmission eigenvalue problem and, more specifically, the corresponding eigenvalues which are called transmission eigenvalues. The transmission eigenvalue problem is a nonlinear and non-selfadjoint eigenvalue problem that is not covered by the standard theory of eigenvalue problems for elliptic equations

In this talk we consider the transmission eigenvalue problem for Maxwell's equations and introduce an integral equation method to study the Fredholm property of this problem under weaker assumption on the contrast of the scattering media as previously used in the literature. The main difficulty of our approach is to establish the correct mapping properties of the involved boundary integral operators. This is a joint work with Houssem Haddar. (Received August 18, 2013)

1093-35-288 **Jerome Goddard II*** (jgoddard@aum.edu) and **R. Shivaji**. *Diffusive logistic equation with negative density dependent emigration on the boundary.*

The structure of positive steady state solutions of a diffusive logistic population model with negative density dependent emigration on the boundary is examined. In particular, a class of nonlinear boundary conditions that depends both on the population density and the diffusion coefficient is used to model the effects of negative density dependent emigration on the boundary. We focus on the effects of constant yield harvesting on the structure of positive steady state solutions. In this presentation, we discuss existence results established via the well-known sub-super solution method. (Received August 19, 2013)

1093-35-290 **xiangwen zhang*** (xzhang@math.columbia.edu), Department of Mathematics, Columbia University, MC 4421, 2990 Broadway, New York, NY 10027. *Some estimates for complex Monge-Ampère equation.*

In the talk, some regularity estimates for the complex Monge-Ampère equations will be presented. More precisely, we will talk about some recent development of the Schauder type estimate for complex Monge-Ampère equations on both complex Euclidean space and general Hermitian manifolds. This talk is based on a joint work with S. Dinew and X. Zhang. (Received August 19, 2013)

1093-35-292 **Louis F Rossi*** (rossi@math.udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *On the dynamics of large swarms with covert leaders.* Preliminary report.

We report on modeling and analysis of large three-zone swarms with *covert leaders*. In three-zone swarming behavior, individual behavior is driven by the position and orientation of neighboring individuals in each of

three concentric zones: repulsion, orientation and attraction. The fundamental purpose of this research is to understand how interactions between individuals are mapped to the dynamics of the entire swarm.

A *covert leader* is treated no differently from a follower but has information that followers do not possess. In the continuum limit, swarms are represented as densities and velocities which are functions of space and time. The dynamics of the swarm is described by a system of partial differential equations capturing conservation principles and the local interactions (i.e. behavior) within the swarm.

Using this approach, we calculate stable structures and determine how they depend upon size and influence of each of the interaction zones. Analytic results explain the emergence of specific axisymmetric and non-axisymmetric structures. Also, we present a new nonlinear model in which a leader will respond more strongly to additional information when the swarm is less dense, meaning there are fewer individuals with which to interact. (Received August 19, 2013)

1093-35-303 **Sunnie Joshi*** (sjoshi@temple.edu) and **Jay R Walton** (jwalton@math.tamu.edu).
Estimating Residual Stresses in Arteries by an Inverse Spectral Technique.

It is known that residual stresses play a significant role in determin- ing the overall stress distribution in soft tissues. A mathematical model is studied to estimate residual stress field in the arterial wall by mak- ing use of intravascular ultrasound (IVUS) imaging techniques. The arterial wall is modeled as a nonlinear, isotropic, slightly compressible elastic body. A boundary value problem is formulated for the resid- ually stressed arterial wall, the boundary of which is subjected to a quasi-static blood pressure, and then an idealized model for the IVUS interrogation is constructed by superimposing small amplitude time harmonic infinitesimal vibrations on large deformations. The analysis leads to a system of second order differential equations with homogeneous boundary conditions of Sturm-Liouville type. By making use of the classical theory of inverse Sturm-Liouville problems, and root finding and optimization techniques, an inverse spectral algorithm is developed to approximate the residual stress distribution in the arte- rial wall, given the first few eigenfrequencies of several induced blood pressures. (Received August 19, 2013)

1093-35-306 **Alina Chertock*** (chertock@math.ncsu.edu), Department of Mathematics, NCSU, Campus Box 8205, Raleigh, NC 27695, and **Jian-Guo Liu** and **Terrance Pendleton**.
Convergence of a Particle Method and Global Weak Solutions for a Family of Evolutionary PDEs.

We provide global existence and uniqueness results for a family of fluid transport equations by establishing convergence results for the particle method applied to these equations. The considered family of PDEs is a collection of strongly nonlinear equations which yield traveling wave solutions and can be used to model a variety of fluid dynamics. The equations are characterized by a bifurcation parameter b, which provides a balance for the nonlinear solution behavior, and a kernel G(x), which determines the shape of the traveling wave and the length scale. For some special cases, the equations are completely integrable and admit solutions that are nonlinear superpositions of traveling waves that have a discontinuity in the first derivative at their peaks and therefore are called peakons.

We apply a particle method to the considered equations and provide a new self-contained method for proving its convergence. The latter is accomplished by using the concept of space-time bounded variation and the associated compactness properties. From this result, we prove the existence of a unique global weak solution to the family of fluid transport equations for b>1 and a particular choice of G(x) and obtain stronger regularity properties of the solution than previously established. (Received August 19, 2013)

1093-35-307 **Federico Tournier*** (fedeleti@aol.com), calle 18 numero 3068, 1897 M.B. Gonnet, Bs As, Argentina. *Global second derivative estimate for the parallel refractor problema.*

This work is concerned with the estimation of the second derivatives up to the boundary for the refractor problem. We treat the near field case when rays emanate in parallel fashion. We find conditions on the domain Ω, the target hypersurface Σ and its projection $\Omega^\star$ that guarantee that a global smooth refractor satisfies an initial condition of oblique type. (Received August 19, 2013)

1093-35-309 **Katharine Ott*** (katharine.ott@uky.edu). *The mixed problem for the Lamé and linear Stokes systems in two dimensions.*

Consider a bounded Lipschitz domain $\Omega \subset \mathbb{R}^2$ with boundary $\partial\Omega$ decomposed as $\partial\Omega = D \cup N$ with $D \cap N = \emptyset$. We specify conditions on the domain, N and D, as well as on the boundary data, so that the mixed problem for the Lamé system of elasticity or the linear Stokes system has a unique solution whose non-tangential maximal function of the gradient belongs to the space L^p of the boundary. This is joint work with Russell Brown and Seick Kim. (Received August 19, 2013)

1093-35-317 **Donatella Danielli*** (danielli@math.purdue.edu), Department of Mathematics, Purdue University, 150 N. University St., West Lafayette, IN 47907, and **Nicola Garofalo**, **Arshak Petrosyan** and **Tung To**. *Optimal Regularity and the Free Boundary in the Parabolic Signorini Problem.*

We give a comprehensive treatment of the parabolic Signorini problem based on a generalization of Almgren's monotonicity of the frequency. This includes the proof of the optimal regularity of solutions, classifi cation of free boundary points, the regularity of the regular set and the structure of the singular set. (Received August 19, 2013)

1093-35-326 **Michael O'Neil*** (oneil@cims.nyu.edu), 251 Mercer St, Room 1105A, New York, NY 10025. *Electromagnetics, Debye sources, and Beltrami fields: Analysis and computation via integral equations.*

Beltrami (force-free) fields are those vector fields which are proportional to their own curl: curl(B) = kB, with "k" a scalar. Beltrami fields arise in several different areas of applied mathematics and physics. For example, in fluid dynamics, Beltrami flows are those flows whose velocity and vorticity are parallel. In plasma physics, magnetic Beltrami fields inside a confinement device at equlibrium arise via Lorentz force balancing. In this talk, I will show that by viewing Beltrami fields as special-case time-harmonic Maxwell fields (with wavenumber "k"), their calculation can be reduced to solving a boundary integral equation similar to those found in electromagnetics. Furthermore, using the recently introduced generalized Debye source formulation of time-harmonic electromagnetic fields, robust representations of Beltrami fields and numerically well-conditioned integral equations are immediate consequences. Lastly, the Debye source representation uniformizes a natural complex structure that is directly related to the Beltrami equation. (Received August 19, 2013)

1093-35-334 **Stephen Robinson*** (sbr@wfu.edu) and **Pavel Drabek**. *An existence theorem for a Fucik Spectrum resonance problem.*

We consider the boundary value problem

$$-\Delta u = \alpha u^+ - \beta u^- + g(u) + h \text{ in } \Omega, u = 0 \text{ on } \partial\Omega,$$

where Δ is the Laplace operator, (α, β) is in the Fucik Spectrum, $g : R \to R$ is continuous with sublinear growth, and Ω is a bounded domain in R^n. We prove an existence theorem subject to a Landesman-Lazer type condition on the primitive of g. The proof relies on a variational characterization of the Fucik Spectrum due to Castro. (Received August 20, 2013)

1093-35-341 **Philippe Guyenne*** (guyenne@math.udel.edu), 15 Orchard Rd, 501 Ewing Hall, Newark, DE 19716. *A viscoelastic model for ultrasound propagation in cancellous bone.*

A composite viscoelastic model for ultrasound propagation through cancellous bone in the time domain is proposed. More specifically, the trabecular matrix of cancellous bone is described as an isotropic viscoelastic material, while the interstitial fluid is modeled by Stokes flow. To simulate realistic bone samples with complicated microstructure, a representative volume element of cancellous bone is constructed by using a two-dimensional random distribution of fluid and solid particles. The system of equations is solved numerically by a staggered-grid finite-difference scheme. Motivated by laboratory experiments, ultrasound attenuation through cancellous bone is examined with the model, and comparison is made with homogenization results. This is joint work with Robert P. Gilbert and Jing Li (University of Delaware). (Received August 20, 2013)

1093-35-347 **Brian Pigott*** (pigottbj@wfu.edu), Department of Mathematics, Wake Forest University, PO Box 7388, Winston-Salem, NC , and **Sarah Raynor** (raynorsg@wfu.edu), Department of Mathematics, Wake Forest University, PO Box 7388, Winston-Salem, NC 27109. *Asymptotic Stability for KdV Solitons in Weighted Sobolev Spaces.*

We consider the KdV equation in the exponentially weighted Sobolev spaces used by Pego and Weinstein. We prove local well-posedness for the perturbation (weighted and unweighted) in a Besov refinement of the Bourgain space $X^{1,b}$. This allows us to recreate the Pego-Weinstein result using an iteration argument. Combining this with the I-method, we expect to be able to prove asymptotic stability for KdV solitons with initial data too rough to be in H^1. (Received August 20, 2013)

1093-35-366 **Nilima Nigam*** (nigam@math.sfu.ca), Nilima Nigam, Department of Mathematics, Simon Fraser University, 8888 University Driv, Burnaby, BC V5C 2V3, Canada. *Fast and efficient numerical methods for eigenproblems with mixed data.*

The numerical approximation of eigenvalues and eigenfunctions of elliptic operators with either Dirichlet or natural boundary conditions is rather well-understood, with a variety of available algorithms. The numerical analysis for elliptic eigenproblems with mixed data - that is, Dirichlet on part of the boundary, natural on the rest

- is less well understood. In particular, the eigenfunctions exhibit singularities even for smooth boundaries. In this talk we quickly review some interesting features of these eigenproblems. We then describe a novel boundary-integral equation based solver for these problems which is both highly accurate and efficient. This is joint work with Eldar Akhmetgaliyev and Oscar Bruno. (Received August 20, 2013)

1093-35-370 **Brian Pigott** and **Sarah Raynor*** (raynorsg@wfu.edu). *A New Approach to Soliton Stability for the KdV Equation.* Preliminary report.

In this work, we consider the KdV equation in the exponentially weighted spaces of Pego and Weinstein. We prove local well-posedness of the perturbation (weighted and unweighted) in the Bourgain $X^{1,b}$ space, allowing us to recreate the Pego-Weinstein result via iteration. By combining this result with the I-method, we expect ultimately to obtain soliton stability for KdV with initial data too rough to be in H^1. (Received August 20, 2013)

1093-35-372 **Charles L Epstein*** (cle@math.upenn.edu), 209 S. 33rd Street, Philadelphia, PA 19104, and **Rafe Mazzeo**. *Degenerate diffusions in population genetics.*

We introduce generalized Kimura diffusions, which are degenerate diffusions on manifolds with corners. This class of operators includes limits of the Wright Fisher Markov Models used throughout population genetics. We explain how to prove existence and regularity of solutions to this class of parabolic equations. (Received August 20, 2013)

1093-35-386 **Rodolfo R Rosales*** (rrr@math.mit.edu), Department of Mathematics, Massachusetts Institute of Technology, Cambridge, MA 02139, and **Benjamin Seibold** and **J-C Nave**. *Model equations for jet schemes.* Preliminary report.

Model equations describe the behavior of numerical schemes in the asymptotic limit when the mesh-size vanishes, and provide information about the nature of the algorithm error in this limit. In particular, they can be used to detect the causes of long wave instabilities (if present), and devise ways to correct them. Because Jet-Schemes use an advect–and–project approach in function space, standard methods for obtaining model equations cannot be used. The numerical solution by a Jet Scheme implicitly carries (small amplitude) grid size structure (as given by the local polynomial interpolant) — modulated on a longer scale by the solution's variations. In this talk we will discuss the model equations for the simple example of a 1-D, 3-rd order jet scheme. (Received August 20, 2013)

1093-35-389 **M. N. Nkashama*** (nkashama@math.uab.edu), Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294-1170. *Asymptotic Constancy for Neutral Functional Partial Differential Equations.* Preliminary report.

We will present some convergence results for initial-boundary value problems for neutral functional partial differential equations for which each constant function is an equilibrium solution. Asymptotic constancy of solutions to delay functional PDEs will also be discussed. (Received August 21, 2013)

1093-35-397 **Truyen Nguyen*** (tnguyen@uakron.edu), **Luan Hoang** (luan.hoang@ttu.edu) and **Tuoc Phan** (phan@math.utk.edu). *On global existence of solutions for the cross-diffusion system.*

We study the initial value problem for a class of cross-diffusion systems in bounded domains of any dimension. A global-time existence of strong solutions is established by deriving global $W^{1,p}$- estimates for weak solutions to a class of nonlinear parabolic equations with nonlinear diffusion. A perturbation argument and a new double scaling technique are used to obtain the estimates for large reaction terms. This is a joint work with Luan Hoang and Tuoc Phan. (Received August 21, 2013)

37 ► Dynamical systems and ergodic theory

1093-37-201 **Almas U. Abdulla**, **Rashad U. Abdulla** and **Ugur G. Abdulla*** (abdulla@fit.edu), Department of Mathematics, Florida Institute of Technology, Melbourne, FL 32901. *Fine Classification of Minimal Orbits of the Continuous Endomorphisms on the Real Line and Universality in Chaos.*

We present a new constructive proof of the result proved independently by Block & Coppel, *Trans. AMS, 297, 2(1986)* and Alseda, Llibre & Serra, *Trans. AMS, 286, 2(1984)* on the structure of minimal $2(2k+1)$-orbits of continuous endomorphisms on the real line. It is proved that there are 4 types of digraphs (and cyclic permutations) with accuracy up to inverse digraphs. Our method reveals the nature and topological structure of all types of digraphs via straightforward construction. Numerical analysis reveals that the first two appearances

of all the $2^n(2k+1)$-periodic windows with $k \geq 3$, within the chaotic regime of the bifurcation diagram of the one-parameter family of logistic type unimodal continuous endomorphisms are distributed according to the following universal law

$$\cdots \to 2^n \cdot 11 \to 2^n \cdot 7 \to 2^n \cdot 9 \to 2^n \cdot 5 \to 2^n \cdot 7 \to 2^n \cdot 3 \to \cdots \to 11 \to 7 \to 9 \to 5 \to 7 \to 3 \to \dots \quad (1)$$

The first appearance of all $2(2k+1)$-orbits is always minimal $2(2k+1)$-orbit with Type I digraph according to our classification. (Received August 13, 2013)

1093-37-214 **Yogesh Joshi*** (yogesh.joshi@kbcc.cuny.edu), 2001 ORIENTAL BOULEVARD, BROOKLYN, NY 11235, and **Denis Blackmore** (denis.l.blackmore@njit.edu), University Heights, Newark, NJ 07102. *Two Types of Strange Attractors in Exponentially Decaying Dynamics.* Preliminary report.

An exponentially decaying discrete dynamical system in $\mathbb{R}^m$ comprises the forward iterates of a smooth map $F : \mathbb{R}^m \to \mathbb{R}^m$ such that there exists an $M > 0$ for which $|F(x)| \leq Me^{|x|}$ for all $x \in \mathbb{R}^m$. These dynamical systems, which have numerous applications, clearly possess a compact globally attracting set A. It turns out that in many instances A or one of its components is actually a strange attractor. Proving that (positively) invariant sets of discrete dynamical systems are actually strange attractors is typically quite difficult, as for example in applying Rank 1 theory. However, we are able to provide relatively simple proofs of the existence of two types of strange attractors (which we call *radial* and *multi-modular* attractors) for exponentially decaying systems under rather mild additional hypotheses that are satisfied for several well-known dynamical models of physical and biological phenomena. (Received August 14, 2013)

1093-37-295 **Amitabha Bose*** (bose@njit.edu), Department of Mathematical Sciences, New Jersey Institute of Technology, Newark, NJ 07102, **Jorge Golowasch** (golowasch@njit.edu), Department of Biological Sciences, New Jersey Institute of Technology, Newark, NJ 07102, and **Farzan Nadim** (farzan@njit.edu), Department of Biological Sciences, New Jersey Institute of Technology, Newark, NJ 07102. *Role of linear and voltage-dependent ionic currents in the generation of slow wave oscillations.*

Neuronal oscillatory activity is generated by a combination of ionic currents that must include at least one inward regenerative current that brings the cell towards depolarized voltages and at least one outward current that repolarizes the cell. Such currents have traditionally been assumed to require voltage-dependence. Here we show that the inward regenerative current need not be voltage dependent. Instead, a linear current with negative conductance is sufficient to produce regenerative activity. Using simple conductance-based models, bifurcation and phase-plane analysis, we show how this linear current interacts with potassium and sag currents to produce stable slow wave oscillations. The model makes several predictions which are confirmed through experiments on neurons from the crab stomatogastric ganglion. (Received August 19, 2013)

1093-37-369 **Aaron Hoffman*** (aaron.hoffman@olin.edu), Olin College, Needham, MA 02492. *The slip-stick process for lattice differential equations.* Preliminary report.

