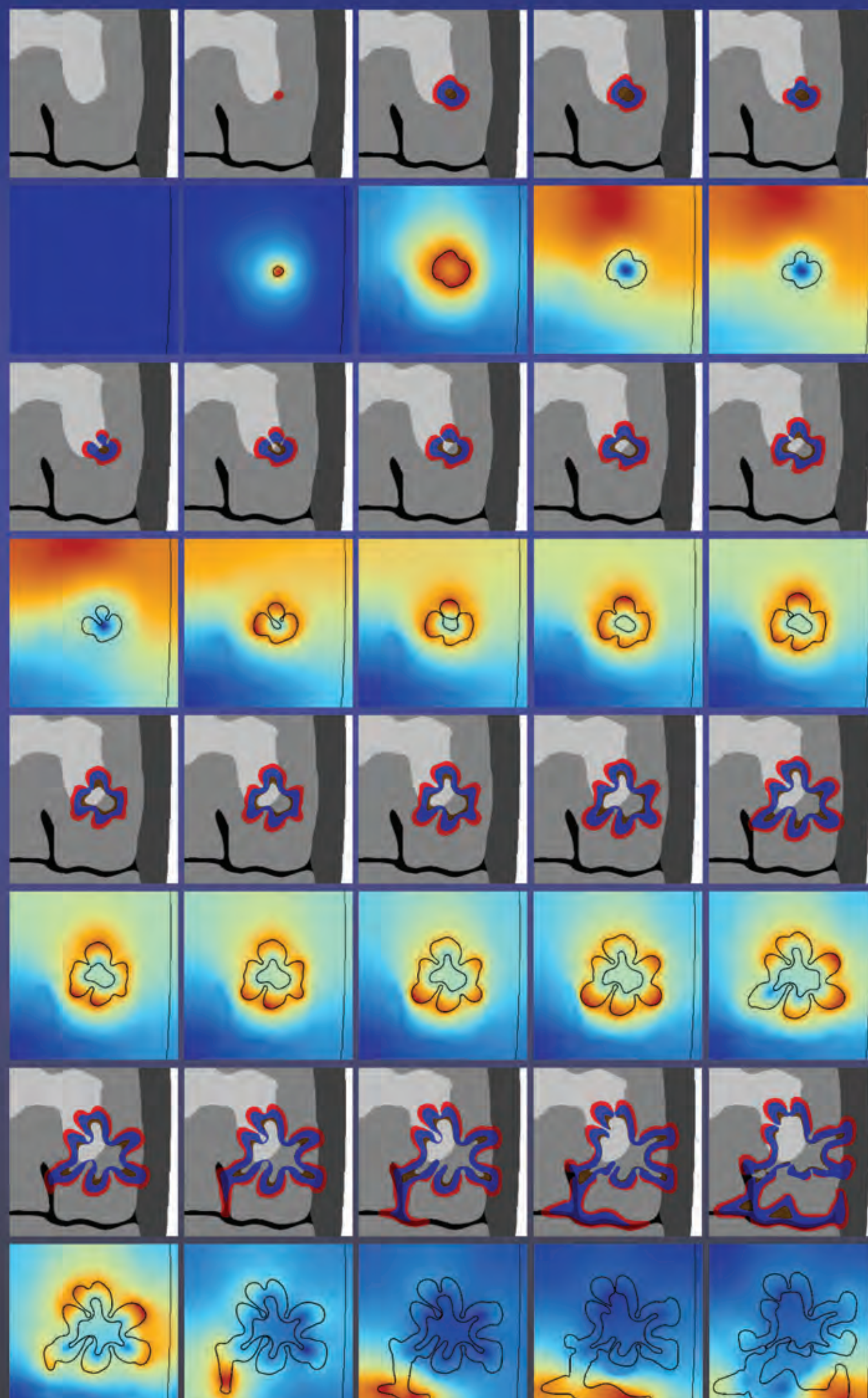
ISSN 0002-9920 (print)
ISSN 1088-9477 (online)

Notices
of the American Mathematical Society

March 2013 Volume 60, Number 3



Simulating the development of a brain tumor *(see page 325)*

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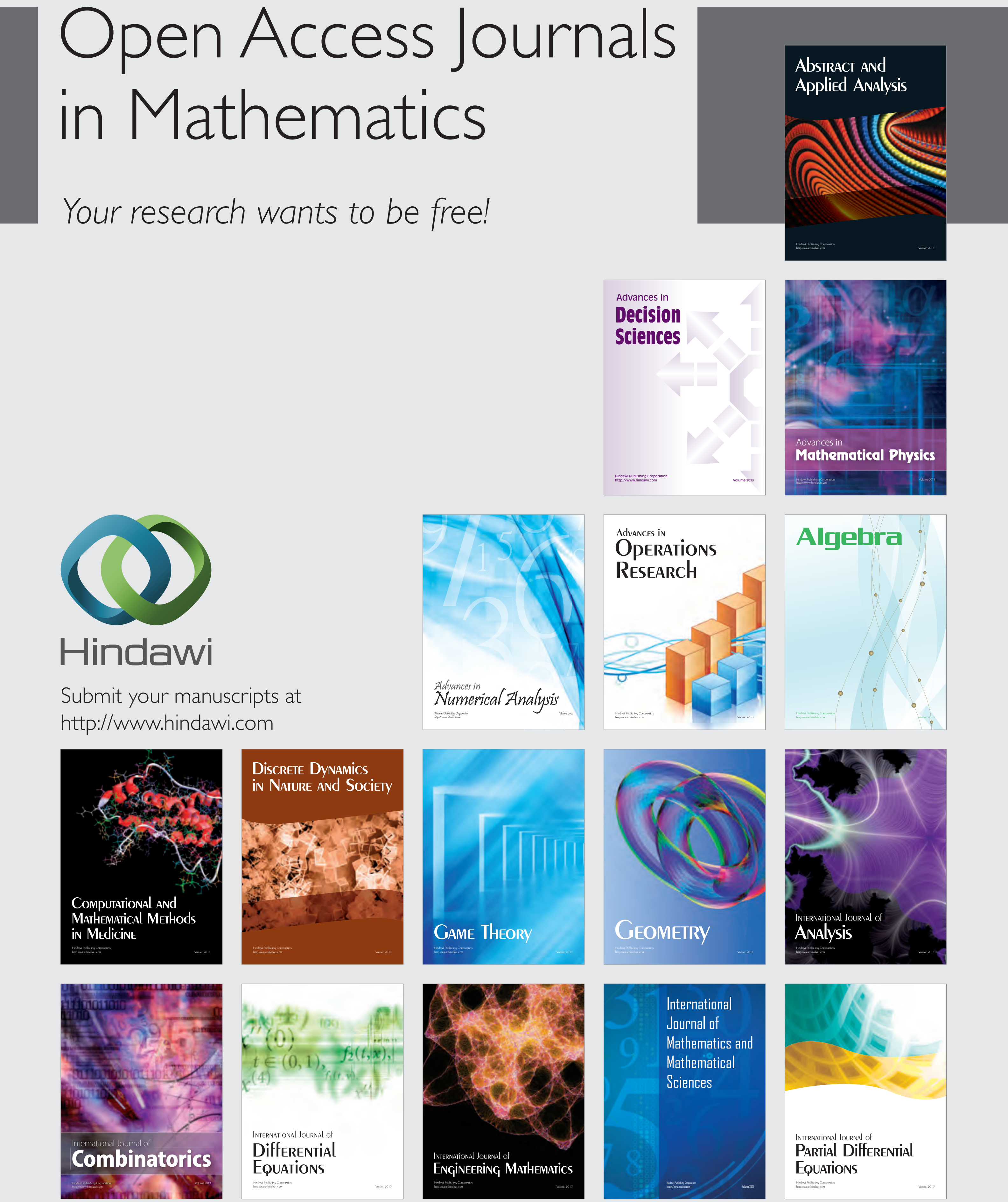
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Notices
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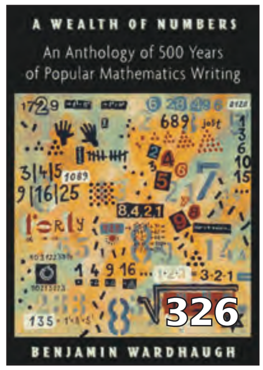
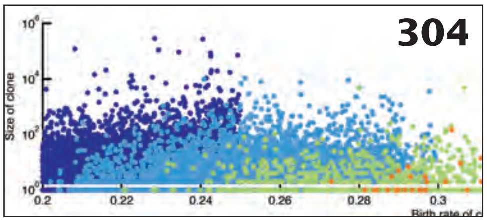
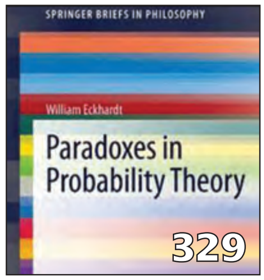
March 2013

Communications

Commentary







Beware the Ides of March. This month we feature an article about the mathematical modeling of cancer, an article about the mathematical theory of quasicrystals, and a memorial article for Walter Rudin. The piece by George Grätzer describes how to do LaTeX on your iPad. And there is an interview with incoming AMS President David Vogan.

—*Steven G. Krantz, Editor*

Features

Notices

of the American Mathematical Society

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[*Notices of the American Mathematical Society* (ISSN 0002-9920) is published monthly except bimonthly in June/July by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294 USA, GST No. 12189 2046 RT****. Periodicals postage paid at Providence, RI, and additional mailing offices. POSTMASTER: Send address change notices to *Notices of the American Mathematical Society,* P.O. Box 6248, Providence, RI 02940-6248 USA.] Publication here of the Society's street address and the other information in brackets above is a technical requirement of the U.S. Postal Service. Tel: 401-455-4000, email: `notices@ams.org`.

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From the AMS Secretary

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In honor of Dr. Wong's contributions to mathematics, career accomplishments, and editorial service to the JMAA, his son James Jr. and daughter Emily have contributed a substantial sum to establish the James S.W. Wong JMAA Prize. This sum was further matched by Elsevier, and is now administered by The American Mathematical Society.

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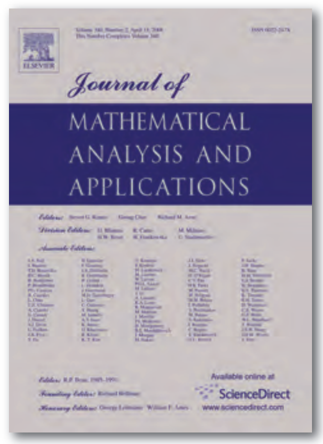

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Remembering Walter Rudin (1921–2010)

Alexander Nagel and Edgar Lee Stout, Coordinating Editors

Walter Rudin, Vilas Professor Emeritus at the University of Wisconsin-Madison, died on May 20, 2010, at his home in Madison after a long battle with Parkinson's disease. He was born in Vienna on May 2, 1921.

The Rudins were a well-established Jewish family which began its rise to prominence in the first third of the nineteenth century. By the 1830s, Walter's great-grandfather, Aron Pollak, had built a factory to manufacture matches; he also became known for his charitable activities, including the construction of a residence hall where seventy-five needy students at the Technical University in Vienna could live without paying rent. As a result, Aron was knighted by Emperor Franz Joseph in 1869 and took the name Aron Ritter Pollak von Rudin. The Rudin family prospered, and Walter's father, Robert, was a factory owner and electrical engineer, with a particular interest in sound recording and radio technology. He married Walter's mother, Natalie (Natasza) Adlersberg, in 1920. Walter's sister, Vera, was born in 1925.

After the *Anschluss* in 1938, the situation for Austrian Jews became impossible, and the Rudin family left Vienna. Walter served in the British Army and Navy during the Second World War, and rejoined his parents and sister in New York in late 1945. He entered Duke University, obtaining a B.A. in 1947 and a Ph.D. in mathematics in 1949. He was a C. L. E. Moore Instructor at the Massachusetts Institute of Technology and began teaching at the University of Rochester in 1952.

Photograph courtesy of Mary Ellen Rudin.

Walter Rudin and sister, Vera, in Vienna.

While on leave visiting Yale in 1958, Rudin received a call from R. H. Bing at the University of Wisconsin-Madison, asking if he would be interested in teaching summer school. Rudin said that, since he had a Sloan Fellowship, he wasn't interested in summer teaching. Then, as he writes in his autobiography, *As I Remember It*, "my brain slipped out of gear but my tongue kept on talking and I heard it say 'but how about a real job?' " As a result, Walter Rudin joined the Department of Mathematics at UW-Madison in 1959, where he remained until his retirement as Vilas Professor in 1991. He and his wife, the distinguished mathematician Mary Ellen (Estill) Rudin, were popular teachers at both the undergraduate and graduate level and served as mentors for many graduate students. They lived in Madison in a house designed by Frank Lloyd Wright, and its intriguing architecture and two-story-high living room made it a center for social life in the department.

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DOI: http://dx.doi.org/10.1090/noti955

Photograph courtesy of Mary Ellen Rudin.

Rudin house, Madison.

Walter Rudin was one of the preeminent mathematicians of his generation. He worked in a number of different areas of mathematical analysis, and he made major contributions to each. His early work reflected his classical training and focused on the study of trigonometric series and holomorphic functions of one complex variable. He was also very influenced by the then relatively new study of Banach algebras and function algebras. One of his important results in this area, building on the work of Arne Beurling, is the complete characterization of the closed ideals in the disk algebra in 1956.

Another major area of Walter's interest was the general theory of harmonic analysis on locally compact Abelian groups. In the late 1950s and 1960s this was a very active and popular area of research, and perhaps only partially in jest, Walter suggested that mathematicians introduce a new word, "lgbalcag", to replace the phrase "Let G be a locally compact Abelian group", which is how almost every analysis seminar began in those days. One of Walter's major achievements in this area was his 1959 work with Helson, Kahane, and Katznelson, which characterized the functions that operate on the Fourier transforms of the L^1-algebra. Rudin synthesized this aspect of his mathematical career in his 1962 book, *Fourier Analysis on Groups*.

Walter's interests changed again in the late 1960s, and he began to work on problems in several complex variables. At that time the study of the analytic aspects of complex analysis in several variables was relatively new and unexplored, and it was not even clear what the right several-variable generalization of the one-dimensional unit disk should be. There are at least two candidates: the polydisk and the ball. Walter did important work with both. For example, he showed for the polydisk (1967) and the unit ball (1976) that the zero sets of different H^p classes of functions are all different. His work on the "inner function conjecture" led to a tremendous amount of research, and after the solution by Aleksandrov and Hakim-Sibony-Løw (1981), Walter made additional important contributions to this question. Much of Rudin's work in several complex variables is presented in three of his advanced books. The first, published in 1969, is *Function Theory in Polydiscs*. The second, published in 1980, is *Function Theory in the Unit Ball of* $\mathbb{C}^n$. His work on inner functions was summarized in a series of NSF-CBMS lectures, which were then published in 1986 as *New Constructions of Functions Holomorphic in the Unit Ball of* $\mathbb{C}^n$.

Walter Rudin is also known to generations of undergraduate and graduate students for his three outstanding textbooks: *Principles of Mathematical Analysis* (1953), *Real and Complex Analysis* (1966), and *Functional Analysis* (1973). In 1993 he was awarded the American Mathematical Society's Leroy P. Steele Prize for Mathematical Exposition. He received an honorary degree from the University of Vienna in 2006.

In addition to his widow, Mary Ellen, Walter Rudin is survived by his four children: Catherine Rudin, professor of modern languages and linguistics at Wayne State College, Nebraska; Eleanor Rudin, an engineer working for 3M in St. Paul, Minnesota; Robert Rudin of Madison, Wisconsin; and Charles Rudin, professor of oncology at the Johns Hopkins University in Baltimore. He is also survived by four grandchildren: Adem, Deniz, Sofia, and Natalie.

Jean-Pierre Kahane

Walter Rudin and Harmonic Analysis

The work of Walter Rudin on harmonic analysis is a good part of his life and also of mine. A guide for most of it is the list of his papers on Fourier analysis on groups at the end of his celebrated book. I shall start with a few of them and add some complements. This is nothing but a glance at a large piece of harmonic analysis.

The general inspiration for Walter was to discover questions and results arising from the algebraic structure of some parts of analysis. Wiener and Gelfand had paved the way. It became the main tendency in harmonic analysis in the middle of the twentieth century.

Part of Walter's work deals with the Wiener algebras, that is, the algebras made of Fourier transforms of integrable functions or summable sequences. A related matter is trigonometric series. Another is convolution algebras of Radon measures. A general framework is the Gelfand theory of Banach algebras. Generally speaking, there are several ways to express the same problems and results: classical in the sense of the nineteenth century or abstract and modern in the sense of the twentieth. Moreover, as far as Fourier analysis is concerned, what happens on a group can be expressed on the dual group. Equivalent definitions can be found everywhere, and Walter was an expert in playing this game.

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Let me start with the first paper of his mentioned in *Fourier Analysis on Groups*. The title is "Non analytic functions of absolutely convergent Fourier series", and the year was 1955 [1]. What he discovered was a positive function with an absolutely convergent Fourier series, vanishing at 0, such that its square root does not enjoy the same property. It was the first result of this type, but the question was in the air, if in different forms. The Wiener-Lévy theorem asserts that an analytic function of a function in the Wiener algebra $A(\mathbb{T})$ (that is, its Fourier series converges absolutely) belongs to $A(\mathbb{T})$. In other words, the analytic functions operate on $A(\mathbb{T})$; that is, the convolution algebra $l^1(\mathbb{Z})$ has a symbolic calculus consisting of analytic functions. Can we replace the analytic functions by a wider class? The Wiener-Lévy theorem can be translated into Banach algebras via the theory of Gelfand. The problem can be translated as well: which are the functions that operate in a given Banach algebra? Great progress was made on this question between 1955 and 1958. I proved that absolute values do not operate on the Wiener algebra, then that functions that operate are necessarily infinitely differentiable. Katznelson proved in 1958 the natural conjecture: only analytic functions operate. That occurred in a very informal meeting in Montpellier just before the International Congress in Edinburgh; besides Katznelson and me, Helson, Herz, Rudin, Salem, and others were there, enjoying life and discussing mathematics. Katznelson's theorem immediately had several versions, involving locally compact abelian groups instead of $\mathbb{T}$. Walter was interested in convolution algebras of measures or, what is the same, in multiplicative algebras of Fourier-Stieltjes transforms. What we proved in [2] is that only entire functions operate. It is a way to recover many previous results, going back to the *Wiener-Pitt phenomenon* (the inverse of a Fourier-Stieltjes transform is not necessarily a Fourier-Stieltjes transform, even when it is bounded), through the discoveries of Schreider in 1950 about the algebra of Fourier-Stieltjes transforms. Our results were published in the form of a series of notes in the *Comptes Rendus*, but Walter was incredibly efficient in making them known among mathematicians: the invited report he made at the Cambridge meeting of the AMS in August 1958, "Measure Algebras on Abelian Groups", contained them all. In the general form about locally compact abelian groups they are exposed in *Fourier Analysis on Groups*.

Walter's last contribution to the subject [3] was an extension of Katznelson's theorem, "A strong converse of the Wiener-Lévy theorem" in 1962: if, for each given f in $A(G)$ with values in the interval $(-1,1)$, the composed function $F(f)$ is a Fourier transform of a function which belongs to $L^p(G^*)$ (here G^* is the dual group of G), with $p < 2$ (depending on f), then F is the restriction on $(-1,1)$ of an analytic function in a neighborhood of the closed interval $[-1,1]$.

Rudin in 1956.

The main event in the domain after 1958 was the theorem of Malliavin on spectral synthesis in 1959. Spectral synthesis can be expressed in many ways, as well as nonspectral synthesis. The contribution of Walter in that subject was to exhibit a function f in $A(G)$ such that the ideals generated by the powers f^n are all different (see [4]).

The question on functions operating on $A(\mathbb{R})$ or $A(\mathbb{T})$ goes back to Paul Lévy (1938) in the paper where the Wiener-Lévy theorem is stated. Paul Lévy asked a second question, on functions operating "below": which are the changes of variables preserving $A(\mathbb{R})$? The obvious example is affine functions.

Actually affine functions are the only ones; it is a theorem of Beurling and Helson, published in 1953. It opened a new and important field, the isomorphisms and endomorphisms of the group algebras. Walter entered the subject in 1956 with his *Acta Mathematica* article [5] on the automorphisms and the endomorphisms of the group algebra of the unit circle. Here is a typical result: a permutation of the integers carries Fourier coefficients into Fourier coefficients if and only if the permutation is equal to an obvious one, up to a finite number of places; an obvious one is a permutation p that satisfies $p(n-g)+p(n+g) = 2p(n)$ for some g. The general result extends both the Beurling-Helson and the Rudin theorems; it deals with homomorphisms of a group algebra into another group algebra and is due to Paul Cohen (1960). Here is a nice particular case, established by Rudin in 1958: the group algebra of a locally compact abelian group G is isomorphic to that of the circle group $\mathbb{T}$ if and only if $G = \mathbb{T} + F$, where F is a finite abelian group.

This question of homomorphism of group algebras is linked with an apparently different question, the characterization of idempotent measures. Here again Helson and Rudin paved the way, and the final result was obtained by Paul Cohen, proving a conjecture of Rudin (Cambridge meeting, 1958): The supports of the Fourier transforms of idempotent measures (these Fourier transforms take values 0 and 1) are the members of the "coset ring" of the group G^*, defined as

Rudin with Jaap Korvaar.

Rudin with Lipman Bers.

Photos courtesy of Mary Ellen Rudin.

generated by all cosets of subgroups of G^* by means of complementation and finite intersection.

There are a number of other results of Rudin in Fourier analysis, about factorization in $L^1(\mathbb{R}^n)$, lacunary sequences, thin sets, weak almost periodic functions, positive definite sequences, and absolutely monotonic functions (another example of *operating functions*). I shall restrict myself to lacunary sequences and thin sets; the name of Rudin is attached to some of them. The name of Rudin appears frequently in relation to automatic sequences and their role in Fourier series; I shall explain the use of Rudin-Shapiro sequences.

Though lacunary sequences and thin sets can be considered in general groups, let me restrict myself to the integers and the circle.

In 1957 Walter defined the Paley sequences as sequences $(n(k))$ such that the coefficients of order $n(k)$ of a function of the Hardy class H^1 (the subspace of $L^1(\mathbb{T})$ generated by the imaginary exponentials with positive frequencies) belong to l^2. The theorem of Paley is that Hadamard sequences (meaning $n(k+1)/n(k) > q > 1$) are Paley. Obviously this extends to finite unions of Hadamard sequences. The theorem of Rudin is that it is a characterization of Paley sequences.

The Sidon sets have very many definitions, and they were studied by Rudin in the important paper of 1960 "Trigonometric series with gaps" [6]. He introduced the $\Lambda(p)$ sets, E, defined by the fact that the L^p norm of a trigonometric polynomial whose frequencies lie in E are dominated by the L^s norms for an $s < p$, up to a constant factor depending on s. He studied the relation between Sidon sets and $\Lambda(p)$ sets, proved an inequality saying that a Sidon set is a $\Lambda(p)$ set for all values of p, and conjectured that this inequality was optimal. This is the case, as proved by Pisier in 1978 using Gaussian processes. Though much is known now about Sidon sets, the main conjecture is still unsolved; it says that Sidon sets are nothing but a finite union of quasi-independent sets, *quasi-independent* meaning that there is no linear relation with coefficients 1, −1, or 0 between its elements. Sidon sets are still a subject of interest, and the subject, including the name of Sidon sets, was introduced by Rudin.