We consider the following simple model of phase separation in two dimensions for spatially discrete media:

$$\dot{u}_{ij} = u_{i+1,j} + u_{i-1,j} + u_{i,j+1} + u_{i,j-1} - 4u_{ij} + u_{ij}(u_{ij} - 1)(\rho - u_{ij}).$$

It is well known that this model exhibits pinning (i.e. the failure of a more energetically favorable equilibrium to invade the domain of a less energetically favorable equilibrium) over a range of parameter values called the pinning region. We study a so-called stick-slip invasion process at the boundary of the pinning region and relate its presence to the sensitive dependence of the wave speed of a planar front in this system on the direction which it faces. This is joint work with HJ Hupkes. (Received August 20, 2013)

39 ► Difference and functional equations

1093-39-16 **Choonkil Park*** (baak@hanyang.ac.kr), Department of Mathematics, Hanyang University, Seoul, 133-791, South Korea. *Functional difference equationa and inequalities.*

In this talk, new functional difference inequalities are introduced. We prove the Hyers-Ulam stability of the functional difference inequalities in various normed spaces. The results are applied to investigate morphisms in various normed spaces such as Banach spaces, fuzzy normed spaces, random normed spaces, operator algebras, fuzzy normed algbras, random normed algebras, matrix normed spaces, matrix fuzzy spaces, matrix random spaces, matrix normed algebras, matrix fuzzy normed algebras and matrix random normed algebras. (Received June 02, 2013)

1093-39-123 **Umang Varma*** (umang.varma10@kzoo.edu), **Archit U Kulkarni** (auk@andrew.cmu.edu), **Philippe Demontigny**, **Thao Do**, **Steven J Miller** and **David Moon**. *Generalizing Zeckendorf's Theorem to f-decompositions.*

A beautiful theorem of Zeckendorf states that every positive integer can be uniquely expressed as a sum of non-consecutive Fibonacci numbers $\{F_n\}$. For sequences $\{G_n\}$ satisfying linear recurrence relations with nonnegative coefficients, there is a notion of a legal decomposition which again leads to a unique representation. The number of summands in the representations of $m \in [G_n, G_{n+1})$ converges to a Gaussian as $n \to \infty$.

Given a notion of legal decomposition, we ask if $\{a_n\}$ exists such that every positive integer can be uniquely decomposed as a sum of terms from $\{a_n\}$. Given $f : \mathbb{N}_0 \to \mathbb{N}_0$, we say that if a_n is in an "f-decomposition" of a number x, then the decomposition cannot contain the $f(n)$ terms immediately before a_n in the sequence. We prove that for any $f : \mathbb{N}_0 \to \mathbb{N}_0$, there exists $\{a_n\}$ such that every positive integer has a unique f-decomposition using $\{a_n\}$. If f is periodic, then the unique increasing sequence $\{a_n\}$ induced by f satisfies a linear recurrence relation. For some class of functions f, we prove that the number of summands in the f-decomposition of integers in a suitable growing interval converges to a normal distribution. (Received August 08, 2013)

1093-39-127 **Chris D Lynd*** (clynd@bloomu.edu), Bloomsburg, PA 17815. *The Class of Anti-Competitive Systems Of Two, First-Order, Rational Linear Difference Equations.* Preliminary report.

There are 49 first-order, rational linear difference equations with two variables. Thus, there are 49 X 49 = 2,401 systems of two equations of this form. Of these systems, 289 have a corresponding map that is anti-competitive for all positive values of its parameters. We will present preliminary results for a theorem that we believe describes the global behavior of the solutions for all 289 anti-competitive systems of two first-order, rational linear difference equations. (Received August 08, 2013)

1093-39-151 **Anatoli F Ivanov*** (afi1@psu.edu), Department of Mathematics, Pennsylvania State University, P.O.Box PSU, Lehman, PA 18627, and **Sergei I Trofimchuk** (trofimch@inst-mat.utalca.cl), Institute of Mathematics and Physics, University of Talca, Casilla 747, Talca. *Periodic Solutions and Global Dynamics in a Periodic Differential Delay Equation.*

Several aspects of global dynamics and the existence of periodic solutions are studied for the scalar differential delay equation

$$x'(t) = a(t)f(x([t-K])),$$

where

(i) $f(x)$ is a continuous function satisfying the negative feedback condition
$$x \cdot f(x) < 0 \quad \text{for all} \quad x \neq 0$$

(ii) $0 < a(t)$ is a continuous periodic function with period $\omega > 0$

(iii) $[\cdot]$ is the integer part function, and the integer $K \geq 0$ is the delay.

The case of integer period ω allows for a reduction to finite-dimensional difference equations. The dynamics of the latter are studied in terms of corresponding discrete maps, including the partial case of interval maps ($K = 0$). Sufficient conditions for the existence of periodic solutions are derived and their stability is studied. Complex behavior of solutions is demonstrated in terms of the well known criteria for interval maps. (Received August 10, 2013)

1093-39-230 **Michael A. Radin*** (michael.radin@rit.edu), Rochester Institute of Technology, School of Mathematical Sciences, College of Science, Rochester, NY 14623, and **Candace M. Kent** (cmkent@vcu.edu), Virginia Commonwealth University, Department of Mathematics, Richmond, VA 23284. *Patterns of Unbounded Solutions of a delayed max-type difference equation.* Preliminary report.

First we investigate the periodic and boundedness nature of second and hogher order max-type difference equations. Furthermore, we will determine the sufficient conditions for every positive solution to be unbounded and the patterns of unbounded solutions as well; how many subsequences go to 0 and how many subsequences go to infinity. (Received August 15, 2013)

1093-39-235 **Emmanouil Drymonis*** (edrymoni@providence.edu), Department of Mathematics and Computer Sc., Providence College, Providence, RI 02918. *Rational Systems: Facts, Open Problems, and Conjectures.* Preliminary report.

We present some facts, some open problems, and some conjectures on rational systems. We are primarily interested in the boundedness nature of solutions, the periodic character of the equation, the global stability

behavior of the equilibrium points, in invariants, and in convergence to periodic solutions including periodic trichotomies. (Received August 16, 2013)

1093-39-268 **Evelina Lapierre*** (elapierre@jwu.edu), **Wirot Tikjha** and **Ed Grove**. *Systems of related of piecewise linear difference equations.*

For the last three years Wirot Tikjha, Ed Grove and myself have been working on the following family of 81 systems of piecewise linear difference equations: $X_{n+1} = X_n + a|Y_n| + b$ and $Y_{n+1} = |X_n| + cY_n + d$, where a, b, c and d take on the values -1, 0 or 1 and (X_0, Y_0) is an element of R^2. I will share some of our results, conjectures and open problems. (Received August 18, 2013)

1093-39-301 **Harold M Hastings*** (harold.hastings@hofstra.edu). *Stochastic difference equation models for extinction or collapse.* Preliminary report.

This talk will discuss stochastic difference equation models for extinction or collapse in model ecological and economic systems. (Received August 19, 2013)

41 ► Approximations and expansions

1093-41-73 **Matthew Lorig** and **Stefano Pagliarani*** (stefanop@math.unipd.it), Via Trieste, 63, 35121 Padova, Italy, and **Andrea Pascucci**. *Analytical approximations in local Lévy models with default.*

We consider a defaultable asset whose risk-neutral pricing dynamics are described by an exponential Lévy-type martingale subject to default. This class of models allows for local volatility, local default intensity, and a locally dependent Lévy measure. Generalizing and extending the novel adjoint expansion technique of Riga, Pagliarani, Pascucci (2013), we derive a family of asymptotic expansions for the transition density of the underlying as well as for European-style option prices and defaultable bond prices. For the density expansion, we also provide error bounds for the truncated asymptotic series. Additionally, for pure diffusion processes, we derive an asymptotic expansion for the implied volatility induced by European calls/puts. Our method is numerically efficient; approximate transition densities and European option prices are computed via Fourier transforms; approximate bond prices are computed as finite series. Additionally, for models with Gaussian-type jumps, approximate option prices can be computed in closed form and theoretical asymptotic estimates for the error are available. (Received July 29, 2013)

42 ► Fourier analysis

1093-42-24 **Ryan Berndt*** (rberndt@otterbein.edu). *Two weight problem for the Fourier transform.*

We discuss conditions on weight functions, u and v, necessary or sufficient, so that the Fourier transform is bounded from one weighted Lebesgue space to another:

$$\|\widehat{f}\|_{L^q(u)} \leq C\|f\|_{L^p(v)}.$$

The sufficient condition and the necessary condition are of the form

$$\left(\int_A u\right)^{1/q} \left(\int_B v^{-p'/p}\right)^{1/p'} \leq C,$$

holding for certain A and B such that $|A||B| = 1$. The two conditions differ only in the types of sets for which this must hold. (Received June 11, 2013)

1093-42-196 **Dorina Mitrea*** (mitread@missouri.edu), University of Missouri, Department of Mathematics, Columbia, MO 65211. *A general jump-formula in the class of tempered distributions.* Preliminary report.

Since the pioneering work of Sokhotsky and Plemelj, jump formulas for singular integral operators have been of basic importance in the treatment of boundary value problems via boundary layer methods. In my talk, I will discuss a result, formulated in the language of tempered distributions, which isolates the active ingredient in any such jump formula. Several applications to problems in PDEs in harmonic analysis will be presented as well. (Received August 13, 2013)

44 ► Integral transforms, operational calculus

1093-44-289 **Sergei Levendorskiĭ*** (levendorskii@gmail.com), , United Kingdom. *Fast and accurate pricing using parabolic inverse Fourier and Laplace transforms, and method of paired contours.*

Fast and accurate methods are constructed for (a) pricing European options wide classes of Lévy and affine models; (b) approximate Laplace inversion, (c) approximate calculation of the Wiener-Hopf factors for wide classes of Lévy processes with exponentially decaying Lévy densities, and (d) approximate pricing of barrier and lookback options. In all cases, we use appropriate conformal change-of-variable techniques, which allow us to apply the simplified trapezoid rule with a small number of terms (the changes of variables in the outer and inner integrals and in the formulas for the Wiener-Hopf factors must be compatible in a certain sense). (Received August 19, 2013)

46 ► Functional analysis

1093-46-202 **Yevgeniy V Galperin*** (egalperin@po-box.esu.edu), 200 Prospect Street, East Stroudsburg, PA 18301. *Inequalities for Weighted Mixed-(quasi)Norm Spaces.* Preliminary report.

Several classical inequalities are extended to the case of weighted mixed-(quasi)norm spaces of sequences and functions. Inequalities that describe embeddings of intersections of sequence spaces $\ell_{a,0}^{p,p'} \cap \ell_{0,b}^{q,q'}$ into the spaces $\ell_{\alpha,\beta}^{r,s}$ and embeddings of intersection of function spaces $L_{a,0}^{p,p'} \cap L_{0,b}^{q,q'}$ into the spaces $L_{\alpha,\beta}^{r,s}$ are also proved. (Received August 13, 2013)

1093-46-350 **Elia Ziadé*** (elia.ziade@temple.edu). *Fredholm Theory on Quasi-Banach Spaces.*

The Fredholm theory on Banach spaces plays a fundamental role in the study of boundary value problems for second and higher order elliptic operators. However, many function spaces naturally arising in the study of these problems are not Banach but merely quasi-Banach, a context in which basic functional analytical tools such as the Hahn-Banach Theorem fail to hold.

In this talk, I will present a number of results pertaining to Fredholm theory on quasi-Banach spaces, overcoming certain salient obstacles, including the conspicuous absence of duality in this setting. This is joint work with I. Mitrea and M. Mitrea. (Received August 20, 2013)

51 ► Geometry

1093-51-166 **Robert J. Young*** (ryoung@math.toronto.edu). *Filling multiples of embedded curves.*

Filling a curve with an oriented surface can sometimes be "cheaper by the dozen". For example, L. C. Young constructed a smooth curve drawn on a Klein bottle in $\mathbb{R}^n$ which is only about 1.3 times as hard to fill twice as it is to fill once and asked whether this ratio can be bounded below. We will use methods from geometric measure theory to answer this question and pose some open questions about systolic inequalities for surfaces embedded in $\mathbb{R}^n$. (Received August 12, 2013)

1093-51-222 **Neil Hoffman** and **Genevieve S Walsh*** (genevieve.walsh@gmail.com). *An introduction to "The Big Dehn surgery graph".*

We present several results on "The big Dehn surgery graph". This is a graph first imagined by W. Thurston where the vertices correspond to homeomorphism classes of closed 3-manifolds and the edges correspond to the existence of a Dehn surgery along a knot. We will discuss the link of S^3, the geometry of the graph, and some interesting subgraphs. (Received August 15, 2013)

1093-51-226 **Kathryn Mann*** (mann@math.uchicago.edu). *Components of representation spaces.*

Let G be a group of homeomorphisms of the circle, and Γ the fundamental group of a closed surface. The representation space Hom(Γ, G) is a basic example in geometry and topology: it parametrizes flat circle bundles over the surface with structure group G, or G-actions of the surface group on the circle. Goldman proved that connected components of Hom(Γ, PSL(2,R)) are completely determined by the Euler number, a classical invariant. By contrast, the space Hom(Γ, Homeo+(S^1)) is relatively unexplored – for instance, it is an open question whether this space has finitely or infinitely many components.

We report on recent work and new tools to distinguish connected components of Hom(Γ, Homeo+(S^1)). In particular, we give a new lower bound on the number of components, show that there are multiple components on which the Euler number takes the same value – in contrast to the PSL(2,R) case – and we identify certain representations which exhibit surprising rigidity. A key technique is the study of rigidity phenomena in rotation numbers, using recent ideas of Calegari-Walker. (Received August 15, 2013)

1093-51-253 **Todd A. Drumm*** (todd.drumm@gmail.com) and **Caleb J. Ashley**. *Rank three discreteness algorithm for PSL(2,R).*

The extension of the discreteness algorithm for rank 2 subgroups of PSL(2,R), by Rosenberger, Purzitsky, Gilman and Maskit, can not be directly exttended to rank 3 groups. We will review the rank 2 algorithm and discuss recent work on the rank 3 algorithm. (Received August 16, 2013)

1093-51-285 **Niels Martin Møller*** (moller@math.princeton.edu), Fine Hall, Washington Road, Room 1210, Princeton, NJ 08544, and **Stephen J Kleene** and **Nikolaos Kapouleas**. *Gluing of Self-Similar Solitons in Mean Curvature Flow.*

I will explain some past and current projects in which gluing constructions for self-similar solitons in geometric evolution problems defined via nonlinear parabolic PDEs (such as the mean curvature flow) are investigated, as a rigorous way of obtaining many new examples of solitons (and hence singularity models for the flow) of nontrivial topology. Some of the presented results are joint with N. Kapouleas and S. Kleene. (Received August 19, 2013)

1093-51-304 **Ian Biringer*** (ianbiringer@gmail.com) and **Cyril Lecuire**. *Iterations in Schottky space.*

If H is a handlebody, then convex-cocompact hyperbolic metrics on H are parametrized by the Teichmuller space of the boundary S of H. We describe the geometric limits of sequences of metrics parametrized by an iteration $f^i(X)$, where f is a homeomorphism of S. This gives a compressible version of examples due to Kerckhoff-Thurston, McMullen and Brock. (Received August 19, 2013)

1093-51-383 **Hwankyu Song*** (hwankyusong@gmail.com), 29 Washington St., Tenafly, NJ 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07670. *Application of a Sequence to Building Construction.*

A valence sequence is a geometrical term used for a group of numbers that each represents the number of edges that meet at each vertex. It is possible to triangulate a given solid by connecting vertices with lines that don't already meet.

The purpose of this experiment is to find patterns between a triangulated Polyhedron and its valence sequence. Finally, this paper shows that there is a clear pattern in the valence sequences for polygons and polyhedrons, and the presented theory is applied to the building structures with truss elements.

This project can help find a new property of a shape. Finding a pattern in the valence sequences could help architects build buildings, bridges with truss elements with more stability. (Received August 20, 2013)

52 ► Convex and discrete geometry

1093-52-91 **David A Cox**, **Christian Haase**, **Takayuki Hibi*** (hibi@math.sci.osaka-u.ac.jp) and **Akihiro Higashitani**. *Integer decomposition property of dilated polytopes.*

Let $\mathcal{P} \subset \mathbb{R}^N$ be an integral convex polytope of dimension d and $k\mathcal{P}$, where $k = 1, 2, \ldots$, for dilations of $\mathcal{P}$. We say that $\mathcal{P}$ possesses the *integer decomposition property* (IDP, for short) if, for any positive integer k and for any $\alpha \in k\mathcal{P} \cap \mathbb{Z}^N$, there exist $\alpha_1, \ldots, \alpha_k$ belonging to $\mathcal{P} \cap \mathbb{Z}^N$ such that $\alpha = \alpha_1 + \cdots + \alpha_k$. A fundamental question is to determine the integers $k > 0$ for which the dilated polytope $k\mathcal{P}$ possesses IDP. Our talk gives several combinatorial invariants related to IDP of dilated polytopes and shows that those invariants satisfy certain inequalities. In addition, various examples of integral convex polytopes, which are important from the viewpoint of IDP of dilated polytopes, will be discussed. (Received August 02, 2013)

53 ► Differential geometry

1093-53-45 **Ovidiu Munteanu*** (ovidiu.munteanu@uconn.edu), Department of Mathematics, 196 Auditorium Rd, Unit 3009, Storrs, CT 06269. *Topology of gradient Ricci solitons.*

We discuss some results about the number of ends of gradient Ricci solitons. The approach to counting ends is analytical, using certain types of harmonic functions. (Received July 14, 2013)

1093-53-82 **Tobias Ekholm** and **Lenhard Ng*** (ng@math.duke.edu). *Legendrian contact homology in* $\#^k(S^1 \times S^2)$.