A question was raised by Rudin on the $\Lambda(p)$ sets: There is a natural inclusion between the collections of $\Lambda(p)$ sets, since every $\Lambda(p)$ is $\Lambda(q)$ when $q < p$. Is this inclusion strict? The answer is negative for indices < 2: all $\Lambda(p)$ are the same for $1 < p < 2$. When p is an even integer > 2, Rudin exhibited a $\Lambda(p)$ set that is not $\Lambda(p')$ for any $p' > p$. Only in 1989 was Bourgain able to extend this to all $p > 2$; therefore, the inclusion is strict for $p > 2$. The situation for $p = 2$ is not yet settled.

The Rudin sets on $\mathbb{R}$ or $\mathbb{T}$ are independent sets over the rationals which carry measures whose Fourier transform tends to 0 at infinity. Because of the Kronecker theorem, this cannot happen with countable sets. They are thin, but not too thin. The construction of Rudin is clever (1960). It can be replaced by a random construction. I believe that I am responsible for the name of Rudin sets.

I may be responsible also for the name of the Rudin-Shapiro sequence. The description and the history are well described in the article [7] of Walter Rudin, "Some theorems on Fourier coefficients" of 1959. It is a beautiful and very useful automatic sequence, and I used it as soon as Walter told me about it. It answered a question asked by Raphaël Salem in our informal Montpellier meeting. Salem had overlooked the fact that Harold Shapiro had already answered the question already in 1951. Shapiro deserves recognition, and a few colleagues would prefer to change the name to Shapiro-Rudin. Likely it is too late. There are abuses of that sort in all parts of mathematics, and they usually benefit strong and well-known mathematicians.

The name of Rudin will stay in the history of mathematics by the importance of his contributions to many parts of analysis and by his exceptional talent for exposition, in his articles as well as in his books. Fourier analysis corresponds to part of his life, but only to a part. His whole life as a mathematician and as a human being deserves to be known.

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Jean-Pierre Rosay

I came to Madison for a one-year visit in 1986 with the hope of working with Walter. I admired Walter's work in several complex variables. I especially liked his book *Function Theory on the Unit Ball in* $\mathbb{C}^n$, a stimulating book of supreme elegance where originality is to be found in the least details.

Our collaboration soon began. Working with Walter was pure enjoyment, with daily exchanges. He always came with challenges that gave rise to an immediate desire to work. That cannot surprise readers of his books. Nothing was rushed. Pieces were kept, without any rushing to premature global writing, and at the end the last pleasure was the magic of his elegant writing (not simply cut and paste!).

As soon as I arrived in Madison, I noticed a very special quality of life in the mathematics department. It is obvious that Mary Ellen and Walter Rudin contributed largely to the atmosphere, and they have been wonderful hosts for many. When unexpectedly (the move was never planned) I was invited to stay at Madison, I quickly accepted. Walter was the main reason, but having great colleagues around Walter, such as P. Ahern, A. Nagel, and S. Wainger also played a role. In addition to a collaboration with Walter, a true friendship with Mary Ellen and Walter developed.

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Edgar Lee Stout

Walter Rudin and Several Complex Variables. The Beginning

Although Walter Rudin began his mathematical career with work in Euclidean harmonic analysis in a thesis on uniqueness problems concerning Laplace series, from very early on he also pursued investigations in complex analysis. Most of his work in complex analysis until the early 1960s was concerned with one-dimensional theory.

Rudin's main work in several complex variables began in the early 1960s after the publication of his book *Fourier Analysis on Groups*. I was present at this beginning and recall it rather clearly. During the academic year 1963–64 a working seminar dedicated to trying to learn something about the then not-widely-known subject of several complex variables was run in Madison by a group of students and some faculty members, including Walter. It was a question of the blind leading the blind. The volume of Fuks [1] had just appeared in an English translation published by the AMS, so we in the seminar set out to read through it systematically, but before long we recognized that this was not really what was desired. About that time someone found the beautiful Tata lectures [2] of Malgrange which give a concise introduction to the modern theory of higher-dimensional complex analysis, including the important notions of coherent analytic sheaves and the associated fundamental Theorems A and B of Cartan and Serre. The seminar turned to these notes and became a great success.


Photo by Yvonne Nagel.

Mary Ellen and Walter Rudin, 1991.

Walter's principal research efforts soon turned to multivariate complex analysis. Not unnaturally, his efforts in this direction began with some function-theoretic questions on the unit polydisc in $\mathbb{C}^n$, which is the n-fold Cartesian product of the unit disc in the plane with itself. For a classically trained analyst who is approaching multidimensional complex analysis for the first time, it is entirely natural to begin by studying the possible extensions of classical results on the unit disc in the plane to analogous results on the polydisc. One soon realizes that some classical results have direct and often easy analogues on the polydisc and that the analogues of some classical results are simply false. The most interesting kinds of results are those that present new phenomena.

The first paper of Rudin's about function theory on the polydisc [5] was written jointly with me and comprises two rather disparate kinds of results. The first is a characterization of the rational inner functions on the polydisc, i.e., the rational functions of n complex variables that are holomorphic on the polydisc and that are unimodular on the distinguished boundary $\mathbb{T}^n$ (which is the Cartesian product of n copies of the unit circle in the plane). These are natural n-dimensional

With John-Eric Fornaess.

Photos by Yvonne Nagel.

Rudin and Pat Ahern, who wrote eight joint papers.

analogues of the finite Blaschke products. The second kind of result the paper contains concerns the extension to the polydisc of the *Rudin-Carleson Theorem*, which characterizes as the closed subsets of length zero of the unit circle the peak-interpolation sets for the disc algebra, that is, the sets on which every continuous function can be matched by a function continuous on the closed unit disc and holomorphic on its interior. This paper contains some examples of peak-interpolation sets in the torus $\mathbb{T}^n$ and was the first paper to address the question of this kind of interpolation in n dimensions. In spite of considerable subsequent work, there is still no characterization of the peak-interpolation sets for the polydisc or for any other domain in $\mathbb{C}^n$ with $n > 1$.

After this paper was written, Rudin continued to think about function theory on the polydisc and published in 1969 his book *Function Theory in Polydiscs*, which contained many results obtained in the preceding few years by him and others. The book contains the foundations of Hardy space theory on the polydisc; a discussion of the zero sets of bounded holomorphic functions and, more generally, of functions of the Hardy class; the theory of peak-interpolation sets; and a discussion of inner functions. All of these subjects are direct analogues of well-understood topics in classical function theory, but to this day not one of them exhibits the refined completion enjoyed by the classical theory.

About the time the polydisc book was published, Rudin's attention turned to function theory on the unit ball in $\mathbb{C}^n$. This is a considerably different subject from analysis on polydiscs, in good measure because of the greater degree of symmetry on the ball. Analysis on the ball is a rich subject in itself and also serves as a model for analysis on the general strictly pseudoconvex convex domain. Walter published in 1980 in Springer's Grundlehren series his *Function Theory on the Unit Ball of* $\mathbb{C}^n$, which is much longer than the polydisc book. There is some overlap in themes, e.g., inner functions, peak-interpolation sets, H^p-theory, zero-set problems. At the time this book was written, it was not at all clear that any nonconstant inner functions—bounded holomorphic functions with radial limits almost everywhere of modulus one—exist on the ball. The book contains several results of the general sort that a nonconstant inner function on the ball must behave in very complicated ways, but it neither proves nor disproves their existence. It was eventually shown by Alexandroff and by Hakim-Sibony-Løw that nonconstant inner functions do exist. It is curious that although inner functions on the disc play a fundamental role in many function-theoretic considerations, so far those on the ball have not found many applications. When it appeared, this book gave a panoramic view of almost the entire known theory of functions on the ball, and it has served as the standard reference since.

Walter's interests were much broader than suggested so far. For example, in [3] he gives a characterization of the algebraic varieties in $\mathbb{C}^n$, and in [4] he obtains the structure of a proper holomorphic map from the ball in $\mathbb{C}^n$ to a domain in $\mathbb{C}^n$. He also gave two series of CBMS lectures, the first on the edge-of-the-wedge theorem, the second on constructions of functions on the ball. Both were very well received.

Quite aside from the breadth and depth of his research efforts, one must notice the clarity and elegance of Walter's expository work. His style is concise yet clear and can well serve as a model of mathematical exposition.

I count myself very fortunate to have been a student of Walter Rudin, first in a wonderful year-long course in complex variables—his *Real and Complex Analysis* had not yet appeared—and subsequently as a doctoral student. While I studied with him for my doctorate, Walter was always very helpful, always ready with a technical suggestion about some point under consideration, and, more importantly always very encouraging, which is essential for beginning students. He and his wife, Mary Ellen, herself a distinguished mathematician, were very generous with their hospitality, both to their students and to their former students. What a pleasure it has been to enjoy their friendship over the last half-century.

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John Wermer

Walter Rudin has made important contributions to a very wide range of problems in analysis. Of special interest to me is some of Walter's work on problems linking the theory of commutative Banach algebras and complex function theory.

The following question was raised by Isadore Singer in the 1950s. The disk algebra $A = A(\mathbb{D})$ is the algebra of continuous complex-valued functions on the closure $\overline{\mathbb{D}}$ of the open unit disk $\mathbb{D} = \{z \in \mathbb{C} \mid |z| < 1\}$ which are holomorphic on the open disk. Singer asked, to what extent is $A(\mathbb{D})$ characterized by the following two properties:

(1) A is an algebra of functions continuous on the closed unit disk,
(2) the maximum principle holds with respect to the boundary of the disk.

Walter proved the following theorem: Suppose that B is an algebra of continuous functions on the disk such that

(i) the function $f(z) = z$ lies in B;
(ii) for every function f in B and every point $z_0 \in \mathbb{D}$,

$$|f(z_0)| \le \max\{|f(w)| \mid |w| = 1 \text{ so } w \text{ belongs to the boundary of the disk}\}.$$

Then B is the disk algebra.

He gave extensions of this result, using the local maximum principle and replacing the disk by other domains, in [1].

Walter's work was influential in stimulating the development of the theory of function algebras. In the study of polynomial approximation in $\mathbb{C}^n$, one asks, let K be a compact set in $\mathbb{C}^n$ and let P(K) denote the uniform closure on K of polynomials in the complex coordinates. When is $P(K) = C(K)$? In 1926 J. L. Walsh proved (in *Math. Ann.* **96**) that for each continuous arc J in the complex plane, $P(J) = C(J)$. In [2] Walter gave a counterexample to the corresponding statement in $\mathbb{C}^2$.

For each commutative Banach algebra, one would like to identify all the closed ideals. This is usually difficult. Using results of Beurling on the invariant closed subspaces on H^2, Walter solved the corresponding problem for the disk algebra in his paper [3].

A smooth manifold in $\mathbb{C}^n$ is called *totally real* if no tangent space at a point of M contains a complex line (e.g., $\mathbb{R}^n$ is totally real in $\mathbb{C}^n$). Totally real submanifolds play an important role in the complex geometry of $\mathbb{C}^n$. Walter studied totally real embeddings of the 3-sphere in $\mathbb{C}^3$ jointly with Pat Ahern in [4], and totally real embeddings of the Klein bottle in $\mathbb{C}^2$ in [5].

Walter is well known in the mathematical world for his many basic textbooks, some of which are:

- *Functional Analysis. Second Edition*, McGraw Hill (1991)
- *Real and Complex Analysis. Third Edition*, McGraw Hill (1987)
- *Function Theory of the Unit Ball of* $\mathbb{C}^n$, Springer Verlag (1980)
- *Principles of Mathematical Analysis. Third Edition*, McGraw Hill (1976)
- *Function Theory in Polydiscs*, W. A. Benjamin (1969)

I own several of them and have found them excellent and of great value.

Walter Rudin has contributed to so many subjects that the above has touched on only a small part of his work.