I will discuss a combinatorial description of contact homology for Legendrian knots in the contact manifold $S^1 \times S^2$ and connected sums of it. Among other things, this yields a combinatorial formulation for symplectic homology for all Weinstein 4-manifolds, and a (new) proof of the existence of exotic Stein structures on $\mathbb{R}^8$. The story involves some new algebraic wrinkles on the more familiar story, due to Chekanov, for Legendrian contact homology in $\mathbb{R}^3$. (Received August 01, 2013)

1093-53-86 **Peter Spaeth*** (spaeth@psu.edu), Penn State University, Altoona, 3000 Ivyside Park, Altoona, PA 16601. *The helicity invariant and topological strictly contact dynamics.*

If X is a divergence-free vector field on a closed 3-manifold M equipped with a volume form μ, then the 2-form $\iota_X \mu$ is closed. Assuming it is exact, one may choose a primitive 1-form β_X and define the helicity of X to be the real number

$$\text{Helicity}(X) = \int_M \beta_X \wedge d\beta_X .$$

In a joint project with S. Müller, we compute the helicity of a vector field X that preserves a regular contact form α on M in terms of the basic contact Hamiltonian H that generates X. This provides a simple criterion for a loop of α-preserving diffeomorphisms to be non-contractible.

Combined with results from C^0-symplectic and contact topology this computation also allows us to extend the helicity to certain measure preserving isotopies of *homeomorphisms* of M. (Received August 01, 2013)

1093-53-95 **Mao-Pei Tsui*** (mao-pei.tsui@utoledo.edu), Department of Mathematics and Statistics, University of Toledo, 2801 W. Bancroft St, Toledo, OH 43606. *Curvature Decay Estimate of Graphical Mean Curvature Flow in Higher Codimensions.*

K . Ecker and G. Huisken have derived a priori estimate for the curvature(second fundamental forms) when they study the mean curvature flow of the graph of a function in Euclidean space. In this talk, I will explain that a similar curvature estimate also exists for higher codimensional mean curvature flow under certain natural conditions. This is joint work with Knut Smoczyk and Mu-Tao Wang. (Received August 03, 2013)

1093-53-157 **Fei He*** (hef@uci.edu). *The extension problem of the Ricci Flow.*

In the theory of Ricci flow, a natural problem is to find the weakest condition to impose on the curvature tensor, so that the flow can be extended past finite time. We will discuss recent progress on this problem. (Received August 11, 2013)

1093-53-204 **Hung T Tran*** (htt4@cornell.edu) and **Xiaodong Cao**. *The Weyl Tensor of Gradient Ricci Solitons.*

This paper derives several new identities for the Weyl tensor of gradient Ricci solitons, specifically in dimension four. In particular, in the first part, we prove a Bochner-Weitzenböck type formula for the norm of the self-dual Weyl tensor which has several applications including a gap theorem. In the second part, we are mostly concerned with the interaction of different components of curvature, the gradient and Hessian of the potential function. The Weyl tensor arises naturally in these investigations as it is the main distinction in higher dimensions. Applications here are rigidity results (Received August 13, 2013)

1093-53-243 **Christopher Alan Micklewright*** (cmicklew@eastern.edu), Eastern University, 1300 Eagle Road, St. David's, PA 19087. *Circle-Valued Generating Families.*

Legendrian knot theory is the study of knots and links that satisfy a geometric condition imposed by a contact structure. In recent years, generating families and Morse theory have been used to develop new homological invariants for knots and links in contact manifolds equivalent to $\mathbb{R}^3$ and $S^1 \times \mathbb{R}^2$. These invariants parallel Legendrian contact homology, and can be used to show that certain knots and links are topologically equivalent but not Legendrian equivalent. This talk will explore the extension of the generating family approach to circle-valued functions, allowing for the study of Legendrian knots and links in $T^2 \times \mathbb{R}$ (and, more generally, of Legendrian submanifolds in a variety of 1-jets spaces). New invariants are developed using techniques inspired by Morse-Novikov theory, allowing us to address several difficulties presented by the introduction of circle-valued generating families. In particular, we address the ways in which Legendrian submanifolds and their generating families can wrap around a contact manifold, as well as the problem of differentiating multiple components generated by a single family. (Received August 16, 2013)

1093-53-250 **Bo Yang*** (b5yang@math.ucsd.edu), Department of Mathematics, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854. *Two applications of maximum principles in Ricci flow.*

We discuss two applications of maximum principles related to Ricci flow on complete manifolds. The first one gives sharp lower bounds on scalar curvatures of gradient Ricci shrinking solitons. The other is that nonnegative curvature is preserved along $U(n)$-invariant Kähler-Ricci flow on $\mathbb{C}^n$, here we do not assume global upper bounds on curvatures. The first one is joint work with B. Chow and P. Lu and the second is joint with F. Zheng. (Received August 16, 2013)

1093-53-252 **William Wylie*** (wwylie@syr.edu), 215 Carnegie Building, Mathematics Department, Syracuse University, Syracuse, NY 13244. *Warped Product Einstein metrics on homogeneous spaces and homogeneous Ricci solitons.*

Jablonski defines a Ricci soliton on a homogeneous space to be semi-algebraic with respect to a homogeneous structure if the corresponding self similar Ricci flow evolves by automorphisms. We introduce the notion of a normal semi-algebraic soliton and show that this condition is related to when one can build a homogeneous Einstein metric of larger dimension. This is joint work with Chenxu He (Oklahoma) and Peter Petersen (UCLA). (Received August 16, 2013)

1093-53-281 **Lu Wang*** (lwang@math.jhu.edu), 3400 N. Charles Street, Baltimore, MD 21218. *Rigidity of Self-shrinkers Asymptotic to Cylinders.*

In this talk, we show the self-shrinkering end that are asymptotic to the shrinking cylinders in a certain sense must be isometric to the cylinders. Also, we show the asymptotic condition is optimal. Our result holds for all dimensions. (Received August 18, 2013)

1093-53-294 **Peter Lambert-Cole*** (plambe7@lsu.edu). *Legendrian products and Legendrian contact homology.*

This talk discusses a product operation on Legendrian submanifolds in contact topology and the computation of geometric invariants of these submanifolds. Legendrian contact homology is an invariant of Legendrian submanifolds in 1-jet spaces de ned via counts of holomorphic curves. For Legendrian knots, the invariant has a combinatorial description in terms of a knot projection. A similar combinatorial description exists for Legendrian tori obtained as products of Legendrian knots. (Received August 19, 2013)

1093-53-312 **Brett Lawrence Kotschwar*** (kotschwar@asu.edu). *A frequency approach to unique continuation for geometric evolution equations.*

Many natural questions arising in the study of geometric evolution equations can be formulated as problems of unique continuation. I will discuss an alternative approach to such problems for the Ricci flow and other weakly-parabolic geometric systems based on the consideration of certain frequency-type quantities. (Received August 19, 2013)

1093-53-318 **Jeffrey S. Meyer*** (jmeyer@math.ou.edu), Jeffrey S. Meyer, Department of Mathematics, University of Oklahoma, Norman, OK 73019-3103. *On the totally geodesic commensurability spectrum of arithmetic hyperbolic manifolds.*

Mark Kac famously posited in 1966,"can you hear the shape of a drum?" This question simply and elegantly summarizes our quest in spectral geometry to find collections of topological or geometric data that capture a Riemannian manifold's "geometric class." In this talk, we will report on recent work which shows that the collection of commensurability classes of totally geodesic submanifolds of an arithmetic hyperbolic manifold determines the commensurability class of the manifold. In addition to presenting the general results, we will present techniques used in their proofs, in particular the connections between the theories of quadratic forms over local and global fields and the Tits index of an algebraic group. This presentation will be concrete and contain many motivating examples. (Received August 19, 2013)

1093-53-322 **Yuan Yuan***, 101 Lafayette Rd, Syracuse, NY 13205. *A New Parabolic equation on Kahler manifolds.* Preliminary report.

I will introduce a new parabolic equation on Kahler manifolds in the study of constant scalar curvature metrics. (Received August 19, 2013)

1093-53-335 **Gregory R. Schneider***, gschneider@brynmawr.edu. *Detecting Non-Legendrian Isotopy of Rational Tangles.*

A rational tangle is obtained from a pair of disjoint arcs, properly embedded in a 3-ball, by sequentially twisting their endpoints. This sequential twisting can also be used to construct a compressing disc - a properly embedded,

homotopically non-trivial disc - in the complement of the tangle. By studying the way a compressing disc of a Legendrian embedding of a rational tangle interacts with the associated contact structure, it is possible in some cases to identify when a particular type of operation on this tangle will yield non-isotopic Legendrian representatives. Here we will briefly introduce an algorithm for explicitly constructing the characteristic foliations of compressing discs of simple Legendrian embeddings of rational tangles in the standard contact structure on Euclidean 3-space, and discuss what information in these foliations can be used to make such a distinction under these conditions. (Received August 20, 2013)

1093-53-395 **Stephen J Kleene*** (skleene@gmail.com), 8 Blackstone Blvd #1, Providence, RI 02906. *Doubling Minimal Surfaces.*

I will discuss recent work with Nicos Kapouleas and Niels Martin Moller on doubling minimal surfaces in $\mathbb{R}^3$ and other 3 manifolds (Received August 21, 2013)

1093-53-396 **Davi Maximo*** (maximo@math.utexas.edu) and **Ivaldo Nunes**. *Mass and local rigidity of minimal surfaces in three-manifolds.*

In this talk we will discuss a rigidity statement for minimal surfaces in three-manifolds that was inspired by the inverse mean curvature flow. (Received August 21, 2013)

55 ► Algebraic topology

1093-55-51 **Julia Bergner*** (jbergner@ucr.edu) and **Marcy Robertson**. *Topological cluster categories.*

From an algebraic point of view, cluster categories can be defined to be orbit categories of certain triangulated categories by a self-equivalence, or from a more homotopical perspective as the orbit category of a dg category. Instead of working with algebraic triangulated categories, we consider instead cluster categories arising as orbit categories of topological triangulated categories, or those arising as the homotopy category of a stable model category or more general stable $(\infty, 1)$-category. While this theory is compatible with the algebraic one, it allows for new topologically flavored examples. (Received July 16, 2013)

1093-55-136 **Alastair Hamilton*** (alastair.hamilton@ttu.edu). *Batalin-Vilkovisky formalism and classes in the moduli space of Riemann surfaces.*

In this talk I will describe, using the Batalin-Vilkovisky formalism, two constructions producing classes in a compactification of the moduli space of Riemann surfaces. The first produces homology classes and uses as its initial data an enhancement of the notion of an A-infinity structure. The second produces cohomology classes and uses as its initial data more or less the same information as that for a 2d open TFT, namely a Frobenius algebra. The result of evaluating one construction upon another may be expressed in terms of some functional integral, taken over a finite-dimensional space of fields. We will show, using some examples, that by computing such functional integrals we can prove the nontriviality of the classes so produced. (Received August 08, 2013)

1093-55-171 **David Ayala*** (davidayala.math@gmail.com), 1670 N Sierra Bonita Ave, Pasadena, CA 91104. *Poincaré Koszul duality, naively.* Preliminary report.

We present a common generalization of Poincaré duality and of Koszul duality. The central construction is that of "Factorization Homology" – a recent class of manifold invariants which simultaneously generalizes classical homology, and which is known to be sensitive to more than the underlying homotopy type of manifolds. Specifically, we will see Koszul duality mechanically generalize the role of the dualizing sheaf of a (possibly structured, possibly singular) manifold. A few explicit instances and classical applications will be mentioned. (Received August 12, 2013)

1093-55-231 **Christopher L. Rogers*** (crogers@uni-math.gwdg.de), Mathematisches Institut, Georg-August-Universität Göttingen, D-37073 Göttingen, Germany. *Geometric prequantization for homotopy Lie theory.*

I will describe a "homotopical analog" of a procedure developed by Kostant, Kirillov, and Souriau in which symplectic geometry is used to produce central extensions of Lie algebras and their representations. Analogously, our construction geometrically produces L_∞-extensions using higher-degree closed differential forms. Such a form canonically gives an L_∞-cocycle whose homotopy fiber acts as the L_∞ analog of the Poisson algebra. When the form represents an integral cohomology class, this L_∞-algebra is homotopy equivalent to a DGLA corresponding to the infinitesimal autoequivalences of a higher bundle gerbe, in analogy with the prequantization of the Poisson algebra as vector fields on a principal circle bundle. Applications of this procedure include

constructing Heisenberg-like L_∞-algebras such as the "string Lie 2-algebra". This is joint work with Domenico Fiorenza and Urs Schreiber (arXiv:1304.6292). (Received August 15, 2013)

1093-55-398 **Mustafa Hajij*** (mustafa.hajij@yahoo.com), 4243 Burbank Dr Apt 102, Baton Rouge LA, LA 70808. *The tail of a quantum spin network and Andrews-Gordon identities.* Preliminary report.

We use local skein relations to understand and compute the tail of a sequence of admissible trivalent graphs with edges colored n or 2n. We give a natural skein theoretic proof of the stability of the coefficients of the colored Jones polynomial of alternating links. Furthermore, we show that our skein theoretic techniques can be used to prove the Andrews-Gordon identity for the theta function and a corresponding identity for the false theta function. (Received August 22, 2013)

57 ► Manifolds and cell complexes

1093-57-26 **BoGwang Jeon*** (bogwang.jeon@gmail.com), ICERM, Brown University, Providence, RI 02903. *HYPERBOLIC 3-MANIFOLDS OF BOUNDED VOLUME AND TRACE FIELD DEGREE.* Preliminary report.

For a single cusped hyperbolic 3-manifold, Hodgson proved that there are only finitely many Dehn fillings of it whose trace fields have bounded degree. In this paper, we conjecture the same for manifolds with more cusps, and give the first positive results in this direction. For example, in the 2-cusped case, if a manifold has linearly independent cusp shapes, we show that the manifold has the desired property.To prove the results, we use the Habegger's proof of the Bounded Height Conjecture in arithmetic geometry. (Received June 13, 2013)

1093-57-55 **Shijie Gu*** (albertku123@163.com), 1605 N Virginia ST Apt 36, Reno, NV 89503. *Shrinkability of Decomposition of S^n Having Arbitrarily Small Neighborhoods with (n-1)-sphere Frontiers.*

Let G be a usc decomposition of S^n, H_G denote the set of nondegenerate elements and π be the natural projection of S^n onto S^n/G. Suppose that each point in the decomposition space has arbitrarily small neighborhoods with (n-1)-sphere frontiers or boundaries which miss $\pi(H_G)$. If all the arcs are tame in the particular area, Bd $C - F_1 \cup h(F_2)$, on the boundary of an n-cell C in S^n, then this paper shows that this condition implies that S^n/G is homeomorphic to S^n ($n \geq 4$). This answers a weak form of a conjecture asked by Daverman[1, p. 61]. In case $n = 3$, the strong form of the conjecture has an affirmative answer from Woodruff [2]. (Received August 21, 2013)

1093-57-79 **Bulent Tosun*** (tosun@cirget.ca), P. O. Box 400137 Dept. of Mathematics, 311 Kerchof Hall, Charlottesville, VA 22904. *Tight small Seifert fibered spaces with $e_0 = -2$.* Preliminary report.

This talk will be on the classification of tight contact structures on a family of small Seifert fibered spaces. (Received July 31, 2013)

1093-57-92 **Brian C. Rushton*** (brian.rushton@temple.edu), Temple University Math Department, Philadelphia, PA 19122. *Finite subdivision rules for cubulated groups.*

Finite subdivision rules for groups and manifolds are a way to recast questions about quasi-isometries into questions about a sequence of cell structures on a fixed complex X. We show that right-angled Artin groups have associated finite-subdivision rules which restrict nicely to subdivision rules for all compact special cube complexes, and discuss some of the ways that quasi-isometry properties can be deduced from subdivision rules. (Received August 18, 2013)

1093-57-96 **Stavros Garoufalidis** (stavros@math.gatech.edu), **Craig D. Hodgson** (craigdh@unimelb.edu.au), **J. Hyam Rubinstein** (rubin@ms.unimelb.edu.au) and **Henry Segerman*** (henry.segerman@okstate.edu), Department of Mathematics, Oklahoma State University, Stillwater, OK 74078. *Regular triangulations and the index of a cusped hyperbolic 3-manifold.*

Recent work by Dimofte, Gaiotto and Gukov defines the "index" (a collection of Laurent series) associated to an ideal triangulation of an oriented cusped hyperbolic 3-manifold. "Physics tells us" that this index should be a topological invariant of the manifold, not just of the triangulation of it. The problem is that the index is not well defined on all triangulations. We define a class of triangulations of a 3-manifold, depending only on the topology of the manifold, such that the index is well-defined and has the same value for each triangulation in the class.

A key requirement is that the class of triangulations be connected by local moves on the triangulations, since we can prove invariance of the index under these moves. To achieve this requirement we import a result from the theory of regular triangulations of Euclidean point configurations due to Gelfand, Kapranov and Zelevinsky. (Received August 03, 2013)

1093-57-101 **Doug LaFountain*** (d-lafountain@wiu.edu) and **Bill Menasco**. *The generalized Jones conjecture for closed braids.*

The generalized Jones conjecture (sometimes referred to as the *braid geography conjecture*) states that all pairs of braid index and algebraic length values realized by closed braids in a link type can be obtained by stabilizing any minimum braid index representative. First posited by Jones, this conjecture was further developed by Kawamuro and has immediate applications to contact topology. In this talk we will discuss the statement, applications and a proof of Jones' conjecture. (Received August 05, 2013)

1093-57-103 **Whitney K George*** (wgeorge@wcupa.edu). *Twist Knots and Thickenings.*

We will sketch a proof that any neighborhood of a positive twist knot $\mathcal{K}_m$ with $m \geq 3$ and odd with extremal Euler number can be thickened to a standard neighborhood of a maximal Thurston-Bennequin number Legendrian representative of $\mathcal{K}_m$. In particular, we will investigate the restrictions on the twist number and on the neighborhoods which lead to open questions. (Received August 05, 2013)

1093-57-106 **Theo Johnson-Freyd*** (theojf@math.northwestern.edu), Department of Mathematics, Northwestern University, 2033 Sheridan Road, Evanston, IL 60208. *Poisson AKSZ theories and quantization.*

I will describe a Poisson generalization of the AKSZ construction of topological field theories. This version of "classical" AKSZ theory exists for all oriented spacetimes, and resides in the world of dioperads and "quasilocal" factorization algebras. The quantization problem is generically obstructed; as I will discuss, "quantum" AKSZ theories are from the world of properads. The quantization problem is closely related to the formality problem for the E_n operad. It is also closely related to the question of finding a geometrically-meaningful properadic homotopy-Frobenius structure at the chain level, lifting the Frobenius-algebra structure on the homology of spacetime. (Received August 05, 2013)

1093-57-120 **Oliver Dasbach** and **Anastasiia Tsvietkova*** (tsvietkova@lsu.edu). *A refined upper bound for the hyperbolic volume of alternating links and the colored Jones polynomial.* Preliminary report.

Since quantum invariants were introduced into knot theory, there has been a strong interest in relating them to the intrinsic geometry of a link complement. This is reflected, for example, in the Volume Conjecture, which claims that the hyperbolic volume of a link complement in S^3 is determined by the colored Jones polynomial.

In the work of M. Lackenby, and of I. Agol and D. Thurston, an upper bound for volume of a hyperbolic link in terms of the number of twists of a link diagram is obtained. We will discuss how to refine this bound for alternating links, and how to express the refined bound in terms of the first three and last three coefficients of the colored Jones polynomial. (Received August 07, 2013)

1093-57-132 **Tarik Aougab*** (tarik.aougab@yale.edu), Yale University Mathematics Department, 10 Hillhouse Avenue, New Haven, CT 06511. *Optimal intersection numbers in the curve graph.*

Let $S_{g,p}$ be an orientable surface with $W(S) = 3g + p - 4 > 0$. We determine a lower bound, in terms of $W(S)$, on the intersection number of any pair of curves on S which are distance k in the corresponding curve graph, and we present an infinite class of examples which demonstrates that this bound is asymptotically sharp in some sense. We use this to show that curve graphs are uniformly hyperbolic, and train track splitting sequences project to R-quasigeodesics in the curve graph of any essential subsurface, where $R \in O(W(S)^2)$.

As an application, we show how to more effectively identify the pseudo-Anosov maps which are generic, in the sense that the attracting lamination intersects each meridian. (Received August 08, 2013)

1093-57-154 **Kate Petersen*** (petersen@math.fsu.edu) and **Alan Reid**. *Gonality and the Character Variety.*

The (P)SL(2,C) character variety of a finite volume hyperbolic 3-manifold is an algebraic set. Points on the variety correspond to hyperbolic structures on the manifold. There have been many interesting connections between these sets and the topology of the underlying manifold. Notably, Culler and Shalen have shown that one can detect surfaces in manifolds by studying valuations at points at infinity on character varieties. Character varieties are difficult to compute, and therefore we have little insight as to how the topology of a manifold is related to geometry of its character variety. When the manifold has only one cusp, the character variety is a

complex curve (a Riemann surface). I will discuss how the two most popular invariants of curves, genus and gonality, are informed by the topology of the manifold. (Received August 11, 2013)

1093-57-155 **Feng Luo*** (fluo@math.rutgers.edu), **David Gu**, **Jian Sun** and **Tianqi Wu**. *A discrete uniformization theorem for polyhedral surfaces.*

A discrete conformality for polyhedral metrics on surfaces is introduced in this paper which generalizes earlier work on the subject. It is shown that each polyhedral metric on a surface is discrete conformal to a unique polyhedral metric of constant curvature. (Received August 11, 2013)

1093-57-163 **Oliver Dasbach** and **Adam Lowrance*** (adlowrance@vassar.edu). *Khovanov homology of oriented ribbon graphs.*

The all-A ribbon graph of a link diagram is an oriented ribbon graph related to the checkerboard graph of the diagram. We construct Khovanov homology for oriented ribbon graphs and show that the Khovanov homology of the all-A ribbon graph of a link diagram is isomorphic to the Khovanov homology of the link. We extend our results for certain virtual links. (Received August 12, 2013)

1093-57-172 **Hongbin Sun***, Department of Math, Princeton University, Fine Hall, Washington Road, Princeton, NJ 08540. *Virtual Homological Torsion of Closed Hyperbolic 3-manifolds.* Preliminary report.

We will generalize Kahn and Markovic's construction of almost geodesic surfaces to construct certain π_1-injective 2-complexes in closed hyperbolic 3-manifolds. Such 2-complexes are locally almost totally geodesic except along a 1-dimensional subcomplex. Using Agol's result that fundamental groups of hyperbolic 3-manifolds are LERF, we will show that closed hyperbolic 3-manifolds virtually contain any prescribed homological torsion: For any finite abelian group A, and any closed hyperbolic 3-manifold M, we can find a finite cover N of M, such that A embeds into $Tor(H_1(N;\mathbb{Z}))$. (Received August 12, 2013)

1093-57-208 **Jason DeBlois*** (jdeblois@pitt.edu), **Stefan Friedl** and **Stefano Vidussi**. *Rank gradient and the JSJ decomposition.*

I will state a couple of results on rank gradient of cyclic covers of 3-manifolds, then focus on a key topological argument in one of them. It bounds the number of times an immersed cylinder can cross a surface S embedded in a hyperbolic 3-manifold M, using the JSJ decomposition of the manifold-with-boundary obtained by cutting M along S. Marc Culler's name for it gives an idea how it goes: 'vegematic argument'. (Received August 14, 2013)

1093-57-216 **John B Etnyre*** (etnyre@math.gatech.edu), **Shea Vela-Vick** and **Rumen Zarev**. *Sutured manifolds, limits and knot Heegaard Floer homology.*

We will discuss how to define two invariants of knots using sutured Heegaard Floer homology, contact structures and limiting processes. These invariants turn out to be a reformulation of the plus and minus versions of knot Heegaard Floer homology and thus give a"sutured interpretation" of these invariants and point to a deep connection between Heegaard Floer theory and contact geometry. If time permits we will also discuss the possibility of defining invariants of non-compact manifolds and of contact structures on such manifolds. (Received August 14, 2013)

1093-57-217 **Lakeland Grant**, 1409 W. Green St., Urbana, IL 61802, and **Christopher Leininger***, 1409 W. Green St., Urbana, IL. *Systoles and Dehn Surgery for 3-manifolds.*

Given a closed hyperbolic 3-manifold M of volume V, and a link $L \subset M$ such that the complement $M \setminus L$ is hyperbolic, we establish a bound for the systole length of $M \setminus L$ in terms of V. This extends a result of Adams and Reid, who showed that in the case that M is not hyperbolic, there is a universal bound of 7.35534... . As part of the proof, we establish a bound for the systole length of a non-compact finite volume hyperbolic manifold which grows asymptotically like $\frac{4}{3}\log V$. This is joint work with Grant Lakeland. (Received August 14, 2013)

1093-57-218 **Jennifer Hom*** (hom@math.columbia.edu). *An infinite rank summand of topologically slice knots.* Preliminary report.

Let C_{TS} be the subgroup of the smooth knot concordance group generated by topologically slice knots. Endo showed that C_{TS} contains an infinite rank subgroup, and Livingston and Manolescu-Owens showed that C_{TS} contains a $\mathbb{Z}^3$ summand. We show that in fact C_{TS} contains a $\mathbb{Z}^\infty$ summand. The proof relies on the knot Floer homology package of Ozsváth-Szabó and the concordance invariant ε. (Received August 14, 2013)

1093-57-227 **Michael Brad Henry*** (mbhenry@siena.edu) and **Dan Rutherford** (drruther@uark.edu). *Ruling polynomials and augmentations of Legendrian links.*

For any Legendrian link L in the standard contact structure on $\mathbb{R}^3$ we define invariants $Aug_m(L,q)$ as normalized counts of augmentations from the Legendrian contact homology DGA of L into a finite field of order q where the parameter m is a divisor of twice the rotation number of L. Generalizing a result of Ng and Sabloff for the case $q = 2$, we show that the augmentation numbers $Aug_m(L,q)$ are determined by specializing the m-graded ruling polynomial, $R^m_L(z)$, at $z = q^{1/2} - q^{-1/2}$. As a corollary, we deduce that the ruling polynomial invariants are determined by the Legendrian contact homology DGA. (Received August 15, 2013)

1093-57-242 **Christopher R Cornwell*** (cornwell@math.duke.edu). *Knot contact homology and representations of the knot group.*

Knot contact homology (KCH) is a robust invariant of knots defined using the symplectic geometry of the cotangent bundle. KCH shares a number of relationships with other knot invariants. These relationships (and others that are conjectured) are found by studying augmentations of the underlying DGA. We will discuss a specialization of KCH where it is known that a certain kind of representation of the knot group (a KCH representation) induces an augmentation on KCH. We show that, in fact, augmentations on this specialization all arise from KCH representations in this way. We also discuss how this correspondence enhances our understanding of the two-variable augmentation polynomial and its relationship to the A-polynomial. (Received August 16, 2013)

1093-57-245 **Dan Rutherford*** (drruther@uark.edu) and **Michael Sullivan**. *On computation of Legendrian contact homology in dimension* 2. Preliminary report.

This is a preliminary report on joint work in progress with Michael Sullivan. The aim is to provide formulas that give the Legendrian contact homology DGA (Differential Graded Algebra) of a 2-dimensional Legendrian in the 1-jet space of a surface. Our approach requires as input a polygonal decomposition of the surface into squares subject to some technical restrictions and so that above each square the crossing and cusp locus of the Legendrian fits one of several standard forms. A DGA stable tame isomorphic to the Legendrian contact DGA of L should then arise so that each closed 2-cell of the decomposition corresponds to a sub-DGA for which the differential has an explicit formula determined by the form of the Legendrian above the 2-cell. (Received August 16, 2013)

1093-57-257 **Tye Lidman** (tlid@math.utexas.edu), Department of Mathematics, University of Texas, 1 University Station C1200, Austin, TX 78712, and **Allison H. Moore*** (allison.h.moore@rice.edu), Department of Mathematics, Rice University, 6100 Main St., Houston, TX 77005. *Pretzel knots admitting L-space surgeries.*

A rational homology sphere whose Heegaard Floer homology is the same as that of a lens space is called an L-space. We will classify pretzel knots with any number of tangles which admit L-space surgeries, and discuss interesting questions that this raises about essential Conway spheres and knot Floer homology. (Received August 17, 2013)

1093-57-258 **Christopher R Cornwell*** (cornwell@math.duke.edu). *The augmentation polynomial of knot contact homology and knot group representations.*

From knot contact homology a three-variable polynomial, called the augmentation polynomial, can be defined. There is a conjectured relationship, similar to the AJ conjecture relating the A-polynomial to colored Jones polynomials, between the augmentation polynomial and the colored HOMFLY-PT polynomials (colored by the symmetric representation).

A specialization of the algebra used in knot contact homology yields a two-variable augmentation polynomial, which is known to have the A-polynomial as a factor. We describe a correspondence between augmentations in this specialization and certain representations of the knot group (KCH representations). The correspondence shows that the two-variable augmentation polynomial may be viewed as a generalized A-polynomial, in that it records the restriction of KCH representations to the peripheral subgroup and 2-dimensional KCH representations give precisely the A-polynomial factor.

As a bonus, the dimension of irreducible KCH representations provides a new method for studying the meridional rank of the knot group and its relationship to the bridge number. (Received August 17, 2013)

1093-57-259 **Keiko Kawamuro***, 14 MacLean Hall, Iowa City, IA 52242, and **Tetsuya Ito**. *The self-linking number of transverse links and sharpness of Bennequin-Eliashberg inequality.* Preliminary report.

I present a braid-theoretic formula of the self-linking number of transverse links in general contact manifolds. The formula generalizes the Bennequin's formula for the standard contact 3-sphere. Then I discuss sharpness of the celebrated Bennequin-Eliashberg inequality that is used to detect tightness of a given contact structure. (Received August 17, 2013)

1093-57-260 **Abhijit Champanerkar** (abhijit@math.csi.cuny.edu), College of Staten Island and Graduate Center, CUNY, New York, NY , and **Philip Ording*** (pording@mec.cuny.edu), Medgar Evers College, CUNY, Brooklyn, NY. *On quasi-alternating Montesinos links.*

Quasi-alternating links are a generalization of alternating links. They are homologically thin for both Khovanov homology and knot Floer homology. Recent work of Greene and Champanerkar-Kofman resulted in the classification of quasi-alternating pretzel links in terms of their integer tassel parameters. Replacing tassels by rational tangles generalizes pretzel links to Montesinos links. This talk presents conditions on the rational parameters of a Montesinos link to be quasi-alternating. Using recent results on left-orderable groups and Heegaard Floer L-spaces, we also obtain conditions on the rational parameters of a Montesinos link to be non-quasi-alternating. (Received August 17, 2013)

1093-57-261 **Olga Plamenevskaya***, Department of Mathematics, Stony Brook University, Stony Brook, NY 11794. *Loose Legendrians and the Plastikstufe.*

In $(\mathbb{R}^3, \xi_{std})$, Legendrian knot theory is very rich. However, in overtwisted contact 3-manifolds, Legendrian knots disjoint from an overtwisted disk can be completely described by their classical invariants. Murphy discovered that in higher-dimensional contact manifolds, such loose knots (whose Legendrian type is determined by classical invariants) exist in abundance; any knot becomes loose after a certain stabilization procedure. This contrasts sharply with the 3-dimensional case: Murphy's result is not limited to "overtwisted" manifolds. In fact, the tight vs. overtwisted dichotomy is not known in higher dimensions, although there are some conjectural generalizations of the overtwisted disk, such as a "plastikstufe". It turns out that in presence of a plastikstufe, all knots that are disjoint from it are loose. (Joint with E. Murphy, K. Niederkrüger, and A. Stipsicz.) (Received August 17, 2013)

1093-57-263 **Elena Pavelescu*** (elena.pavelescu@okstate.edu), Oklahoma State University, Department of Mathematics, Stillwater, OK 74078, and **Danielle O'Donnol** (odonnol@math.okstate.edu), Oklahoma State University, Department of Mathematics, Stillwater, OK 74078. *Transverse push-offs of Legendrian graphs.*

We define the transverse push-off of a Legendrian graph and we determine its self linking number for Legendrian $\theta-$graphs. In the case of topologically planar $\theta-$graphs, we prove that the topological type of the transverse push-off is that of a pretzel link $L(a_1, a_2, a_3)$, whose coefficients a_1, a_2, a_3 are determined by the Thurston-Bennequin number of the graph. (Received August 18, 2013)

1093-57-272 **David Futer***, Mathematics Department, Temple University, 1805 North Broad St., Philadelphia, PA 19147. *The geometry of tunnel systems.* Preliminary report.

In a 3-manifold with torus boundary, a collection of arcs is called a *tunnel system* if their complement is a handlebody. If a tunnel system consists of a single arc, we call it an *unknotting tunnel*.

A longstanding question of Adams asks whether every unknotting tunnel of a hyperbolic 3-manifold is isotopic to a geodesic. I will survey what is known about this question as well its (somewhat subtle) generalization to tunnel systems with multiple arcs.

This is based on joint work with subsets of Daryl Cooper, Jessica Purcell, and Saul Schleimer. (Received August 18, 2013)

1093-57-293 **Jason DeBlois*** (jdeblois@pitt.edu). *A one-parameter family of two-disk packing problems on hyperbolic surfaces.*

"Boröczky's theorem" implies sharp upper bounds r_1 and r_2 for the radius of one or, respectively, two equal-radius metric disks embedded in a hyperbolic genus-two surface without overlapping. For r between r_1 and r_2 and a disk of radius r embedded on such a surface S, I will describe an upper bound on the radius of a second disk embedded on S without overlapping the first. (Received August 19, 2013)

1093-57-297 **Neal W Stoltzfus*** (stoltz@math.lsu.edu), Dept Maths, LSU, Baton Rouge, LA 70803. *Geometric Constructions in Link Theory & Polynomial Invariant Formulae.* Preliminary report.