One nonmathematical book of Walter's is his autobiography, *The Way I Remember It*, published by the American Mathematical Society. I found it of particular interest, since Walter and I are fellow refugees from Nazi-occupied Vienna in the late thirties, and so his fascinating story was of special concern to me. I remember one line from him. It was oral and may not be in the book. Walter said, "During the war, I served in the British Army. After that, nothing ever bothered me...."

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Cancer Modeling: A Personal Perspective

Rick Durrett

Cancer modeling comes in a wide variety of styles. Indeed, it can involve almost any type of applied mathematics. My personal favorite approach is the use of probability models to understand how genetic mutations lead to cancer progression, metastasis, and resistance to therapy. Ordinary differential equations can be used to study the growth of tumor cell populations, often leading to a conclusion of Gompertzian growth [21]. PDE models using cell densities and nutrient concentrations as state variables can be used to analyze various spatiotemporal phenomena; see [13].

Individual and agent-based models that treat cells as discrete objects with predefined rules of interaction can offer an improvement over PDE methods in some situations, such as the study of angiogenesis, the development of new blood vessels to bring nutrients to a growing tumor [1]. For a comparison of individual-based and continuum approaches in one particular example, see [4]. Agent-based systems are one of many computationally intensive methods [24] and are often components of multiscale models (see [16], [6], and [8]).

Rather than spend the entire article in the land of generalities with random pointers to the literature, I will next give a description of a useful, simple, and flexible model: multitype branching processes. The types represent stages in the cancer progression. For example, in colon cancer, type 1 cells have one copy of the gene APC inactivated, type 2 cells have both copies inactivated, type 3 cells have the KRAS turned on, and type 4 cells have a mutation in P53. For more on this example, see the classic paper by Luebeck and Moolgavkar [17] or Steven Frank's book [12].

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DOI: http://dx.doi.org/10.1090/noti953

I realize that many readers of this article have not heard of these three genes. For the purposes of this article, it is enough to know a few simple facts. APC is a tumor-suppressor gene. When both copies are knocked out in a cell, trouble starts. KRAS is an oncogene. A mutation of one copy changes the behavior of the cell. In population genetics these would be called advantageous mutations, but what is advantageous to a subset of your cells is not necessarily good for the whole. Finally, P53, which is named for its 53 Kilo-Dalton size, is a housekeeping gene that helps keep the cell-replication machinery running smoothly.

Exactly what these three genes do is not important. Indeed, in many cases, such as the BRCA genes, there was a long time interval between when they were discovered to have a statistically significant correlation with breast cancer and when the mechanism that caused this association was understood. For the branching process model we are about to describe, the key fact, which is used to give estimates of the mutation rates u_i, is that there is a fairly specific sequence of mutations that leads to the disease. Before turning to the mathematical details of the model, one last thing that should be said is that this "key fact" is an oversimplification. In 20 percent of colon cancers, APC is not mutated, but the oncogene β-catenin, which is in the same metabolic pathway as APC, is turned on. The fact that pathways and not individual genes are the targets of cancer-causing mutations has greatly complicated the tumor genome sequencing approach to understanding the mechanisms of cancer.

In multitype branching processes, cells of type i die at rate b_i, give birth to nonmutant offspring at rate a_i, and produce cells of type $i+1$ at rate u_{i+1}. Here the rates are the transition rates of a continuous time Markov chain; e.g., the probability a cell gives birth in t units of time is $a_i t + o(t)$ as $t \to 0$. Let $Z_i(t)$ be the number of cells of type i at time t. The behavior of the type 0's has been known for many years; see, e.g., the classic book by Athreya and Ney [2]. If $\lambda_i = a_i - b_i$ is the net growth rate, then the expected number of type 0 at time t is

$$EZ_0(t) = e^{\lambda_0 t} Z_0(0).$$

If $a_0 > b_0$, then the probability that the type 0's do not die out is λ_0 / a_0, and when they do not die out

$$e^{-\lambda_0 t} Z_0(t) \to V_0 = \text{exponential}(a_0/\lambda_0).$$

Here $\to$ indicates that with probability one the sequence of numbers converges. $V = \text{exponential}(r)$ is read "exponential with rate r" and means $P(V > v) = e^{-rv}$ for $v \geq 0$.

Since the types progress $0 \to 1 \to 2 \to \dots$, this process at first seems childishly simple. Breaking things down according to the time of the mutation to type 1, the expected number of type 1's satisfies

$$EZ_1(t) = \int_0^t EV_0 e^{\lambda_0 s} \cdot u_1 \cdot e^{\lambda_1 (t-s)}\, ds.$$

The first factor gives the size of the type 0 population at time s, the second the mutation rate, and the third the number of offspring the mutant has at time t. However, if $0 < \lambda_0 < \lambda_1$, the expected value $EZ_1(t)$ drastically overestimates the number of type 1's. The main contribution to the integral comes from times near 0, but in cancer u_1 is very small (10^{-5} or less), so, as in the state lottery, the expected value comes from a rare event that produces a very large result.

In analyzing the growth of the multitype process, it is more productive to focus one's attention on times at which $V_0 e^{\lambda_0 s} \approx 1/u_1$ and type 1's are being produced at a positive rate. In terms of the theory of stochastic processes, mutations to type 1 are a nonhomogeneous Poisson process. Using elementary properties of the Poisson process and simple computations with Laplace transforms, one can show that

$$e^{-\lambda_1 t} Z_1(t) \to V_1 \quad \text{with} \quad Ee^{-\theta V_1} = (1 + c u_1 \theta^{\alpha})^{-1},$$

where $\alpha = \lambda_0/\lambda_1$. This result is more easily understood (and generalized to types $k > 1$) if one conditions on the value of V_0.

$$E(e^{-\theta V_1} | V_0) = \exp(-c u_1 V_0 \theta^{\alpha}).$$

See [11] for more details. The right-hand side is the Laplace transform of a one-sided stable law. These distributions come up in a typical graduate course in probability because they are part of the answer to the question, "What are the possible limits of normalized sums of independent random variables $(S_n - b_n)/a_n$? "

The appearance of stable laws in this setting is (at first) somewhat surprising, but as we will see in a moment, it is very useful in quantifying the relative frequency of mutations that make up a tumor. Understanding the amount of tumor heterogeneity is important for several reasons. Higher levels of heterogeneity have been correlated with tumor aggressiveness in a clinical study of Barrett's esophagus [19] and is thought to be predictive of malignant progression in other cancers as well. In addition, tumor heterogeneity poses challenges for the development of successful therapies. For example, increased genetic heterogeneity means a higher probability that a tumor harbors cells resistant to treatment. On the other hand, there are some new therapies that take advantage of the competition between different types of tumor cells. See [20] (which is available for free at PubMedCentral) for an explanation and for more on the causes and consequences of heterogeneity.

One measure of tumor diversity, Simpson's index R_k, can be defined as the probability that two randomly chosen type k cells are descended from the same mutation. In genetics this is called the homozygosity. Using some of the facts about stable laws that have accumulated over the last seventy years, one can prove a remarkably simple result for type k cells:

$$ER_k = 1 - \alpha_k, \quad \text{where } \alpha_k = \lambda_{k-1}/\lambda_k.$$

With more work one can compute moments of R and obtain insights into its distribution. See [10] for more details.

Two things make these results possible: (i) A Poisson process representation of the relative contribution of the different mutations to the cancer cell population, which is the key to identifying the limits V_i as stable laws. See Figure 1 for a graphical

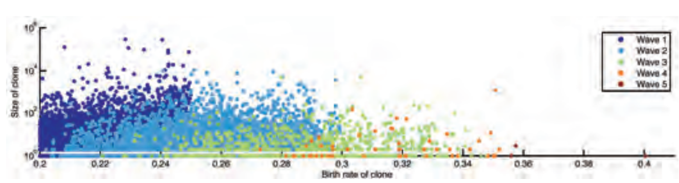

Figure 1. Tumor heterogeneity in a multitype branching process. Generalizing the model discussed in the text, the growth rate of a mutant is that of its parent plus an amount uniformly distributed on [0, .05]. Dots indicate the growth rate of the mutant and the logarithm of the number of its descendants at a fixed time. Note that a half dozen type 1 families are responsible for most of the population. Figure by Jasmine Foo.

display of tumor heterogeneity in a simulation of a multitype branching process. (ii) Mathematicians who have done intensive study of Poisson-Dirichlet distributions, which appear naturally in a wide variety of topics from the infinite alleles model in biology to properties of the cycle structure of randomly chosen permutations. See Pitman's book [23] for more details.

An Application to Ovarian Cancer

While it is nice that our multitype branching processes have a detailed and interesting theory, it is more important that they are useful in applications. One simple example comes from work I did with Duke undergraduate Kaveh Danesh to answer a question asked by two doctors in Duke Medical Center's Department of Obstetrics and Gynecology. Evan Myers and Laura Havriletsky wanted to know, "How often should ovarian cancer screening be done in order to be effective?" To address this question, we built a multitype branching process model in which type 0 cells are in the primary tumor in the ovary or fallopian tube, type 1 cells are floating in the abdominal cavity, and type 2 cells are those that have attached to the peritoneum. Type 2 cells infiltrate the cellular matrix and eventually metastasize to distant organs, so when they are present in significant numbers, the cancer is classified as stage III. Note that in this model, the transitions from type $0 \to 1$ and $1 \to 2$ involve migration of cells, not genetic mutation.

One of the problems with ovarian cancer is that many cases are diagnosed in stage III or IV, with a five-year survival rate of less than 30 percent, compared to 90 percent for stage I tumors, so many lives could be saved if they were caught in stage I, when the cancer has not spread. (Contrary to intuition, the clinically defined stage II—tumors in both ovaries/fallopian tubes—often does not come between stages I and III.) We defined the window of opportunity for screening to be $T_2 - T_0$, where T_0 is the first time the primary tumor is 0.5 cm in diameter (and hence visible on a transvaginal ultrasound) and T_2 is the first time there are 10^9 cells of type 2 (which corresponds to one gram). These definitions are somewhat arbitrary, but our formulas easily give results for other cutoffs.) Using what is known about tumor growth and mutation rates, we concluded that the window of opportunity was 2.9 years, with most of the distribution concentrated on $[2.5, 3]$ years. Thus, in order to be effective, screening needs to be done every two years. See [7] for more details. Figure 2 gives a picture of the growth of the three cell populations on a log scale.

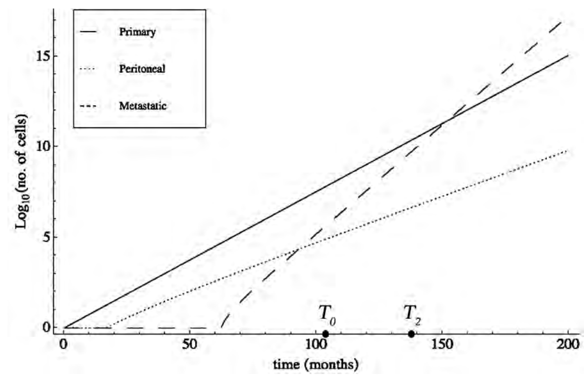

Figure 2. Plot of the sizes of the Primary (solid line), Peritoneal (dotted line), and Metastatic (dashed line) cell subtypes in the ovarian cancer model on a logarithmic scale. The window of opportunity for screening is $[T_0, T_2]$, where T_0 is the first time the primary tumor has diameter 0.5 cm. T_2 is the time at which there are 10^9 metastatic cells (approximately one gram). Figure by Kaveh Danesh.

Models: Simple or Detailed?

I prefer simple models that can be analyzed mathematically. For example, early in my career I studied percolation and the Ising model. In the stochastic Ising model each iron atom has a spin that can be +1 (up) and −1 (down), and spins flip at a rate that depends on the number of neighbors of the opposite type. Of course, in a real iron bar, atoms have a spin that points in some direction in three-dimensional space, and spins interact with other than their nearest neighbors. However, despite these simplifications, the Ising model yields insights into qualitative properties of the magnetization phase transition.