Many geometric constructions in the theory of classical links can be mirrored in combinatorial setting of the associated Kauffman state ribbon graphs (e.g. all-A or Seifert). In particular, connected sum, mutations, closed braid powers can be treated by these techniques. Analogous constructions will be described for the associated state graphs, together with associated formulae for the rank polynomial & the associated link polynomial invariants. (Received August 19, 2013)

1093-57-330 **Matt Mastin*** (mastinjm@wfu.edu), Department of Mathematics, Wake Forest University, Winston-Salem, NC 27109. *An Enhanced Prime Decomposition Theorem for Knots.*

The prime decomposition theorem for knots, proved by Schubert in 1948, states that a knot can be decomposed uniquely as a connected sum of prime knots. In 1949 Schubert published his result with a new proof which utilized incompressible tori in knot complements. We will discuss an enhanced version of the prime decomposition theorem, inspired by the JSJ decomposition of a knot complement, which incorporates an algebraic structure that is quite useful for tabulating composite knots and computing their intrinsic symmetries (i.e., invertibility and chirality). (Received August 19, 2013)

1093-57-338 **Vaibhav Gadre** and **Saul Schleimer*** (s.schleimer@warwick.ac.uk), Mathematics Institute, University of Warwick, Coventry, CV4 7AL, United Kingdom. *Quasi-convexity in the curve complex.* Preliminary report.

Suppose that τ is a train track on a surface S. Let $C(\tau)$ be the set of curves carried by τ. We show that $C(S) - C(\tau)$ is quasi-convex in the curve complex $C(S)$. (Received August 20, 2013)

1093-57-339 **Thomas C Jaeger*** (tcjaeger@syr.edu). *A decomposition of deformed Khovanov-Rozansky Homology.* Preliminary report.

Khovanov and Rozansky's $\mathbf{sl}(n)$ homology associates a graded chain complex to a knot K. Any polynomial $P(x)$ of degree $n+1$ gives rise to an (ungraded) deformation of this theory, as first observed by Gornik. We show that this deformation decomposes as a direct sum of complexes associated to the roots of $P'(x)$. We conjecture that these summands are isomorphic to $\mathbf{sl}(n_i)$ homology, where the n_i are the multiplicities of the corresponding roots. This generalizes work of Lee and Bar-Natan–Morrison in the $\mathbf{sl}(2)$ case and by MacKaay–Vaz for $\mathbf{sl}(3)$. (Received August 20, 2013)

1093-57-344 **Chris Hays***, cshays@math.msu.edu. *k-fold sums.*

We develop a method for creating concave fillings of certain torus bundles over S^1 by using a configuration of k pairs of symplectic surfaces $\{S_i, T_i\}_{i=1}^k$ in a closed symplectic 4-manifold, such that S_i intersects T_i transversely in a single point and T_i is symplectomorphic to S_{i+1}. We proceed to identify the induced contact structure on the boundary. In many cases we can find a convex filling for this contact structure, allowing us to extend the concave filling to a closed symplectic 4-manifold. (Received August 20, 2013)

1093-57-361 **Patricia Cahn*** (pcahn@math.upenn.edu) and **Asa Levi**. *Finite-Type Invariants of Virtual Legendrian Knots.*

We introduce a theory of virtual Legendrian knots. A virtual Legendrian knot is a cooriented wavefront on an oriented surface up to Legendrian isotopy of its lift to the unit cotangent bundle and stabilization and destablization of the surface away from the wavefront. We show that the groups of Vassiliev invariants of virtual Legendrian knots and of virtual framed knots are isomorphic. In particular, Vassiliev invariants cannot be used to distinguish virtual Legendrian knots that are isotopic as virtual framed knots and have equal virtual Maslov numbers. (Received August 20, 2013)

1093-57-379 **Yair N Minsky*** (yair.minsky@yale.edu), Yale University Dept. of mathematics, 10 Hillhouse Ave, New Haven, CT 06520. *Uniform phenomena on boundaries of 3-manifolds.*

When a hyperbolic 3-manifold is obtained as a boundary gluing of simpler 3-manifolds, the geometry of the result is controlled by the geometry of the pieces but not always in a way that is easy to quantify. I will discuss some uniformity properties of such gluings, in particular control of Thurston's skinning map in some settings (joint with Kent) and of JSJ decompositions in other settings (joint with Brock, Namazi and Souto). (Received August 20, 2013)

58 ► Global analysis, analysis on manifolds

1093-58-185 **Pierre Albin*** (palbin@illinois.edu), Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 West Green Street, Urbana, IL 61801. *Hodge cohomology on singular spaces.*

The cohomology of any smooth closed manifold can be represented analytically as the de Rham group of closed forms modulo exact forms. If the manifold has a Riemannian metric, then in each cohomology class we can find a unique harmonic representative.

On singular spaces the situation is more complicated. If the singularities are geometrically controlled, in that the space is 'stratified,' then there is an analogous story as long as the cohomology and the metric are adapted to the singularities. These spaces arise naturally when studying smooth spaces or maps, for instance, as algebraic varieties, orbit spaces or moduli spaces.

The seminal work on these cohomologies is due to Goresky-MacPherson and Cheeger. I will report on joint work with Eric Leichtnam, Rafe Mazzeo, and Paolo Piazza extending and refining these theories to general stratified spaces. (Received August 13, 2013)

1093-58-187 **Jochen W. Brüning*** (bruening@mathematik.hu-berlin.de), Institute for Mathematics, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany. *On the spectral theory of Whitney stratified spaces.*

Let W be a Whitney stratification in the sense of [1], which we assume to be compact, oriented, with dense top stratum, M of dimension m, and without strata of codimension 1. We fix a conic metric, g, on M and consider its Hodge-de Rham operator, i.e. the self-adjoint operator

$$D := \bar{d} + d^* : \mathcal{D}(\bar{d}) \cap \mathcal{D}(d^*) \to \lambda_{(2)}(M).$$

Here, $\lambda_{(2)}(M)$ denotes the Hilbert space of g-square integrable differential forms on M, $\bar{d}$ the closure of d with domain the compactly supported forms in $\lambda_{(2)}(M)$, and d^* its adjoint. We will describe conditions under which D has resolvent in the Schatten class of order p, for any $p > m$, and discuss the index calculation for reductions of D by self-adjoint anticommuting involutions in $\lambda_{(2)}(M)$. The method we use is closely related to the work in [2]. Finally, we will discuss the question to what extent the singular character of W can be detected by the spectrum of D.

[1] J. Mather, *Notes on topological stability*, Bull. AMS **49** (2012), 475-506.

[2] J. Brüning, *The signature operator on manifolds with a conical singular stratum*, Astérisque **328** (2009), 1-44.

(Received August 13, 2013)

1093-58-188 **Ursula Ludwig*** (ursula.ludwig@math.u-psud.fr), Département de Mathématiques, Faculté des Sciences d'Orsay, Université Paris-Sud, 91405 Orsay Cedex, France. *Witten deformation on singular spaces using radial Morse functions.*

The Witten deformation is an analytical method proposed by Witten in the 80's which, given a Morse function $f : M \to \mathbb{R}$ on a smooth compact Riemannian manifold M, leads to a proof of the famous Morse inequalities.

The aim of this talk is to present a generalization of the Witten deformation to a singular space X with cone-like singularities and radial Morse functions. As a result one gets Morse inequalities for the L^2-cohomology, or dually for the intersection homology of the singular space X. Moreover, as in the smooth theory, one can relate the Witten complex, *i.e.* the complex generated by the eigenforms to small eigenvalues of the Witten Laplacian, to an appropriate geometric complex (a singular analogue of the smooth Morse-Thom-Smale complex).

Radial Morse functions are inspired from the notion of a radial vectorfield on a singular space. Radial vectorfields have first been introduced by Marie-Hélène Schwartz to define characteristic classes on singular varieties. (Received August 13, 2013)

1093-58-189 **Chris Kottke***, Department of Mathematics, Northeastern University, 360 Huntington Ave, Boston, MA 02115. *Callias' index theorem and monopole deformation.*

I will discuss an extension of the classical index theorem of Callias, the principal application of which is a computation of the virtual dimension of the moduli space of SU(2) magnetic monopoles on asymptotically conic 3-manifolds. I will also discuss ongoing work on the construction of such monopoles by gluing methods. (Received August 13, 2013)

1093-58-191 **Kiril Datchev***, Department of Mathematics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Room E17-301R, Cambridge, MA 02139. *Quantitative limiting absorption principles and improvements away from the trapped set.*

We present a new, simplified proof of Burq's quantitative limiting absorption principle for semiclassical Schrödinger operators. As a byproduct we obtain improved resolvent estimates away from the trapped set in the style of Burq and Cardoso–Vodev. (Received August 13, 2013)

1093-58-192 **Emily B. Dryden*** (emily.dryden@bucknell.edu), Department of Mathematics, One Dent Drive, Bucknell University, Lewisburg, PA 17837, **Thomas Kappeler** (thomas.kappeler@math.uzh.ch), Institut für Mathematik, Universität Zürich, Winterthurerstrasse 190, 8057 Zürich, Switzerland, and **Michiel van den Berg** (m.vandenberg@bris.ac.uk), School of Mathematics, University of Bristol, University Walk, Bristol, BS8 1TW, United Kingdom. *Isospectrality and heat content.*

The examples of isospectral non-isometric "drums" constructed by Carolyn Gordon, David Webb, and Scott Wolpert show that one cannot hear the shape of a piecewise smooth planar domain D. They also tell us that the eigenvalues of the Dirichlet Laplace operator acting on smooth functions on D form an incomplete set of geometric invariants, and it is therefore natural to look for ways to distinguish such non-isometric sound-alike drums. We will discuss what we can learn from heating these drums and studying the amount of heat in them over time. (Received August 13, 2013)

1093-58-193 **Patrick McDonald*** (mcdonald@ncf.edu), Department of Mathematics, New College of Florida, 5800 Bay Shore Road, Sarasota, FL 34243. *Inverse problems for metric graphs and heat content.*

Metric graphs have found applications in a wide variety of contexts, both inside and outside of mathematics. The literature on metric graphs includes a well-developed spectral theory with a number of associated inverse spectral results. We investigate a collection of related problems involving the heat content for metric graphs. In particular, we prove that there are isospectral nonisometric metric graphs which are distinguished by their heat content. In addition, we establish conditions under which it is possible to determine a metric graph using heat content. (Received August 13, 2013)

1093-58-194 **Iosif Polterovich** (iossif@dms.umontreal.ca), Département de mathématiques, Université de Montréal, CP 6128 succ. Centre-Ville, Montreal, QC H3C 3J7, Canada, and **David A. Sher*** (dsher@umich.edu), Department of Mathematics, University of Michigan, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109-1043. *Heat invariants of the Steklov problem.*

We study the heat invariants associated to the Steklov eigenvalue problem on a Riemannian manifold with boundary. Using the Seeley calculus, we prove a general structure theorem for these invariants. We also compute the first few heat invariants explicitly, which identifies several new Steklov spectral invariants. In particular, we prove that the total mean curvature is a Steklov spectral invariant whenever the dimension of the manifold is at least 3. As an application, we prove global Steklov spectral rigidity for a ball in $\mathbb{R}^3$: if a compact domain in $\mathbb{R}^3$ with smooth connected boundary has the same Steklov spectrum as a ball, then it is a ball. (Received August 13, 2013)

60 ► Probability theory and stochastic processes

1093-60-15 **Triet M Pham*** (pmtriet00@yahoo.com). *Non-Markovian zero-sum stochastic differential games and path dependent Bellman-Isaacs equations.*

We present our recent results on non-Markovian two person zero-sum stochastic differential games where both players use feedback controls. In the literature, stochastic control and game problems have been studied extensively. A very useful technique there is to characterize the value process as the viscosity solution of the corresponding HJB equation (in a control problem) or Bellman Isaacs equation (in a game problem). But in order to apply this technique, the problem has to be Markovian in nature. From recent work on viscosity solutions of path dependent PDEs, a notion recently introduced by Ekren-Keller-Touzi-Zhang and Ekren-Touzi-Zhang, non-Markovian problems can be investigated in a similar way. In this talk, we will present the main definitions and results of viscosity solutions to path dependent PDEs. Finally we will go back to the game problem, and show that the game has value by the characterization technique. This is joint work with Jianfeng Zhang. (Received June 02, 2013)

1093-60-18 **Ibrahim Ekren*** (ekren@usc.edu), 3620 s Vermont ave, USC Math dept, KAP 104, Los Angeles, CA 90089-2532. *Viscosity solutions of obstacle problems for Fully nonlinear path-dependent PDEs.*

In this talk, we adapt the definition of viscosity solutions to the obstacle problem for fully nonlinear path-dependent PDEs with data uniformly continuous in (t, ω), and generator Lipschitz continuous in (y, z, γ). We prove that our definition of viscosity solutions is consistent with the classical solutions, and satisfy a stability result. We show that the value functional defined via the second order reflected backward stochastic differential equation is the unique viscosity solution of the variational inequalities. (Received June 03, 2013)

1093-60-37 **Tim Leung*** (tl2497@columbia.edu) and **Jinbeom Kim**. *Reaction-Diffusion PDEs in Mathematical Finance.* Preliminary report.

We discuss a number of reaction-diffusion PDEs and their applications to Mathematical Finance. In order to solve these PDEs, we provide a fixed-point theorem that yields the unique generalized solution. This naturally leads to an iterative finite-difference method based on contraction mapping. (Received July 01, 2013)

1093-60-43 **José Enrique Figueroa-López** (figueroa@purdue.edu), 250 N. University Street, Department of Statistics, Purdue University, West Lafayette, IN 47907-2066, **Ruoting Gong*** (rgong@math.rutgers.edu), 110 Frelinghuysen Road, Department of Mathematics, Rutgers University, Piscataway, NJ 08854-8019, and **Christian Houdré** (houdre@math.gatech.edu), 686 Cherry Street, School of Mathematics, Georgia Institute of Technology, Atlanta, GA. *Small-time Asymptotics for ATM option prices under exponential Lévy models.*

The short-time asymptotic behavior of option prices for a variety of models with jumps has received much attention in recent years. In the present work, a novel second-order approximation for ATM option prices is derived for a large class of exponential Lévy models with or without Brownian component. The results hereafter shed new light on the connection between both the volatility of the continuous component and the jump parameters and the behavior of ATM option prices near expiration. The asymptotic behavior of the corresponding Black-Scholes implied volatilities is also addressed. Our approach is sufficiently general to cover a wide class of Lévy processes which satisfy the latter property and whose Lévy densities can be closely approximated by a stable density near the origin. Our numerical results show that first-order term typically exhibits rather poor performance and that the second-order term significantly improves the approximation's accuracy. (Received August 15, 2013)

1093-60-68 **Dan Pirjol*** (dpirjol@gmail.com). *Moment explosion in the Hull-White stochastic volatility model in discrete time.*

The talk considers moment explosion in the Hull-White stochastic volatility model with log-normally distributed instantaneous volatility (log-normal SABR model) with zero correlation, under a time discretization given by the Euler-Maruyama scheme. The positive integer moments can be computed exactly and are found to have explosive behavior at certain critical values of the vol of vol parameter. The explosion and its properties can be related to the position of the complex zeros of a polynomial, which is similar to the Lee, Yang picture of the phase transitions in statistical mechanics. The known continuous time results are recovered in the limit of a very small time step. (Received July 27, 2013)

1093-60-71 **Andrea Pascucci*** (andrea.pascucci@unibo.it), **Matthew Lorig** and **Stefano Pagliarani**. *Implied vol for any local-stochastic vol model.*

We consider an asset whose risk-neutral dynamics are described by a general local-stochastic volatility model. In this setting, we derive a family of asymptotic expansions for the transition density of the underlying as well as for European-style option prices and for implied volatilities. Our expansions are numerically efficient. Approximate transition densities and implied volatilities are explicit; they do not require any special functions nor do they require numerical integration. Approximate option prices require only a Normal CDF (as is the case of the Black-Scholes setting). Additionally, we establish rigorous error bounds for our transition density expansion. To illustrate the accuracy and versatility of our implied volatility expansion, we implement this expansion under classical model dynamics: Heston stochastic volatility, 3/2 stochastic volatility, and SABR local-stochastic volatility. Our implied volatility expansion is found to perform favorably compared to other well-known expansions for these models. (Received July 28, 2013)

1093-60-72 **Ioannis Karatzas** (ik@math.columbia.edu), 2990 Broadway, New York, NY 10027, and **Qinghua Li*** (ms.qinghuali@gmail.com), Unter den Linden 6, 10099 Berlin, Germany. *Impulse Control of a Diffusion with a Change Point.*

This paper solves a Bayes sequential impulse control problem for a diffusion, whose drift has an unobservable parameter with a change point. The partially-observed problem is reformulated into one with full observations, via a change of probability measure which removes the drift. The value function of the control problem is characterized as the unique viscosity solution to a non-stationary variational inequality. The optimal impulse controls can be expressed in terms of the solutions and the current values of a Markov process adapted to the observation filtration. We shall illustrate the application of our results to algorithmic trading in a geometric Brownian motion stock price model with drift uncertainty. (Received July 28, 2013)

1093-60-93 **Moustapha N Pemy*** (mpemy@towson.edu), Mathematics Department, 8000 York Road, Towson, MD 21252. *Optimal Stopping of Markov Switching Lévy Processes.*

We consider a finite time horizon optimal stopping of a regime switching Lévy process. We prove that the value function of the optimal stopping problem can be characterized as the unique viscosity solution of the associated Hamilton-Jacobi-Bellman (HJB) variational inequalities. We apply our result in the investigation of the best selling time for financial securities in a regime-switching Lévy market. A numerical example is provided. (Received August 02, 2013)

1093-60-124 **Steven J Miller*** (sjm1@williams.edu), 18 HOXSEY ST, WILLIAMSTOWN, MA 01267. *Mind the Gap: Distribution of Gaps in Generalized Zeckendorf Decompositions.*

Zeckendorf proved that any integer can be decomposed uniquely as a sum of non-adjacent Fibonacci numbers, F_n. Using continued fractions, Lekkerkerker proved the average number of summands of an $m \in [F_n, F_{n+1})$ is essentially $n/(\phi^2+1)$, with ϕ the golden ratio. Miller-Wang generalized this by adopting a combinatorial perspective, proving that for any positive linear recurrence the number of summands in decompositions for integers in $[A_n, A_{n+1})$ converges to a Gaussian distribution as $n \to \infty$.