On the other hand, cancer biologists often prefer models that include all of the relevant details. Chapter 6 of Cristini and Lowengrub's book [6] describes a model of ductal carcinoma in situ, the most prevalent precursor to invasive breast cancer. The authors use an agent-based modeling framework that takes cell motility and various cell-cell interactions into account, but then one ends up with more than two dozen parameters, simulations that are restricted to a 1 mm duct, and a model that treats a two-dimensional slice instead of the three-dimensional tube. See Figure 3 for a picture of a simulation.

While the model is complex and analysis can only be based on simulation, it has the advantage of being realistic. At the SIAM Life Sciences meeting in San Diego, August 7–10, 2012, I heard Paul Macklin talk about how computations with this model were useful in informing medical treatment decisions [18]. The issue is that the calcified core of dead cells in a breast cancer duct, which is

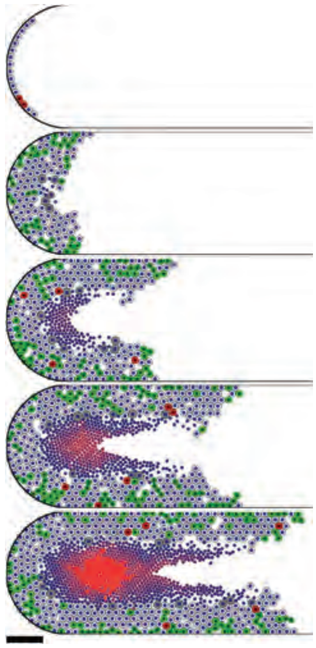

Figure 3. Simulation of ductal carcinoma in situ. Cell nuclei are the small dark blue circles; quiescent (resting) cells are pale blue; proliferating cells are green; apoptosing (dying) cells are red; and necrotic (dead) cells are grey until they lyse, after which their solid fraction remains as debris (dark circles in center of duct). The shade of red in the necrotic debris indicates the level of calcification. Simulated times (from top to bottom): 0, 7, 14, 21, and 28 days. Figure from [18], reprinted with the permission of the *Journal of Theoretical Biology*.

what can be seen in a mammogram, is smaller than the region in which cancer cells are present. Thus one must estimate the size of the region of the breast to be removed. This is an important problem, because 50 percent of women who have a lumpectomy must return for a second surgery because not all the cancer cells were removed the first time.

If you are interested in learning more about detailed models, the first 2012 issue of *Mathematical Medicine and Biology* has the proceedings of a 2009 SIAM three-part minisymposium, "State of the Art in Computational Modeling of Cancer". This style of modeling does not suit my skill set very well, but the approach is valuable, and I am doing my best to educate myself about it. Simple and detailed models complement each other. Simple models give insight into the working of detailed models. Detailed models give mechanistic insights that shape the form of the simple models and rigorously calibrate their parameters.

Breast Cancer Heterogeneity

An article like this would not be complete without some unsolved problems, so I'll mention two. Due to the introduction of microarray analysis and the use of statistical classification techniques [22], a subdivision of breast cancers into a half dozen subtypes has been developed. The grouping of tumors according to the established markers estrogen receptor (ER), progesterone receptor (PR), and HER2 has improved treatment outcomes, but challenges remain. The first and most obvious is that 16 percent of tumors show none of these markers and are classified as triple-negative [27].

During the summer of 2012, one of my postdocs, Marc Ryser, and I learned of another issue in a meeting with Kimberly Blackwell, a researcher in the Duke Cancer Institute. Due to tumor heterogeneity, a small sample of one section of the tumor may not reflect all of the mutations present. Thus, one would like to understand the spatial structure of heterogeneity in breast cancer, with the aim of conducting more informative biopsies. That is, one wants to avoid false negatives due to insufficient sampling and tumor heterogeneity.

Much is known about the heterogeneity of breast cancer between and within patients (see [25]). However, despite a large amount of money spent on tumor-sequencing studies, many of the things we need to know concerning mechanisms of that disease in order to develop a model are not known, so it is hard to know where to begin. Being a mathematician, my approach is to study a simple spatial model and to understand how the observed patterns of heterogeneity depend on the model's parameters. In this way we have results that can be applied to a variety of cancer types.

An Exciting New Development

Announced in the August 23, 2012, issue of *Nature* (see pages 462–463 for the "News and Views" summary) is the fact that there is now conclusive evidence of the existence of cancer stem cells (CSC) that can produce tumor cells in the same way that ordinary stem cells can produce normal tissue. The existence of CSC has long been controversial. For example, transplantation studies have shown that human cancer cells when injected into mice rarely cause cancer, leading to the conclusion that only a small fraction of the tumor cells are responsible for the disease. However, skeptics have pointed out that removing cells from their natural environment may change their behavior. For more see [29].

The three new papers, two in *Nature* [5], [9] and one in *Science* [26], avoid this objection by using a genetic technique called lineage tracing to track cells in an existing tumor. The laboratory techniques are ingenious and for most of us are difficult to read and understand. However, I believe that mathematics can play an important role in sorting out whether the assumed stem cell dynamics will indeed produce the behavior observed in the laboratory experiments. To see what I have in mind, read [28] or just look at their Figure 1, which compares tumor morphology under the CSC and classical models.

It is remarkable what simple facts are not known about the normal stem cells in our bodies, whose existence is well documented. They sit at the bottom of each of the 10^7 crypts in the colon, but the best estimate is that there are 4–20 of them in each crypt. Stem cells in the bone marrow produce white blood cells, and some of them are quiescent at any one time, but the quiescent fraction may be 10 percent or it may be 90 percent.

For a long time it was thought that stem cells always divide asymmetrically, producing one stem cell and one progenitor cell. However, recent studies have shown that sometimes the result of cell division is two stem cells and sometimes two progenitor cells; see [15]. I found it interesting that the authors' analysis led them to a thirty-year-old paper of Bramson and Griffeath on the voter model [3] and that they applied its result for the one-dimensional system to their data on colon crypts.

Where Are the Math Problems in the Last Two Sections?

Biology is not physics. Statistical mechanics, quantum mechanics, relativity, and string theory have given rise to complex mathematical problems which can be happily studied by mathematicians with no knowledge of physics. However, in my twenty-five-year experience of working on problems that come from ecology, genetics, and now cancer, 80 percent of the problem in a biological application is to figure out what the question is, what mathematical tools to use, and, in my case, how to find a model that is simple enough to study analytically and that can say something useful about the application.

If You Are Excited About Cancer Modeling, Then What's Next?

Well, you just missed the SIAM Life Sciences Meeting in San Diego, August 7–10, 2012, where a lot of cancer modeling was discussed. Presumably the 2014 meeting will have more of the same. An easy entry into the subject will be provided by the 2014–2015 year on cancer modeling at the Mathematical Biosciences Institute. Till then you can read a few of the papers in the references, visit my webpage to see some of my papers, or go to `http://michorlab.dfci.harvard.edu/index.php/publications` for a more extensive set of publications by collaborator Franziska Michor.

There are more papers to read than anyone has time. When I searched MathSciNet recently, it reported 2,423 papers on cancer and 212 on breast cancer since 2000, but many of the latter are statistical analyses. PDE people will probably have more fun with the more than one hundred papers on angiogenesis. The quantitative biology section of the arXiv has cancer modeling papers, but by far the most comprehensive collection is the open-access PubMedCentral, where NIH grantholders are required to put their papers. This is good news and bad news: There are 3,800 papers with "breast cancer" in the title since 2010.

While you can get a lot of information from journals and books, by far the best way to get into math biology is to find a biologist or medical researcher to talk to. Bridging the communication gap and trying to figure out what you can do to help with their research is not easy, but then again, things that are worth doing rarely are.

Acknowledgements

I would like to express my appreciation to Jasmine Foo, Kevin Leder, and Marc Ryser, who each read several versions of the paper. I would like to thank ShiShi Luo, Paul Macklin, Peter Mucha, Mike Reed, and several anonymous referees, whose comments helped improve this article. My research has been supported by the National Science Foundation and the National Institutes of Health. The views expressed here are my own and may not agree with the views of the NSF, NIH, or AMS.

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A Revolutionary Material

Charles Radin

The 2011 Nobel Prize for Chemistry was awarded to Dan Shechtman for the discovery of quasicrystals, an exotic class of materials. The discovery was published in 1984 and was quickly treated as revolutionary, with front-page headlines in newspapers.

While the award was for chemistry, the revolution was more broadly based within the interdisciplinary subject of materials science. This can be described easily, and we will begin with a sketch of the idea. The multifaceted implications for mathematics are more complicated, and we will try to elucidate them afterwards.

The basic fact is that quasicrystals are equilibrium solids which are not crystalline. Not only is their pattern of atoms not crystalline, the pattern has a fascinating hierarchical structure. However, we emphasize that the hierarchical pattern is not essential to the revolutionary significance of quasicrystals to materials science.

It had been understood for many years, following the development of X-ray diffraction, that common inorganic solids (for instance all solids composed of only one chemical element) are crystalline, and great practical success followed from incorporating this into standard modeling, essentially by analyzing various perturbations of a crystalline atomic configuration. This is evident from basic textbooks on solid state physics from the 1970s. The startling fact uncovered by the discovery of quasicrystals was the existence of a previously unknown class of inorganic solids, of unknown diversity, for which a fundamentally different approach would be needed, specifically without the help of an underlying crystalline structure. That was the revolution in materials science.

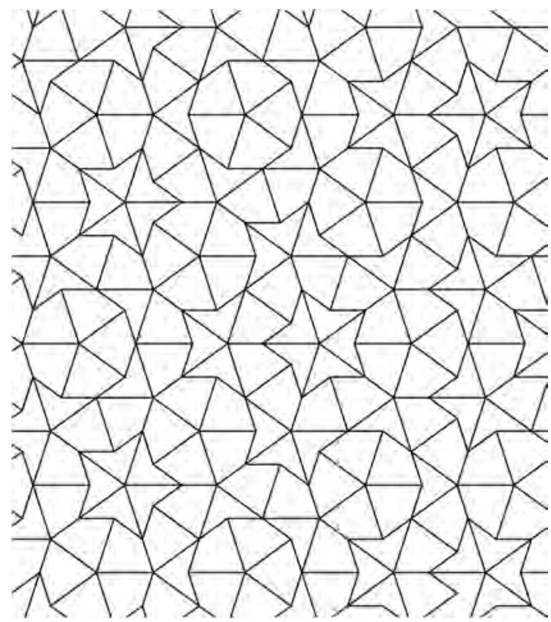

Figure 1. A Penrose kite and dart tiling of the plane.

As for the implications for mathematics, one path quickly developed from the hierarchical atomic patterns, which played a central role in the theory of Levine and Steinhardt based on aperiodic tilings such as the Penrose "kites and darts" (see Figure 1).

This led to interesting mathematics. The developments with which I am familiar are in the ergodic theory of aperiodic tilings and the theory of density in hyperbolic spaces, but there are

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This research was supported in part by NSF grant DMS-1208941.

DOI: http://dx.doi.org/10.1090/noti954

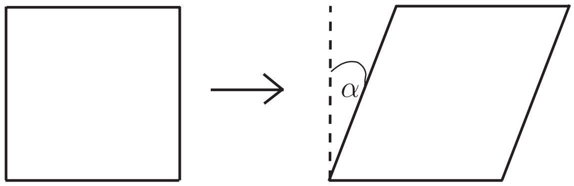

Figure 2. A strain angle α.

undoubtedly many more developments inspired by the hierarchical structure.

That was the first, early line of development in mathematics coming from quasicrystals. But there is also significant mathematics intimately related to the revolutionary character of quasicrystals: the basic fact that quasicrystals are noncrystalline solids. Clarifying this mathematical connection is the goal for the rest of this article. This will require some review of the nature of solids and their modeling using equilibrium statistical mechanics, which we will motivate by focusing on a certain phenomenon.

To understand a material scientifically, one typically studies the experimental response to a disturbance; one kicks it and examines the reaction. Electrical conduction concerns the response to an applied voltage, sound propagation concerns the response to a (rapidly varying) applied pressure, elastic stress coefficients model the response to applied mechanical forces, and so on. Let us explore mechanical forces in more depth through the following specific problem.

It is natural that if you tried to stand on an ocean surface you would sink, because the water molecules would move out of the way of the force applied by your feet. Why then can you stand on a glacier? It turns out that, the more one analyzes these two contrasting material responses, of water and of ice, the more intriguing the question becomes, and we will use that idea to clarify the significance within mathematics of the discovery of quasicrystals. So we will keep in mind the problem:

(1) Why can you stand on ice but not water?

We begin with a certain classification of applied mechanical forces, or stresses. Suppose we have one balloon filled with water and another filled by a single block of ice. The possible stresses we could apply to the balloons are commonly classified into "pressure", which tends to change the volume but not the shape of the balloon, and "shear stress", which tends to change the shape but not the volume. Shape is quantified by angles denoting "strain"; see Figure 2.

We can view the force and the associated geometric change as responses to one another: applying a force yields a change in the geometry of the bulk material, and effecting a change in the geometry is resisted by a corresponding force from the material. The response is generally a nonlinear function of its cause, but the coefficient of the linear approximation is useful. The linear coefficient of response forces to changes in geometry are called moduli: (elastic) bulk modulus for pressure and (elastic) shear modulus for shear.

Getting back to our question (1) and the need to distinguish the response of ice from that of water, we choose to concentrate on shear, in particular, the shear moduli of ice and water. Pressure would be much simpler to analyze but of little value, since water is an incompressible fluid with almost the same bulk modulus as ice. But water deforms rather than supports any (static) shear at all, while ice is hard to deform, so the shear modulus of water is zero while that for ice is large. So, to answer (1) we shall try to understand through models why the shear moduli of water and ice are so different. Perhaps we can also reverse focus and ask whether this difference is the key to the fundamental difference between water and ice.

We will explore our problem now in more depth, beginning with the thermodynamic model of matter as an intermediate step towards the statistical mechanics model. For convenience we will restrict our modeling to "simple" materials which are (macroscopically) homogeneous, isotropic, uncharged, and of only one chemical species, and which are not acted on by magnetic, electric, or gravitational forces. The model will thus be restricted to questions of internal energy, such as the transfer of energy between two systems in contact, and the interaction of these with mechanical operations on the systems. A typical application might concern the energy of a gas in the chamber of a piston, the whole bathed in a fluid at fixed temperature, when the chamber of the piston is expanded.

The formalism of thermodynamics makes use of a quantity called the entropy density of the system. Experiment demonstrates that a simple system can be put into thermal equilibrium, where it has a range of well-defined equilibrium states, parameterized in several equivalent ways but, for instance, by the two quantities of energy density e and mass density m, so that all thermodynamic quantities, including the entropy density and the various mechanical properties, have unique values for given (e, m). Furthermore, it is found that all thermodynamic properties are computable from the entropy density function, $s(e, m)$. For instance, $\partial s/\partial e$ is inversely proportional to the temperature. A transform of $s(e, m)$, called the Gibbs free energy density, $g(P, T)$—basically a Legendre transform of $s(e, m)$—can play a role alternative to $s(e, m)$ but with variables P, T, the pressure and temperature respectively.

(2) All thermodynamic properties are uniquely determined by the entropy density $s(e, m)$, or, alternatively, by the Gibbs free energy density, $g(P, T)$.

We next show how useful this observation can be in the modeling of mechanical properties.

The experimental states of bulk matter in thermal equilibrium can be organized into "phases". A phase is a set of states in an open connected subset of the parameter space $\{(P, T)\}$ which is maximal with respect to the property that, within that subset, all thermodynamic properties are analytic. From (2) it suffices to require this of just $g(P, T)$, so the boundary of a phase consists of singularities of $g(P, T)$.

The simplest phase of any material is the (isotropic) fluid phase, the phase which contains all (P, T) with P sufficiently low and T sufficiently high. The complement of the fluid phase for any material contains those (P, T) with P sufficiently high and T sufficiently low, and it contains one or more distinct "solid" phases, typically with distinct crystal structure. See Figure 3, which includes the curves of singularities of $g(P, T)$ bounding the fluid and solid phases. We note that a phase can bound itself; in fact, the part of the boundary of the fluid phase at which that phase bounds itself is where the gas and liquid forms of the fluid phase coexist; see Figure 3.

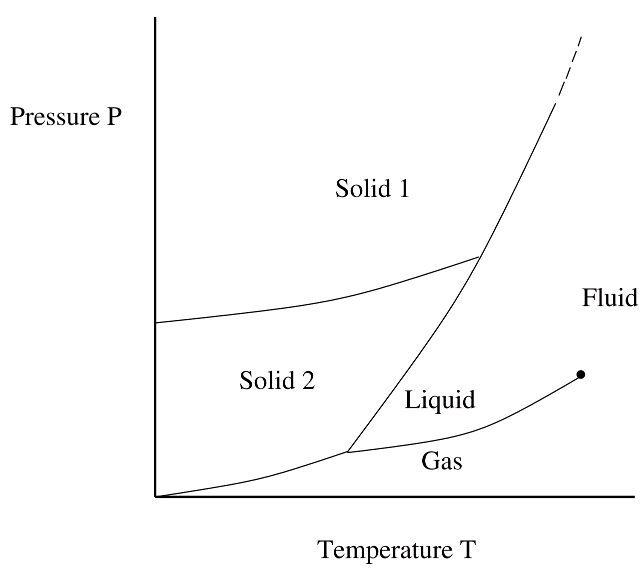

Figure 3. A schematic experimental parameter space.

Using the language of phases, our problem is to understand why the shear moduli of the fluid and solid phases of water are so different. We sketched the thermodynamic analysis of simple matter, but this formalism does not address the causes of the phenomena it describes. Traditionally one goes to a deeper level of analysis, equilibrium statistical mechanics, for such understanding.

In brief, statistical mechanics tries to show how the thermodynamic properties of a material follow from the *interaction* of constituent particles, which we will call molecules; note that water and ice are both made from H_2O molecules with the same interaction. The pressure of a gas, which has a natural meaning in terms of the mechanical properties of the bulk material, can also be understood in terms of momentum transfer between the molecules and between the molecules and the environment of the gas. The internal energy of the system can be understood in terms of the mechanical notions of potential and kinetic energies. However, the biggest step in the development of statistical mechanics, due to Boltzmann, was the model of entropy density as $(1/V)\ln[\Gamma_V(e, m)]$, where V is the volume of the material in space and $\Gamma_V(e, m)$ is the (high-dimensional) volume of the set of all joint states c of the molecules that have total (kinetic plus potential) energy density $e(c)$ and mass density $m(c)$. The advantage of such modeling is that if we can compute the potential and kinetic energies between the molecules (even in a model with unrealistic interactions), we can, in principle, compute the entropy density $s(e, m)$ (or Gibbs free energy density $g(P, T)$), from which all thermodynamic information would follow. This would provide a deeper understanding of the thermodynamic properties; the all-important function $s(e, m)$, or $g(P, T)$, would follow from the interactions of the component molecules.

One feature of statistical mechanics that was omitted above, but which we need, concerns the phases. Since we are trying to understand the fundamental difference between these phases, it is necessary that we have access to them in our modeling. Now it has been known for many years that, if we accept the conventional meaning of phase boundaries as singularities of $s(e, m)$ or $g(P, T)$, we must take the limit of system size to infinity in the models. So to model the entropy density we use

$$s(e, m) = \lim_{V \to \infty} \frac{1}{V} \ln[\Gamma_V(e, m)]. \tag{3}$$

The above was a superficial introduction to the standard modeling of bulk materials in thermal equilibrium, including the notions of fluid and solid phases, but even though superficial, we can see that this modeling is insufficient to deal with our problem of the rigidity of solids. The difficulty is that the above theory does not address the response of a material to an applied shear strain! In fact, it has been proven that the above entropy density $s(e, m)$ and Gibbs free energy density $g(P, T)$ are independent of the shape of the material, and indeed we can look up material properties without specifying the shape of our material sample. And if $g(P, T)$ is independent of shape, how can we compute from it a response to changing the shape? This is our problem: for a macroscopic system of interacting molecules in thermal equilibrium, how do we model the response to shear strain and, in particular, show that it is high for state parameters (P, T) corresponding to the solid phase but identically zero for (P, T) corresponding to the fluid phase?

We will sketch two approaches to this matter. The first, by Aristoff and the author, gets around the above difficulty by three steps. One is the observation that the response to strain is in fact computable using the statistical mechanics of a finite system before taking the limit in system size. The next idea is a bit technical, namely, to use a response of a simpler nature than the reaction force of the system, i.e., the volume or mass density of the system. That is, one changes the shape and measures whether or not the volume changes. This is mildly counterintuitive, since shear is not supposed to change volume, but indeed it can, and this is actually a well-known phenomenon of sand called *dilatancy*. More formally, it is reasonable if we note that, because of the singularities of the free energy all along the boundary separating phases, $g(P, T)$ is intuitively a completely different function in different phases. So we might well expect every thermodynamic quantity, including the mass density, to be singular as (P, T) crosses the boundary between phases.

The last idea is to look for a difference as we interchange limits, namely, the infinite size limit and the limit of infinitely small strain implicit in the derivative of mass density with respect to strain. More specifically, it is not hard to write a formula for a system of finite fixed size for the linear response, in other words, the derivative, of the (average) mass density with respect to shear strain. Then we can take the limit in the size of the system. To repeat: we take the limit of vanishingly small shear *before* we take the limit of infinite size. As noted above, we know that taking the limits in the other order cannot work, because as we take the infinite size limit, the free energy loses its dependence on the shape of the system. But does interchanging the limits help? The quantity we end up with, the volume limit of the derivative, is no longer the linear coefficient in an expansion of a response, since there is no response by the infinite system. But it still might be meaningful. We focused on the response because we thought it might distinguish water from ice, and the quantity we end up with may not be easy to interpret as a response, but it still could play a useful role in distinguishing fluid from solid in models. Does it do this, and if it does, what does it represent physically?

I said we can write a formula for the response, but it is a complicated integral, with parameters P, T, and V in high dimension, and I did not say we could compute it analytically or even get useful qualitative information from it. The only evidence there is for the above theory comes from simulation in a standard model called "hard disks". For that model one can let a computer (actually *many* computers) apply Monte Carlo techniques to simulate the desired equilibrium quantities, and the result is that the linear response of mass density with respect to shear strain jumps from identically zero to nonzero precisely (within error!) as the thermodynamic parameter values cross the phase transition boundary between fluid and solid. So it seems to work precisely as desired in an important model, though this still leaves open its physical interpretation.

We now note a somewhat different approach to our basic problem (1) of distinguishing water from ice by Sausset, Biroli, and Kurchan, which uses the response to a time-dependent shear, a shear with constant *strain rate*, a standard quantity when analyzing fluids. The linear response of a fluid to a constant shear strain rate, namely, the (linear coefficient in the) response force to that deformation rate, is called *viscosity*. Sausset et al. analyze the viscosity of crystals using various traditional physics approximations and conclude that the difference between a fluid and a solid is that, within a solid the viscosity diverges in the limit of zero shear strain, while within a fluid the viscosity vanishes in the limit of zero shear strain. This offers a different intuitive picture of the essential difference between ice and water from that discussed earlier.