We prove the probability of a gap larger than the recurrence length converges to decaying geometrically, and that the distribution of the smaller gaps depends on the coefficients of the recurrence. These results hold both for the average over all $m \in [A_n, A_{n_1})$, as well as holding almost surely for the gap measure associated to individual m. The techniques can also be used to determine the distribution of the longest gap between summands (which is similar to the distribution of the longest gap between heads in tosses of a biased coin), as well as for far-difference representations (where positive and negative summands are allowed). This is joint work with Amanda Bower, Louis Gaudet, Rachel Insoft, Shiyu Li and Phil Tosteson. (Received August 08, 2013)

1093-60-126 **Konstantinos Spiliopoulos*** (kspiliop@math.bu.edu), Boston University, Department of Mathematics and Statistics, 111 Cummington Mall, Boston, MA 02215, and **Andrew Papanicolaou**. *Filtering the Maximum Likelihood for Multiscale Problems.*

In this talk, I will discuss recent work on filtering and parameter estimation under partial information for multiscale problems. Under suitable assumptions, the nonlinear filter converges in mean square sense to a filter of reduced dimension. Additionally, we establish a central limit theorem correction for the the conditional (on the observations) log-likelihood process. To achieve this we assume that the operator of the (hidden) fast process has a discrete spectrum and an orthonormal basis of eigenfunctions. Based on these results, we then propose to estimate the unknown parameters of the model based on the limiting log-likelihood, which is an easier function to optimize because it is of reduced dimension. We also establish consistency and asymptotic normality of the maximum likelihood estimator based on the reduced log-likelihood. Simulation results illustrate our theoretical findings. Partial motivation for this work is the statistical analysis of partially observed multiscale diffusion models coming from financial applications, e.g., nonpredatory high frequency trading (HFT) or detection of an increased bid-ask spread which may correspond to increased volatility. This is joint work with Andrew Papanicolaou. (Received August 08, 2013)

1093-60-143 **Igor Cialenco** (igor@math.iit.edu), Engineering 1, Room 125B, 10 W. 32nd Street, Chicago, IL 60616, and **Liaosha Xu*** (lxu29@hawk.iit.edu), 2800 S Lowe Ave. Side 2R, Chicago, IL 60616. *Hypothesis Testing for Stochastic PDEs Driven by Additive Noise.*

In this paper, we study the simple hypothesis testing problem for the drift/viscosity coefficient for stochastic fractional heat equation driven by additive space-time white noise colored in space. We assume that the first N Fourier modes of the solution are observed continuously over time interval $[0,T]$. We introduce the notion of asymptotically the most powerful test, and find explicit forms of such test in two asymptotic regimes: large time asymptotics $T \to \infty$, and increasing number of Fourier modes $N \to \infty$. The proposed statistics are derived

based on Maximum Likelihood Ratio. Over the course of proving the main results, we obtain a series of technical results that are also of independent interest. In particular, we find the cumulant generating function of the log-likelihood ratio, we obtain some sharp large deviation type results for both $T \to \infty$ and $N \to \infty$, and find some useful asymptotics for the power of the likelihood ratio type tests. (Received August 09, 2013)

1093-60-152 **Kasper Larsen*** (kasperl@andrew.cmu.edu), kasperl@andrew.cmu.edu, and **Mete Soner** and **Gordan Zitkovic**. *Face-lifting in convex optimization.* Preliminary report.

In the Brownian diffusion setting we consider a general class of non-linear convex minimization problems phrased over a convex set of probability measures. We explicitly compute the value function's boundary and maturity behavior. Our main result provides necessary and sufficient conditions for the non-existence of a face-lift (boundary layer) at maturity.

Joint work with Mete Soner and Gordan Zitkovic. (Received August 11, 2013)

1093-60-174 **Martin Larsson*** (martin.larsson@epfl.ch), Swiss Finance Institute, Ecole Polytechnique Fédérale de Lausanne, 1022 Lausanne, Switzerland. *Polynomial preserving diffusions and applications in Finance.*

Polynomial preserving processes is a class of multivariate Markov processes extending the important class of affine processes. They are defined by the property that the semigroup leaves the space of polynomials of degree at most n invariant, for each n, which has significant consequences for the tractability of models based on these processes. In this talk I will indicate how such models can be constructed, and then focus on existence and uniqueness of polynomial preserving diffusions via SDE methods. As in the affine case, a key difficulty is that the coefficients of the SDE become degenerate at the boundary of the state space. In the context of PDE based pricing in finance, this reinforces the need for methods capable of dealing with the boundary degeneracies. *This research is joint work with Damir Filipović, funded by the European Union's Seventh Framework Programme (FP/2007-2013) / ERC Grant Agreement n. 307465-POLYTE.* (Received August 13, 2013)

1093-60-200 **Tomasz R. Bielecki** (bielecki@iit.edu), **Igor Cialenco** (igor@math.iit.edu) and **Marcin Pitera*** (marcin.pitera@uj.edu.pl). *Dynamic limit growth indices.*

We will focus on the dynamic analog of Risk sensitive criterion, which is an objective function designed to measure the efficiency of the long run cumulative growth of the portfolio. The main result of our work is full time-consistency characterisation, with respect to the time-consistency definition proposed for dynamic acceptability indices by T. R. Bielecki, I. Cialenco and Z. Zhang (2012). We show that for risk-seeking case acceptance consistency is preserved, for risk-averse case we have rejection consistency and risk-neutral case does not possess any kind of consistency in general. Next we propose a new class of assessment indices which could be seen as a generalisation of the risk sensitive criterion. With infinite discrete time horizon and a wealth process V they could be described as

$$\varphi(V) := \liminf_{T\to\infty} \frac{\mu(\ln \frac{V_T}{V_0})}{T}$$

where $\mu : L^1 \to \bar{\mathbb{R}}$ is an assessment index. Next we define the dynamic analog of such indices and discuss its properties, propose explicit families and show connections with dynamic acceptability indices. (Received August 13, 2013)

1093-60-299 **Samuel F Feng*** (sffeng@math.princeton.edu). *The neural dynamics of (almost) optimal decisions.* Preliminary report.

Moment by moment, we make decisions which involve both difficult deadlines and noisy information. How do we do this? How do our brains formulate decisions and actions based on prior experience, poor data, and time pressure? Furthermore, how do the dynamics of ≈100 billion neurons reflect the underlying computations which result in almost optimal behavior? In this talk, I will describe the mathematical models, psychophysical experiments, and neurophysiological discoveries which have illuminated neural mechanisms responsible for some simple decision making scenarios. The remainder of the talk will focus on some recent modeling work and results further some experimentally observed behaviors. In particular, we will propose that modeling evidence accumulation with a Lévy process produces good fits to experimental data, compared to other popular reaction time models. Furthermore, by using such stochastic processes, we give another account for why humans behave almost optimally in certain simple decision making situations.

This talk will draw on joint work with Jonathan Cohen, Philip Holmes, and Michael Schwemmer. This research is supported by Princeton University, AFOSR, and NIH. (Received August 19, 2013)

1093-60-302 **Michael Carlisle*** (michael.carlisle@baruch.cuny.edu), New York, NY, and **Olympia Hadjiliadis** and **Ioannis Stamos**. *Trends and Trades: Trend-based trading scheme using CUSUM.* Preliminary report.

In this work, we build a trend following algorithm based on the sequential statistical rule known as the cumulative sum (CUSUM), which has traditionally been used for the online detection of abrupt changes in the distribution of sequences of observations. We draw connections between these statistics and the problem of online statistical surveillance and quality control, which dates back to the 1930s. We build a trading strategy based on the CUSUM stopping rule and apply it to high-frequency tick data from 5-year and 30-year US Treasury notes sold at auction. We analyze the performance of the proposed trend following strategy in detail. In particular, it is seen that the proposed trading rule is most profitable during times of market instability and long trends. We further calculate in closed form the expected value of the gain of the proposed strategy for a class of random walk models. Not surprisingly, it is seen that the suggested strategy is most profitable in biased random walks but is indifferent to the direction of the bias. We also examine the performance of the proposed strategy in simulated data from a variety of random walk models and analyze this behavior in relation to the analytical results and the results of the performance of the strategy on the actual data. (Received August 19, 2013)

1093-60-311 **Yu-Jui Huang*** (jayhuang0512@gmail.com), **Xiaoshan Chen**, **Qingshuo Song** and **Chao Zhu**. *The Stochastic Solution to a Cauchy Problem Associated with Nonnegative Price Processes.*

We consider the stochastic solution to a Cauchy problem corresponding to a nonnegative diffusion with zero drift, which represents a price process under some risk-neutral measure. When the diffusion coefficient is locally Hölder continuous with some exponent lying in $(0, 1]$, the stochastic solution is shown to be a classical solution. A comparison theorem for the Cauchy problem is also proved, without the linear growth condition on the diffusion coefficient. Moreover, we establish the equivalence: the stochastic solution is the unique classical solution to the Cauchy problem if, and *only if*, a comparison theorem holds. (Received August 19, 2013)

1093-60-314 **Samu Alanko*** (samu.alanko@nyu.edu), Courant Institute of Mathematical Sciences, New York University, 251 Mercer Street, New York, NY 10012, and **Marco Avellaneda** (avellaneda@courant.nyu.edu), Courant Institute of Mathematical Sciences, New York University, 251 Mercer Street, New York, NY 10012. *Reducing variance in the numerical solution of BSDEs.*

Numerical methods based on time discretization and estimation of conditional expectations for solving backward stochastic differential equations (BSDEs) have been the object of considerable research, particularly in view of the applications to finance. We introduce and implement a simple control variate technique to reduce the simulation error of the conditional expectation estimates in BSDE methods. These modifications increase the accuracy of the existing algorithms without additional computational cost. (Received August 19, 2013)

1093-60-354 **James M. Haley*** (kapucensko51@comcast.net). *Avoiding Financial Chaos.*

This paper analyzes the conditions that make financial forecast errors evolve in a chaotic or normal way. For example, if nonlinear feedback exists in the stock market, financial chaos can emerge, when short and long term interest rates diverge. These skewed errors can be modeled by a Sprott dynamic system, a simple way to model chaotic cycles in continuous time. It can be demonstrated that a prudent policy exists that avoids financial chaos. What is required is to synchronize the short and long term interest rates to be the same, fixed real expectation. Only then will everyone, including central banks, make more reliable forecasts. In this case stock returns are more normally distributed, such that the stock market becomes a fair game. (Received August 20, 2013)

65 ► Numerical analysis

1093-65-110 **Dong Zhou*** (dzhou@temple.edu), 1805 N broad st, Room 638 Wachman Hall, Department of Mathematics Temple University, philadelphia, PA 19122. *Jet Schemes for Hamilton-Jacobi Equations Using an Evolve-and-project Framework.* Preliminary report.

Jet schemes are based on tracking characteristics and using suitable Hermite interpolations to achieve high order. For Hamilton-Jacobi equations, the characteristic equations are in general nonlinear, i.e. the characteristic curves may collide or emanate radially for local extrema. We demonstrate that in these situations, the use of explicit schemes for solving the characteristic equations can yield incorrect results. We therefore propose an implicit update rule that is based on solving a constrained polynomial optimization problem in each grid cell, and then reconstructing the solution from Hermite interpolations and evolving it in time. Numerical tests show that this

implicit approach approximates entropy solutions correctly and achieves high order accuracy in the smooth part of the solution. Moreover, we demonstrate that this approach can be interpreted as an evolve-and-project process similar to the advect-and-project approach for linear advection equations. (Received August 06, 2013)

1093-65-228 **Vladimir Druskin***, druskin1@slb.com, and **Rob Remis** and **Mikhail Zaslavsky**. *Matrix Functions and Their Krylov Approximations for Wave Propagation in Unbounded Domains.*

Solution of wave problems in unbounded domains requires computation of the exponential of the spatial PDE operator with continuous spectrum. To avoid spurious resonances, the reduced order model should preserve spectral continuity of the original problem. The authors introduce so-called stability-corrected time-domain exponential (SCTDE) of dumped discretization matrix possessing this conservation property. However, convergence of the Krylov subspace approximation of the SCTDE matrix function decelerates due to appearance of the square root singularity. We improve convergence by employing extended Krylov subspace. (Received August 15, 2013)

1093-65-279 **Benjamin Seibold*** (seibold@temple.edu), Philadelphia, PA, **Prince Chidyagwai**, Baltimore, MD, **Rodolfo Ruben Rosales**, Cambridge, MA, **David Shirokoff**, Montreal, Canada, and **Dong Zhou**, Philadelphia, PA. *Meshfree Finite Differences for a Pressure Poisson Equation Reformulation of the Navier-Stokes Equations with Electric Boundary Conditions.*

We present a specific Pressure Poisson Equation (PPE) reformulation of the Navier-Stokes equations for whose approximation meshfree finite difference present themselves advantageous over alternative approaches. In contrast to projection methods, PPE reformulations solve a Poisson equation for the pressure before, rather than after, the update step for the velocity field, and thus are devoid of numerical boundary layers and allow for high-order time stepping. The specific form studied here satisfies "electric" boundary conditions. Its convergent numerical approximation via unstructured mesh finite element approaches fails without the choice of sophisticated elements; and in immersed boundary approaches, the electric boundary condition must be imposed in a non-intuitive least-squares sense. In contrast, a straightforward meshfree finite difference discretization of the PDE and its boundary conditions turns out to lead to a successful numerical scheme. (Received August 18, 2013)

1093-65-296 **Louis F Rossi*** (rossi@math.udel.edu), Department of Mathematical Sciences, Newark, DE 19716. *Visualizing Vorticity: Using BlobFlow to study the inverse cascade.*

The inverse cascade refers to the relaxation of chaotic distributions of vorticity into a small number of concentrated regions of vorticity under the dynamics of the two-dimensional Navier-Stokes equations. A small number of analytical results and a larger body of computational results suggest that the vorticity field should relax into a small number Lamb-Oseen monopoles surrounded by vast regions of irrotational fluid. The majority of computational studies are limited to periodic boundary conditions with hyperviscosity. The elliptical corrected core spreading vortex method (ECCSVM) is a different approach that captures the viscous Navier-Stokes equations on unbounded domains using high order elliptical Gaussian basis functions. We present new BlobFlow calculations demonstrating the emergence of stable coherent dipoles from disordered initial conditions. BlobFlow is an open, parallel implementation of ECCSVM that facilitates accurate extended calculations of vorticity fields. One of the challenges of using meshfree methods is a dearth of friendly tools for exploring results that are representation as linear combinations of anisotropic basis functions. We present a new tool for visualizing and sharing meshfree, computational results over the internet. (Received August 19, 2013)

1093-65-300 **Quan Deng**, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716, and **Tobin A. Driscoll*** (driscoll@udel.edu), Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Fast adaptive multiquadric interpolation.*

Multiquadric (MQ) radial basis functions are a popular choice for meshfree interpolation and the solution of PDEs. They provide highly accurate approximations that use degrees of freedom efficiently. However, MQ interpolation leads to dense and potentially ill-conditioned linear algebra problems. Previous work has shown that residual-based adaptation of the nodes and shape parameters can control the conditioning. Pairing this strategy with a treecode for fast forward evaluation and an embarrassingly parallel restricted additive Schwarz preconditioner allows the solution on n nodes to be done in nearly $O(n \log n)$ time on typical cases. (Received August 19, 2013)

1093-65-316 **Alexander Kurganov*** (kurganov@math.tulane.edu). *Particle Methods for PDEs Arising in Financial Modeling.*

We numerically study convection-diffusion equations arising in financial modeling. We focus on the convection-dominated cases, in which the diffusion coefficients are small. Both finite-difference and Monte-Carlo methods which are widely used in the problems of this kind might be inefficient due to severe restrictions on the meshsize and the number of realizations needed to achieve high resolution.

We propose an alternative approach based on particle methods which have extremely low numerical diffusion and thus do not have the aforementioned restrictions. Our approach is based on the operator splitting: The hyperbolic steps are made using the method of characteristics, while the parabolic steps are performed using either a special discretization of the integral representation of the solution (which leads to a deterministic particle method) or a stochastic random walk approach.