We cannot easily sketch the argument using viscosity, because it concentrates on time dependence, which is difficult to mesh with a well-defined notion of phase. In modeling requires time-independent equilibrium systems of infinite size. But we have included the approach specifically to bring up the important issue of time dependence, both in the physical material and in models of it. Throughout our discussion we have emphasized that quasicrystals are materials in thermal equilibrium, meaning they have the stability property that if perturbed by "annealing", the details of which are unimportant here, the system would return to its original state as measured by all thermodynamic properties. It is easy to prepare simple dilute gases in thermal equilibrium; all that is needed is to provide a steady environment of given pressure and temperature, and the system will naturally and quickly approach equilibrium. This is much harder to do with solids, and in practice many solids would change their state if annealed. Indeed, it is common to purposely prepare solids out of equilibrium in order to obtain desirable features: permanent magnets are examples, as are (structural) glasses such as window glass. From X-ray diffraction we know that the atomic positions in window glass are indistinguishable from that of the material in a liquid state at some (P', T') corresponding to its manufacture process rather than being crystalline, as it would be in the true equilibrium state of the material at the (P, T) of room pressure and temperature. And yet of course window glass is quite rigid. So a system which technically is just a very sluggish ("viscous") fluid, not in thermal equilibrium, can behave like an equilibrium solid. This makes (nonequilibrium) glasses notoriously difficult to model. When we model a quasicrystal we can use the fact that the material really is in thermal equilibrium, in effect that an infinite time limit has been taken; and clearly in our modeling we must analyze the proper order of taking that limit and the other limits of interest, namely, the (technically challenging) infinite size limit and the limit of zero strain. The proper simultaneous handling of these three limits is highly nontrivial, and such modeling issues cry out for the attention of serious applied mathematics. The traditional role for mathematics in open physics problems—for instance, concerning phase transitions—is to give proofs in standard, simplified models. However, because of the sophisticated technical issues involved, this problem seems to call for a different sort of role for mathematics, namely, in helping to determine the correct intuitive understanding of the phenomenon at hand: the difference between fluids and solids in thermal equilibrium.

In summary, there is a fundamental open problem in condensed matter physics to understand the essential difference between water and ice. In physics language we are looking for the right "order parameter" to distinguish the fluid and solid phases of matter in thermal equilibrium. It is perhaps surprising that no one has ever found an order parameter with which it could actually be proven, in some simple but convincing model, that a molecular system has a sharp transition between fluid and solid phases, so we could say that the shear modulus (or alternatively the derivative of density with respect to strain, or the viscosity, both sketched above) might play that role. Many of the older attempts to find such an order parameter focused on the difference in symmetry: the complete Euclidean symmetry of the fluid versus the crystalline symmetry of the solid. The existence of quasicrystals has affected this basic problem by showing that crystalline symmetry, and, by extension, perhaps symmetry itself, may not be relevant to an understanding of the fundamental difference between fluid and solid phases, and this fact motivated the attempts sketched above. The present physical theory of the wide range of phase transitions of materials developed, in part, by motivating significant progress in combinatorics and probability. Finally coming to grips with this most fundamental of phase transitions, the fluid/solid transition, may well require something different, a close collaboration of mathematics and physics in the basic modeling, and this is just one natural fallout of the quasicrystal revolution.

Some References for the Physics

These are the initial reports on the experimental discovery, and theory, of quasicrystals:

D. Shechtman, I. Blech, D. Gratias, and J. W. Cahn, Metallic phase with long-ranged orientational order and no translational symmetry, *Phys. Rev. Lett.* **53** (1984), 1951–1953.

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Here are standard references on thermodynamics and statistical mechanics:

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Chapter 2 of the following contains an intriguing analysis of the role of "rigidity" in understanding phase transitions.

P. W. Anderson, *Basic Notions of Condensed Matter Physics*, Benjamin/Cummings, Menlo Park, 1984.

These are the two papers proposing theories of shear which are discussed in the article:

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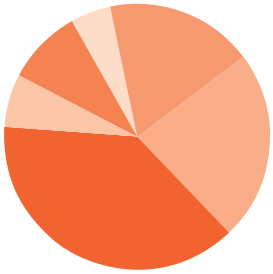


Preliminary Report on the 2011-2012 New Doctoral Recipients

Richard Cleary, James W. Maxwell, and Colleen Rose

This report presents a statistical profile of recipients of doctoral degrees awarded by departments in the mathematical sciences at universities in the United States during the period July 1, 2011, through June 30, 2012. All information in the report was provided over the summer and early fall of 2012 by the departments that awarded the degrees. The report includes a preliminary analysis of the fall 2012 employment plans of 2011–2012 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, sex, and racial/ethnic group. This preliminary report will be updated to reflect subsequent reports of additional 2011-2012 doctoral recipients from the departments that did not respond in time for this report, along with additional information provided by the doctoral recipients themselves. A list of the nonresponding departments is on page 324. Note this report uses the new groupings of doctorat-granting mathematics departments recently adopted by the Joint Data Committee. Additional detail is provided on page 323.

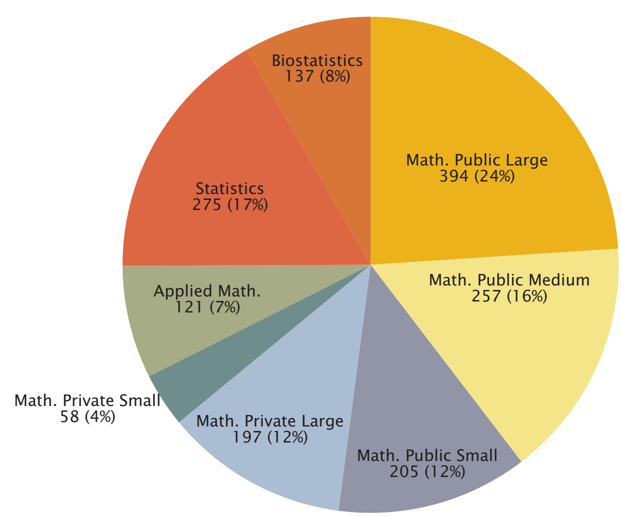
Detailed information, including tables which traditionally appeared in this report, is available on the AMS website at `www.ams.org/annual-survey/2012Survey-NewDoctorates-Prelim`.

Doctoral Degrees Awarded

Based on the data collected it appears the number of Ph.D.s being awarded increased in 2011–2012, and the final figure is likely to exceed the record total of 1,653 reported the previous year. For 2011–2012, the preliminary count for new Ph.D.'s awarded by the 277 responding departments is 1,644. This is an increase of 6.5% over the 1,543 degrees awarded by the same set of departments in 2010–2011. (See page 324 for a list of departments still to respond.)

29% (473) of the new Ph.D.'s had a dissertation in statistics/biostatistics (including 72 from mathematics and applied mathematics combined), followed by algebra/number theory (226) and applied mathematics (235) both with 14%.

Figure A.1: Number and Percentage of Degrees Awarded by Department Grouping*



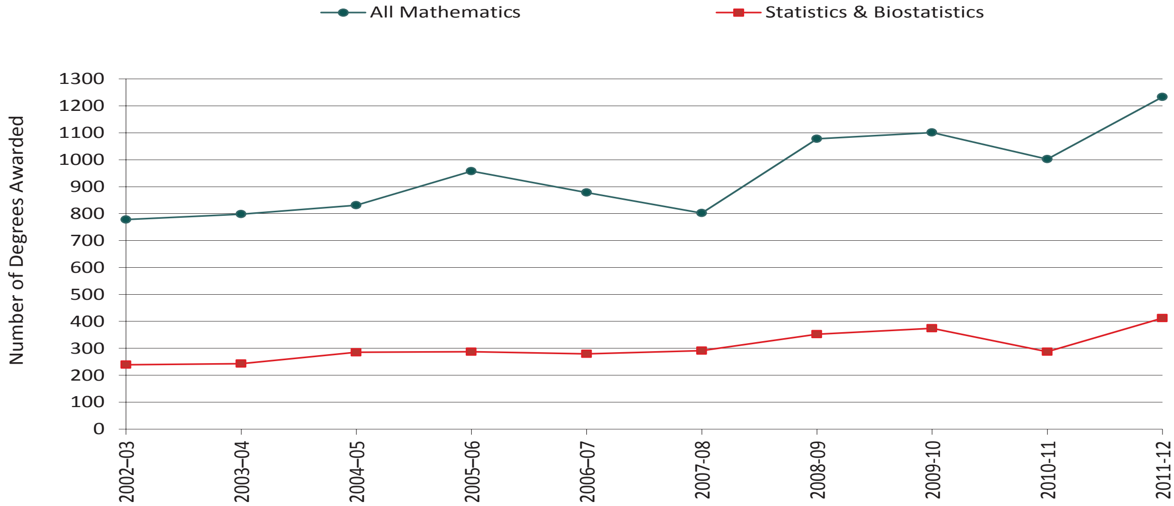
Total Degrees Awarded: 1,644

*A description of the department groupings is on page 323.

Richard Cleary is a professor in the Department of Mathematical Sciences at Bentley University. James W. Maxwell is AMS associate executive director for special projects. Colleen A. Rose is AMS survey analyst.

Doctoral Degrees Awarded

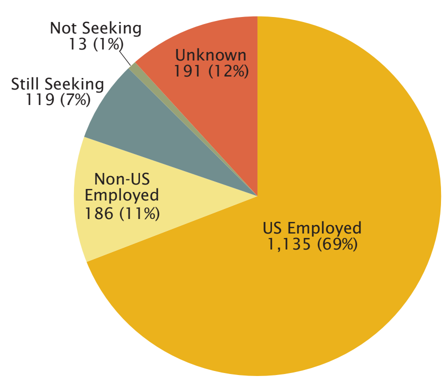
Figure A.2: New Doctoral Degrees Awarded by Combined Groups, Preliminary Counts



Employment of New Doctoral Recipients

The number of new doctoral recipients employed in the U.S. is 1,135. The comparable figure for the 2010–2011 cohort of new doctoral recipients is 942.

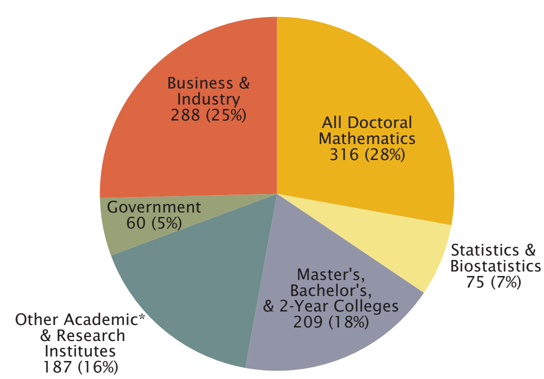
Figure E.1: Employment Status



Total New Ph.D.'s Reported: 1,644

- 9% of new Ph.D.'s are working at the institution which granted their degree, the same as last year.
- 52% (595) of those employed in the U.S. are U.S. citizens, down from 54% last year.
- 14% of new Ph.D.'s are employed outside of the U.S. compared to 13% last year.
- 73% (540) of non-U.S. citizens known to have employment are employed in the U.S.; the remaining 196 non-U.S. citizens are either employed outside of the U.S. or unemployed.

Figure E.2: U.S. Employed by Type of Employer



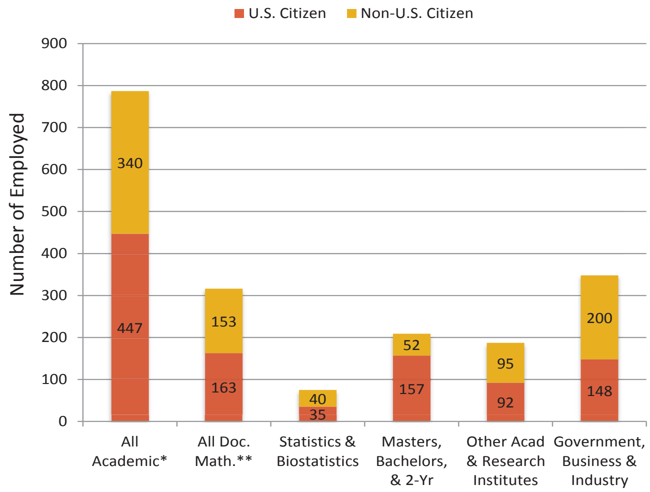
Total U.S. Employed: 1,135

*Other Academic consists of departments outside the mathematical sciences including numerous medical related units.