We apply the designed particle methods to a variety of test problems and the numerical results indicate high accuracy, efficiency and robustness of both the deterministic and stochastic methods. In addition, our numerical experiments clearly demonstrate that the deterministic particle method outperforms its stochastic counterpart. (Received August 19, 2013)

1093-65-327 **Zhenyu He*** (zhenyuhe@math.udel.edu), 15 Orchard Rd, Rm 116, Newark, DE 19716, and **Lou Rossi** (rossi@math.udel.edu), 524 Ewing Hall, Department of Mathematical Sciences, University of Delaware, Newark, DE 19716. *Comparison study of meshfree methods for viscous flow.*

We compare and contrast two meshfree schemes for viscous flow: Smoothed particle hydradynamics (SPH) and vortex methods (VM). SPH and VM are widely used meshfree particle in fluid dynamic applications. SPH is more flexible for capturing multiphysics problems. VM is better developed theoretically but has a more limited scope of applications. In SPH, the state of fluid system is represented by a set of moving basis functions which represent material properties such as density and momentum. Vortex particle methods represent a discretization of the vorticity field and use a Greens kernel to determine the velocity field. Our aim is to clarify the role played by the most commonly used viscous terms in SPH and VM in simulating incompressible fluid flow. Special test problems are used in order to remove the boundary effect to the results. We will present the accuracy and the efficiency of the different schemes which highlight the importance of key parameters in the algorithms including core width, overlap and equations of state. (Received August 19, 2013)

1093-65-345 **Stephen Shipman*** (shipman@math.lsu.edu), **Oscar Bruno**, **Catalin Turc** and **Stephanos Venakides**. *Evaluation of 2D-periodic 3D EM scattering at Wood-anomaly frequencies.*

Computation of EM scattering by a doubly periodic grating near cutoff, or Wood, frequencies is notoriously difficult because of the divergence of the Green function. This is due to one of the Fourier modes striking the grating at grazing incidence. To compute scattering in this regime, we modify the Green function by adding two types of terms to it. The first type adds weighted spatial shifts of the Green function to itself with singularities below the grating; this yields algebraic convergence. The second-type terms are quasi-periodic plane wave solutions of the Helmholtz equation. They reinstate (with controlled coefficients) the grazing modes, effectively eliminated by the terms of first type. These modes are needed in the Green function for guaranteeing the well-posedness of the boundary-integral equation for the scattered field. (Received August 20, 2013)

1093-65-346 **David Nicholls*** (davidn@uic.edu), Department of Math, Stat, and CS, University of Illinois at Chicago, 851 South Morgan Street (MC 249), Chicago, IL 60607, and **David Ambrose**. *Fokas Integral Equations for Layered Media Scattering.*

In this talk we describe a class of Integral Equations to compute Dirichlet-Neumann operators for the Helmholtz equation on periodic domains inspired by the recent work of Fokas and collaborators on novel solution formulas for boundary value problems. These Integral Equations have a number of advantages over standard alternatives including: (i.) ease of implementation (high-order spectral accuracy is realized without sophisticated quadrature rules), (ii.) seamless enforcement of the quasiperiodic boundary conditions (no periodization of the fundamental solution, e.g. via Ewald summation, is required), and (iii.) reduced regularity requirements on the interface profiles (derivatives of the deformations do not appear explicitly in the formulation). We show how these can be efficiently discretized and utilized in the simulation of scattering of linear acoustic waves by periodic layered media which arise in geoscience applications. (Received August 20, 2013)

1093-65-388 **Jinpyo Hong*** (alexitooo7@gmail.com), 29 Washington St., Tenafly, NJ 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07670. *Influence of Eccentric Loading and Size of Implant Fixture on the Stress Distribution in the Implant.*

The objective of this study is to analyze the relation between eccentricity-implant diameter and reaction force-implant diameter. The effects of the eccentric loading, and the size of the implant fixture are the study's main focus.

Finite element models were constructed in mandible having a single screw-type implant fixture connected to the premolar superstructure, in order to evaluate how the length, diameter and platform shape of a screw-type fixture influenced the stress in the supporting tissue around the fixtures. These finite element models varied in terms of length, diameter, and platform shape of the fixture.

It is shown that through distributed loading, the stress is larger at the abutment/fixture interface, and in the crestal bone, compared to the stress pattern under vertical loading. Around the wider fixture, the stress was decreased at the abutment/fixture interface, and the bone crest and increased in the cancellous bone area apical to the fixture. Around the fixture having wider platform, less stress was produced at the abutment/fixture interface and the upper part of the cortical bone, compared to the fixture having standard platform. The amount of stress at the superstructure was similar regardless of the length, diameter, and platform shape of a fixture. (Received August 21, 2013)

68 ► Computer science

1093-68-9 **A Rao*** (angie.rao@gmail.com), **Y Liu**, **Y Feng** and **J Shen**. *Bounds on the Number of Huffman and Binary-Ternary Trees.* Preliminary report.

Huffman coding is a widely used method for lossless data compression because it optimally stores data in Huffman trees based on how often the characters occur. An n-ary Huffman tree is a connected, cycle-free graph where each vertex has either n "children" vertices connecting to it, or 0 children. Vertices with 0 children are called *leaves*. We let $h_n(q)$ represent the number of n-ary Huffman trees with q leaves. We use a recursive method to generate bounds on $h_n(q)$ and get $h_2(q) \approx (0.1418532)(1.7941471)^q + (0.0612410)(1.2795491)^q$ for $n = 2$. This matches the best results achieved by Elsholtz et al. in 2011. Our approach reveals patterns in Huffman trees that we extended to Binary-Ternary (BT) trees we created, opening a new door in data compression. Our study of BT trees paves the way for designing data-specific trees, minimizing possible wasted storage space from Huffman coding. We prove a recursive formula for the number of BT trees with q leaves and provide further proofs to reach numeric bounds. Our discoveries have broad applications in computer data compression. These results also improve graphical representations of protein sequences that facilitate in-depth genome analysis used in researching evolutionary patterns. (Received March 24, 2013)

70 ► Mechanics of particles and systems

1093-70-393 **Eugene Lee** (eugenelee0419@gmail.com), 29 Washington St., Tenafly, NJ 07670, **Suh Jin*** (jinimex@gmail.com), 29 Washington St., Tenafly, NJ 07670, **Ash Zheng** (ashzheng2@gmail.com), 29 Washington St., Tenafly, 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07670. *Mechanical Stability Analysis of Wheelchair.*

There are approximately 40, 000 wheelchair related injuries each year in the United States; 75 percent of such injuries are from tips and falls. Unfortunately, this rate is rising every year.

When a wheelchair user reaches and leans, the static stability decreases in the direction of the lean and increases in the opposite direction. A wheelchair will tip over when the forces and moments acting on the chair become unbalanced. When the wheelchair tips to a point where the center of gravity of the user is vertically aligned with the point where the wheel contacts the ground, the chair is unstable.

The purpose of this study was to determine the static forward, rear, and lateral stability on a tilting platform. This paper shows the extent of the effect of body position on wheelchair stability, and also the study calculated the force required to climb increasing curb heights with wheels of varied radii. (Received August 21, 2013)

1093-70-394 **Katherine Oh** (katherine.oh96@gmail.com), 29 Washington St., Tenafly, NJ 07670, **Dongeun Kim*** (window6000@gmail.com), 29 Washington St., Tenafly, NJ, **Jin Suh** (jinimex@gmail.com), 29 Washington St., Tenafly, NJ 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07627. *Study on the Tibia Fracture.*

High contact pressure and compressive forces can cause stresses on the proximal tibia. Repetitive loads applied to the upper surface of the tibia, together with the thermal stress due to temperature changes created in the upper tibia joint, can also lead to dangerous bone damage.

To minimize the undesirable effect, the tibia bone and its joint need to be analyzed empirically and biomechanically. Sometimes a mathematical and physical model of a two-dimensional bone model of the tibia is useful to study bone fracture, since the front view of the bone is almost symmetric.

In this research, comparing the energy required to break the tibia, four different physical conditions have been tested. Assuming that the energy carried by the subject's lower leg before the collision is totally transferred to the bone during the impact, we found a velocity of the object colliding with the tibia that causes the fracture of the tibia.

Also, using the cross sectional area of the tibia, we can calculate bone stresses with changing cross sectional areas. Under the static loads, stress distributions along the y- axis are also shown. (Received August 21, 2013)

76 ► Fluid mechanics

1093-76-39 **Wanjiao Liu**, Department of Mechanical Engineering, 111 Church Street SE, Minneapolis, MN 55455, and **Sean C Garrick*** (sgarrick@me.umn.edu), Department of Mechanical Engineering, 111 Church Street SE, Minneapolis, MN 55455. *A Lagrangian Volume-of-fluid approach for the simulation of turbulent multiphase flows.*

A new approach is proposed for modeling and simulation of turbulent multiphase flows. These flows are of great interest due to their broad applications. In the past several years, several researchers have successfully carried out direct numerical simulations (DNS) to investigate primary breakup in such flows. DNS is accurate, but requires extensive computational resources. In comparison, large eddy simulation (LES) is more practical, resolving only large-scale flow structures and modeling the small-scale effects. The major difficulty with LES of multiphase turbulent flows is the need to model the interfacial subgrid-scale terms. The subgrid-scale (SGS) surface tension force, for example, plays an important role in small droplet formation process. Our methodology combines the filtered density function (FDF) methodology with a Lagrangian volume of fluid (VOF) method. The FDF is advantageous in that the non-linear surface tension force appears (and other SGS terms) in a closed form and thus needs no modeling. The Lagrangian VOF is advantageous as it is highly accurate with no dispersive or dissipative errors (as opposed to eulerian approaches). We present the methodology as well as results from simulations of turbulent multiphase flows. (Received July 02, 2013)

1093-76-391 **Chi-Ming Tseng*** (chimingtseng@gmail.com), 29 Washington St., Tenafly, NJ 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07670. *Cargo Weight vs. Submerged Surface Area Effects on Ship Efficiency.*

Ship hulls are designed in many different shapes and forms. This experiment uses the most common cargo ship hull design to draw out ship hull model. Ship resistance has many different factors to it. It is possible to increase or decrease drag by changing ship hull color, roughness, shape, weight and other properties. However, there are two different types of ship resistances, frictional resistance and residual resistance. Frictional resistance is the resistance of water due to its friction as it passes through the ship. Residual resistance is the resistance of water due to the pressures of pushing the water aside.

This project represents a continuous effort to investigate possible ways to reduce fuel consumption in shipping transportation. The experiment tested five ship models with different surface texture roughness on a specified distance and recorded the time each ship took to travel the distance. The ship with the roughest ship hull surface was found to have taken the most amount of time to travel the distance.

Therefore, the experiment proved that reducing ship hull surface roughness through regular hull cleaning can lower the cost of shipping transportation. (Received August 21, 2013)

78 ► Optics, electromagnetic theory

1093-78-113 **Natalie Cartwright*** (cartwrin@newpaltz.edu). *Propagation of Pulses in a Lossy Plasma.* Preliminary report.

Asymptotic methods are used to provide an asymptotic approximation, valid for large propagation distances z, of an electromagnetic pulse traveling through a lossy plasma. The plasma is modeled by a causal dielectric permittivity that exhibits both dispersion and attenuation. The input pulse considered is a rectangular-modulated signal with either a fixed carrier frequency or linearly-chirped frequency. The asymptotic expressions are obtained on any plane $z > 0$ from the integral representation of the propagated field

$$E(z,t) = \frac{1}{2\pi} \int_{ia-\infty}^{ia+\infty} \tilde{E}(0,\omega) \exp\left[i\tilde{k}(\omega)z - i\omega t\right]. \tag{1}$$

Here, a is greater than the abscissa of absolute convergence of the input pulse $E(0,t)$, $\tilde{E}(0,\omega)$ is the initial pulse spectrum, and $\tilde{k}(\omega) = (\omega/c)\sqrt{\epsilon(\omega)}$ is the complex wave number, with c denoting the speed of light in vacuum. A relative magnetic permeability $\mu = 1$ is assumed. The propagated signal is seen to be the sum of three components: the high, low, and carrier frequency responses of the material to the applied field. We consider matched filters based on these three components, and their effect on pulse compression. (Received August 06, 2013)

1093-78-329 **Miao-jung Yvonne Ou*** (mou@math.udel.edu), 408 Ewing Hall, University of Delaware, Newark, DE 19716, and **Wai-Yip Chan**, **Yen-Hsi Richard Tsai**, **Seong Jun Kim** and **Luis Cardoso**. *Fast Algorithms for Computing the Effective Dielectric Properties of Cancellous Bone from Micro-CT scans.*

Cancellous bone is a two-phase composite with solid trabeculae and bone marrow. Effective properties of cancellous bones are important in assessing bone health. Computation of the effective dielectric properties is carried out by solving partial differential equations in the domain constructed from micro-CT scans. Due to the very complex microstructure of the trabeculae, traditional meshing softwares fail to handle the meshing task. A state-of-the-art 3D segmentation algorithm was applied to a stack of micro-CT scans of cancellous bone, followed by the construction of the signed distance function of the 3D structure. We developed a meshing algorithm modified from Matlab-based DISTMESH, which can efficiently generate high-quality boundary mesh for the cancellous bone. Finally, the partial differential equations were solved by the Boundary Element Method (BEM) accelerated by the Fast Multipole Method (FMM), which is an O(N) fast algorithm. This talk presents the key ideas of the algorithms, the implementations and the numerical results. (Received August 19, 2013)

81 ► Quantum theory

1093-81-83 **Kenneth Chan** (kenhchan@math.washington.edu), University of Washington, Department of Mathematics, Seattle, WA 98195, **Pavel Etingof** (etingof@math.mit.edu), Massachusetts Institute of Technology, Department of Mathematics, Cambridge, MA 02139, **Ellen Kirkman** (kirkman@wfu.efu), Wake Forest University, Department of Mathematics, P.O. Box 7388, Winston-Salem, NC 27109, **Chelsea Walton*** (notlaw@math.mit.edu), Massachusetts Institute of Technology, Department of Mathematics, Cambridge, MA 02139, **Yanhua Wang** (yhw@mail.shufe.edu.cn), Shanghai University of Finance and Economics, Department of Applied Mathematics, Shanghai, 200433, Peoples Rep of China, and **James J Zhang** (zhang@math.washington.edu), University of Washington, Department of Mathematics, Seattle, WA 98195. *Recent results in Noncommutative Invariant Theory.*

In this talk, I will provide an overview of recent work pertaining to Hopf algebra actions on (noncommutative) regular algebras. Many examples of such actions will be presented. I will also list several open questions for future work. The results discussed here are from joint works with Kenneth Chan, Pavel Etingof, Ellen Kirkman, Yanhua Wang, and James Zhang: see papers arXiv:math/1210.6432, 1211.6513, 1301.4161, 1303.7203. (Received August 01, 2013)

83 ► Relativity and gravitational theory

1093-83-276 **Michael C Dickerson** and **Charles E Dickerson*** (c.dickerson@lboro.ac.uk), Garendon Wing, Holywell Park, Loughborough University, Loughborough, Leics LE11 3TU, United Kingdom. *An alternative calculation of the mass of the Universe based on the non-monochromatic distribution of cosmic background radiation and the finite speed of gravity: Preliminary findings.*

The standard cosmological model calculates the mass energy contribution of the Cosmic Background Radiation (CBR) to the mass of the Universe from the single energy density currently observed. The model assumes a homogeneous energy distribution at zero red shift and applies the energy density across the Universe. After reviewing the Friedmann equations for a matter dominated universe and Lemaître extension of the spacetime metric to relativistic energy, we offer an alternative mathematical calculation of the mass energy of the CBR component: a complete propagation history of the photons comprising the CBR is used rather than only the current energy density. Because the effects of gravity travel at the speed of light (according to general relativity), and using hot big bang cosmology, we suggest that the higher energy states of the CBR photons in the past also contribute to the currently observed gravitational effects. In our alternative calculation, the CBR energy density is integrated over a range of red shifts in order to account for the gravitational effects of the energy density as it was in the past. By accounting for propagation effects, the resultant mass energy calculated for the CBR radiation component almost exactly equals the amount attributed to dark energy. (Received August 18, 2013)

86 ► Geophysics

1093-86-241 **Bogdan G Nita*** (nitab@mail.montclair.edu), Department of Mathematical Sciences, Montclair State University, 1 Normal Avenue, Montclair, NJ 07405, and **Catherine Wilshusen** and **Marcus Jeffrey**. *Examining a Seismic Imaging Algorithm with Band Limited Data.*

One of the biggest difficulties in current seismic imaging methods is the lack of low frequencies in the collected data. In this talk we present a one dimensional inverse scattering algorithm for geophysical imaging and amplitude correction from measured data. We investigate this algorithm numerically using band limited data which is missing zero and low frequency information. Our examples show excellent results in finding both the location of interfaces and the amplitude of acoustic reflections. (Received August 16, 2013)

91 ► Game theory, economics, social and behavioral sciences

1093-91-287 **Fabian Astic** and **Agnes Tourin*** (atourin@poly.edu), Department of Finance and Risk Engineering, Six MetroTech Center, Brooklyn, NY 11201. *Optimal bank management under liquidity and capital constraints.*

We propose a dynamic model of a financial institution that can invest in both liquid and illiquid assets, and whose goal is to maximize the profit of its shareholders, while complying with some Basel 3-like capital requirement and liquidity constraint.

In this paper, illiquidity is introduced through haircuts that are applied to the illiquid securities when sold. The portfolio is managed dynamically and at any time, liquid assets can be used to buy illiquid assets which typically have a better return and a higher volatility. However, illiquid assets can only be converted into liquid assets at a cost.

We use stochastic control techniques to derive the Variational Inequalities characterizing the dynamic optimal portfolio allocations, as well as the shareholders' optimal gain. Unfortunately, we cannot obtain closed form solutions. Instead, we develop a numerical method for computing the optimal allocations and the shareholder's gain. We also use Monte Carlo simulations to estimate the debt holder's payoff associated with the computed optimal allocations.

Finally, we study experimentally the sensitivity of the optimal allocations, the shareholder's and the debt holder's gains to changes in the minimal capital, liquidity ratio and haircut. (Received August 19, 2013)

1093-91-377 **Ruihua Liu*** (rliu01@udayton.edu), Department of Mathematics, University of Dayton, 300 College Park, Dayton, OH 45469. *Optimal Stopping of Switching Diffusions with State Dependent Switching Rates.* Preliminary report.

This presentation is concerned with a continuous-time and infinite-horizon optimal stopping problem in switching diffusion models. In contrast to the assumption commonly made in the literature that the regime-switching is modeled by an independent Markov chain, we consider in this paper the case of state-dependent regime-switching. The Hamilton-Jacobi-Bellman (HJB) equation associated with the optimal stopping problem is given by a system of coupled variational inequalities. By means of the dynamic programming (DP) principle, we prove that the value function is the unique viscosity solution of the HJB system. As an interesting application in mathematical finance, we examine the problem of pricing perpetual American put options with state-dependent regime-switching. A numerical procedure is developed based on the dynamic programming approach and an efficient discrete tree approximation of the continuous stock price process modeled by a regime-switching geometric Brownian motion. Numerical results are reported. (Received August 20, 2013)

92 ► Biology and other natural sciences

1093-92-65 **Shane Nowack**, **Isaac Klapper*** (klapper@temple.edu) and **Dave Ward**. *Niche character in a temporally oscillating environment.*

Description of niche structure of organisms and how that structure impacts competitiveness has long been a topic of interest among ecologists. It is natural for modelers to suppose organisms exhibit a simple, generic response to, say, variable (in time) conditions - for example, a Gaussian response function with width related to amplitude of environmental variability is often chosen. Here, in the context of a chemostat in an oscillating environment, we do not constrain the functional form but instead allow organisms to choose an optimal response function, and show some consequent predictions that differ in important ways from predictions arising from constrained response functions. (Received July 26, 2013)

1093-92-85 **Tianyu Zhang*** (zhang@math.montana.edu), **Breana Pabst**, **Isaac Klapper** and **Philip S Stewart**. *General Theory for Integrated Analysis of Growth, Gene, and Protein Expression in Biofilms.*

A theory for analysis and prediction of spatial and temporal patterns of gene and protein expression within microbial biofilms is derived. The theory integrates phenomena of solute reaction and diffusion, microbial growth, mRNA or protein synthesis, biomass advection, and gene transcript or protein turnover. Case studies illustrate the capacity of the theory to simulate heterogeneous spatial patterns and predict microbial activities in biofilms that are qualitatively different from those of planktonic cells. Specific scenarios analyzed include an inducible GFP or fluorescent protein reporter, a denitrification gene repressed by oxygen, an acid stress response gene, and a quorum sensing circuit. Though here the analyses have been limited to simultaneous interactions of up to two substrates and two genes, the framework applies to arbitrarily large networks of genes and metabolites. Extension of reaction-diffusion modeling in biofilms to the analysis of individual genes and gene networks is an important advance that dovetails with the growing toolkit of molecular and genetic experimental techniques. (Received August 01, 2013)

1093-92-105 **Jonathan Bell*** (jbell@umbc.edu), Department of Mathematics & Statistics, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250. *Extending dynamics to graph domains: two examples from biology.* Preliminary report.

This presentation introduces two different scenarios where it is appropriate to consider partial differential equations on metric tree graph domains. The first example concerns threshold and conduction properties from neuronal cable theory on a nerve's dendritic tree. The second example concerns species persistence in a river network. A variety of unanswered questions will also be mentioned. (Received August 13, 2013)

1093-92-122 **Sivan Leviyang*** (sr286@georgetown.edu). *Modeling Early HIV Infection.*

During the first weeks of an HIV infection, the immune system mounts a vigorous response, most notably through T cells known as cytotoxic T lymphocyes (CTLs). CTLs kill HIV infected cells, exerting selective pressure on the infecting viral population. In turn, through mutation, HIV evades CTL killing, leading to a complex interplay between immune response and viral evolution. In this talk I will first introduce a model of early HIV infection and then, based on this model, I will discuss approaches for quantifying and inferring the strength of CTL mediated selection in the first weeks of HIV infection. (Received August 08, 2013)

1093-92-133 **Timothy C Reluga*** (treluga@psu.edu), Department of Mathematics, McAllister Hall, University Park, PA 16802. *Exact model reductions for asynchronous boolean networks.*

Boolean networks are a class of finite-state machines used to model cellular biological processes. Boolean networks have a simpler state-space than classical differential equation models and can be easier to parameterize based on qualitative laboratory observations. However, the state spaces still scale exponentially with network size, and model-reduction techniques are very useful in transforming tangled networks into easier-to-understand versions. In this talk, I'll discuss a couple intuitive reduction rules and the challenges of proving basic properties of these rules. Ideas will draw from directed graph theory, topology, and dynamic systems. (Received August 08, 2013)

1093-92-180 **Jason M. Graham*** (jason.graham@scranton.edu), University of Scranton, 204 Monroe Ave, LSC 235, Scranton, PA 18510. *Mathematics of Secondary Cytokine-Induced Injury of Articular Cartilage.*

Injuries to articular cartilage result in the development of lesions that form on the surface of the cartilage. The typical injury response often causes collateral damage, so-called secondary cytokine-induced injury, which results in the spread of lesions beyond the region where the initial injury occurs. In this talk we describe a mathematical model, a system of partial differential equations, and use this to investigate the spread or abatement of such lesions. Furthermore, we define a control parameter, the radius of attenuation, and present some simulations that shed light on how inflammation associated with cartilage injuries impacts the metabolic activity of cartilage cells. We also mention some open questions related to the mathematical study of cartilage injury. (Received August 13, 2013)

1093-92-210 **Michael Crone**, Dept. of Math Sci. MS-3F2, 4400 University Dr., Fairfax, VA 22030, and **Evelyn Sander*** (esander@gmu.edu), Dept. of Math. Sci. MS-3F2, 4400 University Dr., Fairfax, VA 22030. *Bifurcations for a predator-prey model in the context of fisheries.* Preliminary report.

This talk will discuss a bifurcation study for a predator-prey model. The model is ratio dependent, with constant harvest of both predator and prey. Some of the details of the model, including the existence of Takens-Bogdanov points, have been previously studied by Xiao and collaborators. Our aim is to classify biologically relevant bifurcations for the model using a combination of analytical and numerical continuation methods. While this model has general relevance, our primary interest is in the context of commercial fisheries. (Received August 14, 2013)

1093-92-320 **Hye-Won Kang*** (hwkang@umbc.edu). *A mathematical model for microRNAs in lung cancer.*

Lung cancer is the leading cause of cancer-related deaths. Lack of early detection and the limited options for targeted therapies are the main factors to contribute to these statistics. MicroRNAs represent a class of non-coding RNAs that regulate genes and may serve as both diagnostic and prognostic biomarkers in lung cancer. Based on the experimental data, two microRNAs, miR-9 and let-7, are dysregulated in non-small cell lung cancer (NSCLC) and this feature may be helpful to identify lung cancer. In this talk, I will suggest a key signaling pathway involving two microRNAs and introduce a mathematical model using a system of differential equations. Simulations of the model demonstrate that EGFR and Ras mutations in NSCLC, which lead to the process of epithelial-mesenchymal transition, result in miR-9 upregulation and let-7 suppression. By putting random perturbation on microRNAs using stochastic differential equations, I can conclude that the signaling pathway is somewhat robust against random input into miR-9 and more strongly robust against random input into let-7. (Received August 19, 2013)

1093-92-325 **Ted Theodosopoulos*** (ttheodosopoulos@saintannsny.org), 129 Pierrepont St, Brooklyn, NY 11201, and **Patricia Theodosopoulos** (ptheodosopoulos@saintannsny.org), 129 Pierrepont St, Brooklyn, NY 11201. *A hierarchical architecture of NK neuronal assemblies.* Preliminary report.

In this talk we describe a model of the CNS based on tightly integrated neuronal assemblies, originally proposed by Edelman. In our model, these building blocks of the neural architecture are instantiated by NK networks, first introduced by Kauffman as models of genetic epistasis. We link these NK assemblies in looser hierarchical constructs, which recursively drive one another through their respective equilibria. We see this as a first attempt at capturing spontaneous concept formation in a plausible neural architecture. We show that, generically, our NK assemblies possess multiple distinct equilibria, which we associate with primitive concepts. The hierarchical coupling across these NK assemblies then serves to trigger coordinated transitions between these primitive concepts, forming "proto-syllogisms". We proceed to illustrate this concept formation paradigm in the context

of linguistics. In one instance, we associate phonemes to each primitive concept and show how phonological and morphological rules could be plausible instantiated as connections among NK assemblies. Going forward, we attempt to use this framework for shedding light on the putative neural architecture behind the asymmetric hierarchical structure of syntax in the universal grammar. (Received August 20, 2013)

1093-92-337 **Jian Fang** (wujh@mathstat.yorku.ca), **Yijun Lou** (wujh@mathstat.yorku.ca) and **Jianhong Wu*** (wujh@mathstat.yorku.ca). *How fast can an invasive species propagate in a wave-like environment?* Preliminary report.

We consider the issue whether an invasive species can propagate in the same speed as the wave-like environment. This is modeled as a scalar reaction-diffusion equation with a logistic nonlinear term involving the wave-like carrying capacity. Some open problems by Berestycki, Nirenberg and Varadhan are resolved in this setting. The general results are also applied to answer the question whether a pathogen can spread following the invasion of its host. This is a joint work with J. Fang and Y. Lou. (Received August 20, 2013)

1093-92-348 **Robert S Manning*** (rmanning@haverford.edu), Mathematics Department, Haverford College, 370 Lancaster Ave., Haverford, PA 19041. *Monte Carlo simulations of DNA cyclization using a rigid-base model and mechanical properties derived from molecular dynamics.* Preliminary report.

A cyclization J-factor is an experimental measurement on short DNA (50-500 basepairs) related to the propensity of the DNA to form a loop. It has proven to be a useful experimental measurement because it depends sensitively on key mechanical properties of the DNA, such as intrinsic bend, intrinsic twist, and twist and bend flexibility. A mathematical quantity key to understanding cyclization J-factors is the end-to-end probability density function (pdf) on $R^3 \times SO(3)$, the configuration space for the far end of the DNA, once the near end is fixed by choice of coordinates. Monte Carlo simulations allow direct sampling of this pdf, although the typical values of the pdf are small enough that it can be challenging to get decent statistics.

We apply the Monte Carlo technique within a DNA model developed in the laboratory of John Maddocks. This model assumes the DNA bases are rigid (but the two bases within a basepair can move relative to each other). The shape and flexibility of the DNA depends on its sequence, through parameters extracted by Maddocks and co-authors by fitting to a large ensemble of molecular dynamics simulations. We present results illustrating how the cyclization J-factor depends on DNA length and on the specific basepair sequence of the DNA. (Received August 20, 2013)

1093-92-363 **Kathleen A Hoffman*** (khoffman@umbc.edu), 1000 Hilltop Circle, Baltimore, MD 21250, and **P. Robinson**, **K. Daniels**, **J. Meisel**, **D. Thatcher**, **K. Herold**, **J. Ortega** and **A Jackson**. *Modeling the Role of Melanopsin in Vertebrate Phototransduction.* Preliminary report.

Melanopsin is a recently discovered photopigment found in intrinsically photosensitive retinal ganglion cells (ipRGCs). It is involved in non-image forming vision, such as circadian rhythm entrainment and the pupillary light reflex, and light-related disorders such as seasonal affective disorder. Recent experimental results have shown melanopsin activates in response to a flash of light, which in turn initiates a cascade of chemical reactions. Melanopsin deactivation is modulated by phosphorylation of the carboxy tail and binding of a beta-arrestin molecule. Model parameters of the activation and deactivation were determined by fitting the model results to experimental calcium imaging data collected from transfected human embryonic kidney (HEK) cells expressing the melanopsin gene as well as electrophysiology data collected from ipRGCs. Modeling results of the proposed chemical cascade for both activation and inactivation mimic experimental findings in both HEK cells and ipRGCs and further predict experimental results that over express beta arrestin. Ongoing work includes incorporating stochastic effects in the modeling of the chemical cascade and modeling light adaption. (Received August 20, 2013)

1093-92-364 **Bradford E. Peercy*** (bpeercy@umbc.edu). *Model Reduction to One Dimension Directs Discovery of Spontaneous Calcium Waves in a 3-D Cardiac Cell.* Preliminary report.

Calcium release in cardiac cells functions to contract heart muscle. In pathological conditions calcium can spontaneously release from any of thousands of near point source like release units and be electrogenic. Calculating long timescale (>1000ms) solutions from thousands of point sources each with a probability of release in three spatial dimensions provides a computational challenge. A model and parallel algorithm solving this set-up including multiple buffering species has been established but physiological behavior on the long time scale was elusive. We reduce the full model using dimensional analysis and perturbation theory to show the structure of the underlying solution diagram for the one-dimensional reduction. The structure translates to the full model

allowing reproduction of experimentally observed calcium waves. The transition between solutions in parameter space for the full model is richer than in one dimension, and through further expansion around such a boundary, we find transverse waves leading to spiral waves. (Received August 20, 2013)

1093-92-373 **Jemal S Mohammed-Awel*** (jmohammedawel@valdosta.edu), 1500 North Patterson Street, Valdosta, GA 31698, and **Miranda I Teboh-Ewungkem** (tebohewm@lafayette.edu), **Frederick N Baliraine** (fredbaliraine@letu.edu) and **Scott M Duke-Sylvester** (smd3729@louisiana.edu). *The Role of Human Movement on the Spread of Drug-Resistant Malaria during Intermittent Preventive Treatment (IPT) usage.* Preliminary report.

The use of Intermittent Preventive Treatment in pregnant women (IPTp), children (IPTc), infant (IPTi) is increasingly popular preventive strategy aimed at reducing malaria incidence in these vulnerable groups. Studies to understand how this preventive intervention can affect the spread of drug resistance are important especially when there is movement between neighboring low and high transmission area. We expand a previously published mathematical model to include movement between neighboring high and low transmission area. Our results suggest that the introduction of movement results in resistance always spreading fastest in high transmission areas, and the more complete anti-malaria resistance the faster the resistance parasite will spread through a population. Moreover, our results indicate that the demography of infection in low transmission areas tends to change to reflect the demography of high transmission areas when regions are connected by movement. Our results suggest that in the fight to monitor and control drug resistance, different public policies are needed when the area in question is an isolated high or low transmission area, or whether it is close to a neighboring high or low transmission area. (Received August 20, 2013)

1093-92-382 **Talitha M Washington*** (talitha.washington@howard.edu), 2441 Sixth Street NW, Washington, DC 20059. *Understading Calcium Regulation Via Mathematical Modeling.* Preliminary report.

The body has many processes that are synchronized to maintain a specific level of calcium. This regulatory mechanism, calcium homeostasis, provides the necessary mechanism for proper signalling to occur at the cellular level. Muscle contractions, skeletal structure, as well as a variety of signalling pathways need calcium so that proper functions can be accomplished. In this talk, we discuss a preliminary mathematical model of this regulatory mechanism. (Received August 20, 2013)

1093-92-385 **Chan Woo Kim*** (chanwkim1994@gmail.com), 29 Washington St., Tenafly, NJ 07670, **Peter Yoon** (pyoon0810@gmail.com), 29 Washington St., Tenafly, 07670, **Ruby Hong** (rhong1@villanova.edu), 29 Washington St., Tenafly, NJ 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07627. *Hemodynamics in the Aortic Valve with Stenosis.*

High prevalence of aortic valve pathologies has induced a growing need for information on biofluid mechanics analysis for the last couple of decades : these information should be available to cardiac surgeons and in vivo real time 3D echocardiography, including a detailed biophysical properties description.

During ventricular systole, pressure rises in the left ventricle. When the pressure in the left ventricle rises above the pressure in the aorta, the aortic valve opens, allowing blood to exit the left ventricle into the aorta. In this paper, researches based on the biomechanical determinants of blood flow in the stenosed aortic valve has been carried out using numerical and dynamic analysis.

By and large, these approaches have been empirically derived with theoretic justification for their application. Using the biophysical mechanisms of the heart, this research shows the impact of aortic stenosis(AS) on the different components of the aortic valve system. (Received August 20, 2013)

1093-92-387 **Mariel Jung*** (marieljung123@gmail.com), 29 Washington St., Tenafly, 07670, **Jonathan Cui** (cuijonathan@yahoo.com), 29 Washington St., Tenafly, NJ 07670, **Kang Woo Kim** (khan.kim.96@hotmail.com), 29 Washington St., Tenafly, NJ 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07627. *Pressure Analysis of Newtonian Blood Flow in the Venule.*

Blood exchange in the capillaries occurs through diffusion, which is dependent on the concentration of the molecules between the interstitial fluid and the blood. The hydrostatic and osmotic pressure determines the direction of blood flow through the capillaries.

Assuming incompressibility of the blood in the vessel, blood flow dependence on the pressure and diameter of venule was analyzed using Poiseuille's law. This study also analyzes the relation between the flow rate and pressure, viscosity, diameter and length of the vessel.

Newtonian biofluid, Laminar flow(Reynold's numbers below 2000), and no slip conditions at the vascular wall are assumed for the present analysis. Finally, letting all of the parameters except the viscosity remain at the standard values, velocity profile in the venule is found. (Received August 21, 2013)

1093-92-390 **Jonathan Cui*** (cuijonathan@yahoo.com), 29 Washington St., Tenafly, NJ 07670, **Song Kyounglin** (dsong.com@gmail.com), 29 Washington St., Tenafly, NJ 07670, and **Richard Kyung** (nycrick@gmail.com), 29 Washington St., Tenafly, NJ 07670. *Blood Flow Dynamics in the Cardiovascular Valve.*

The mitral valve (MV) is a complex apparatus inserted on the valvular plane through the mitral annulus (MA), which is the support site of two leaflets. In this paper, biomechanical stress and strain static analysis were performed on a disk-type prosthetic mitral valve in heart. The valve is assumed to be in the aortic position and observed the structure of the valve cage influence the flow field near the mitral valve.

For the purpose of computational and mathematical modeling, the laminar incompressible two-dimensional steady flow of a homogeneous Newtonian fluid with constant viscosity was assumed. The flow is considered during the greater part of systole when the valve is fully open. Stress, displacement distributions are computed at every grid point. And two-dimensional velocity profiles across anterior mitral valve are presented. (Received August 21, 2013)

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