- The fraction of new Ph.D.'s taking positions in business & industry has increased to 25% this year compared to 19% this time last year.
- U.S. academic hiring, while up in absolute terms, declined to 69% compared to 76% this time last year.

Employment of New Doctoral Recipients

Figure E.3: Employment in the U.S. by Type of Employer and Citizenship

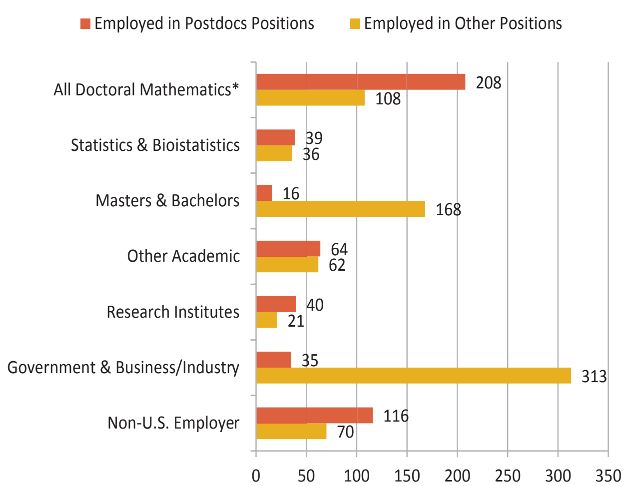


*Includes All Doc. Math., Masters, Bachelors, 2-Yr, other academic and research institutes/nonprofit.
**All Doctoral Mathematics: Public Large, Public Medium, Public Small, Private Large, Private Small, and Applied Mathematics.

Looking at U.S. citizens whose employment status is known:

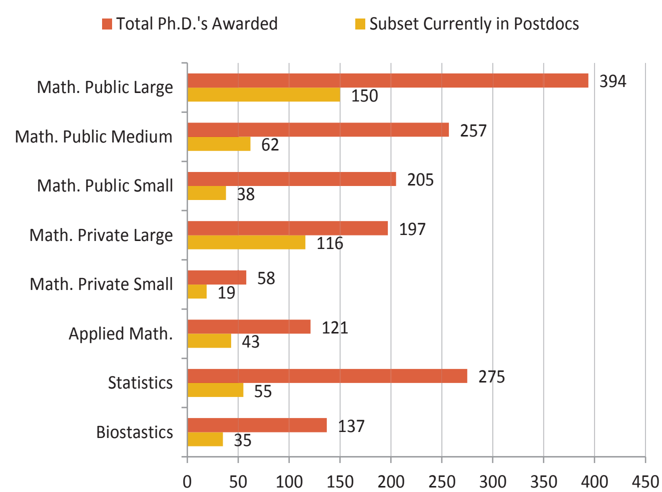
- 83% (595) are employed in the U.S., of these:
  - 33% are employed in Ph.D.-granting departments
  - 42% are employed in all other academic positions
  - 25% are employed in government, business and industry positions

Figure E.5: New Ph.D. Employment by Type of Position and Type of Employer



*All Doctoral Mathematics: Public Large, Public Medium, Public Small, Private Large, Private Small, and Applied Mathematics.

Figure E.4: Ph.D.'s Awarded by Degree-Granting Department Group



- 59% of the new Ph.D.'s from the Math. Public Large Group are employed in postdocs, while only 19% of new Ph.D.'s from the Math. Public Small Group are in postdocs; last year figures were 55% and 13%, respectively.
- 32% (518) of the new Ph.D.'s are reported to be in postdoc positions.
- 22% of the new Ph.D.'s in postdoc positions are employed outside the U.S.
- 47% of the new Ph.D.'s having U.S. academic employment are in postdocs; the same as last year.
- 63% of the new Ph.D.'s employed in Ph.D.-granting departments are in postdoc positions, 29% of these postdocs received their Ph.D.'s from Math. Public Large institutions.

Employment of New Doctoral Recipients

The fall 2012 employment plans are known for 1,453 of the 1,644 new doctoral recipients. 9.5% of the 1,254 individuals based in the U.S. were reported as lacking employment plans for fall 2012. (Another 13 individuals in the U.S. were reported as not seeking employment.)

Figure E.6: Percentage of New Doctoral Recipients Unemployed* 1995-2012

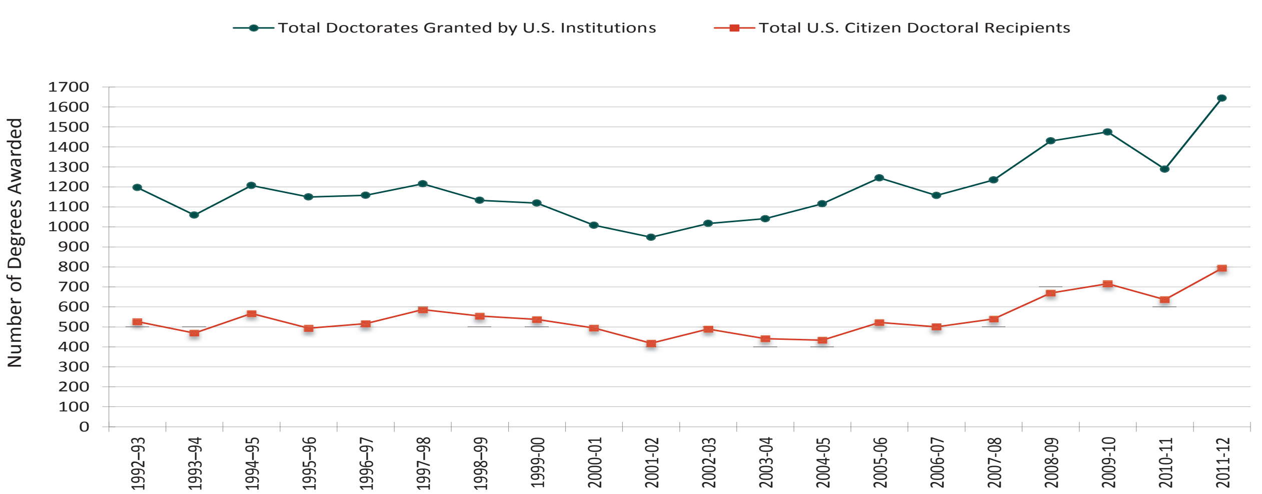
*Individuals reported as lacking employment plans for the fall following the fall of the reporting year.

Looking at unemployment among those new Ph.D.'s in the U.S.:

- Unemployment among those whose employment status is known is 9.5%, up from 4.9% for fall 2011.
- Applied Mathematics Group had the highest unemployment at 17.3%.
- Math. Private Large Group had the lowest unemployment at 5.0%.
- 10.4% of the U.S. citizens Ph.D.'s are unemployed, compared to 6.4% in fall 2011.
- 8.5% of non-U.S. citizens are unemployed; the rates by visa status are 8.9% for those with a temporary visa and 4.9% for those with a permanent visa.

Demographics of New Doctoral Recipients

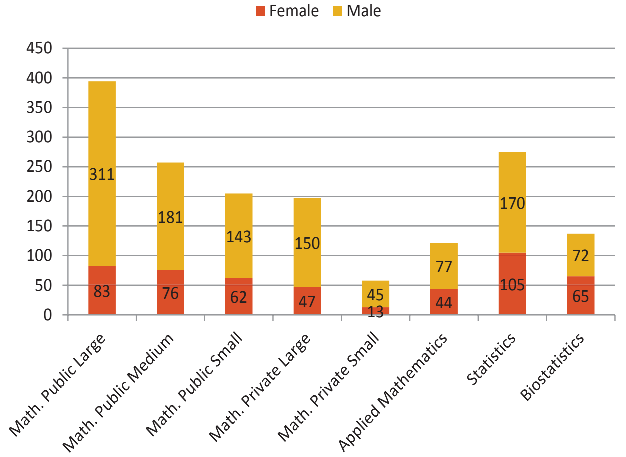
Figure D.1: U.S. Citizen Doctoral Recipients Preliminary Counts



Demographics of New Doctoral Recipients

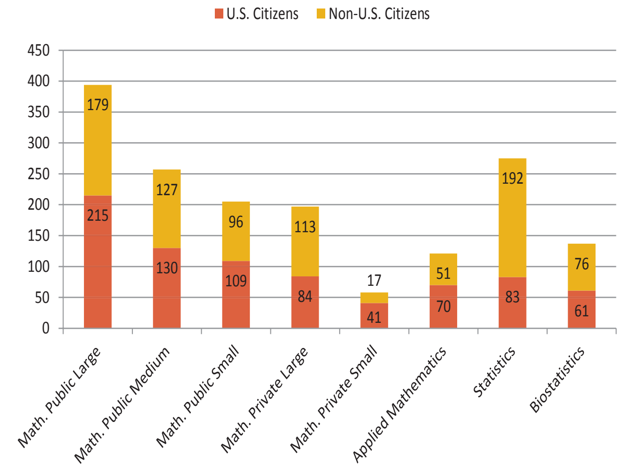
Gender and citizenship was known for all 1,644 new Ph.D.'s reported for 2011-2012. The proportion of U.S. citizens is essentially unchanged at 48%.

Figure D.2: Gender of Doctoral Recipients by Department Grouping



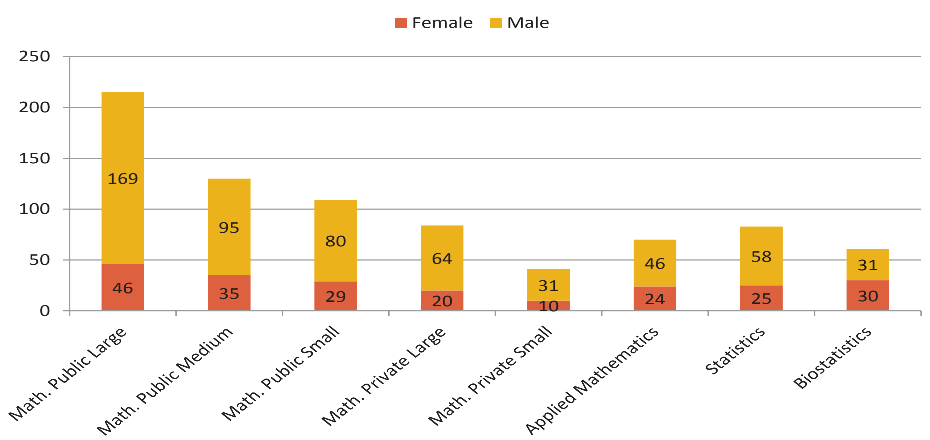
- Females account for 30% (495) of the 1,644 Ph.D.'s; the same percentage as last year.
- 32% (276) of non-U.S. citizens receiving Ph.D.'s were females (down from 34% last year).

Figure D.3: Citizenship of Doctoral Recipients by Department Grouping



- All groups reported awarding more degrees to U.S. citizens than non-U.S. citizens, with the exception of Math. Private Large, Statistics, and Biostatistics Groups which awarded 57%, 70%, and 55%, respectively to non-U.S. Citizens.

Figure D.4: Gender of U.S. Citizen Doctoral Recipients by Degree-Granting Department



- 28% (219) of the U.S. citizens are female; last year's figure was 27%.
- Statistics departments awarded 30% of their degrees to U.S. citizens, the lowest percentage among the groups.
- Math. Private Small groups awarded 71% of their Ph.D.'s to U.S. citizens, the highest percentage among all the groups.
- Among the U.S. citizens: 7 are American Indian or Alaska Native, 52 are Asian, 25 are Black or African American, 32 are Hispanic or Latino, 5 are Native Hawaiian or Other Pacific Islander, 622 are White, and 50 are of unknown race/ethnicity.

Female New Doctoral Recipients

The proportion of female new doctoral recipients has remained flat at 30% (495), based on preliminary counts. The number of females receiving Ph.D.'s increased from 30% (393) in fall 2011. The unemployment rate for females is 9.9%, compared to 9.3% for males and 9.5% overall.

Figure F.1: Females as a Percentage of New Doctoral Recipients Produced by and Hired by Department Grouping

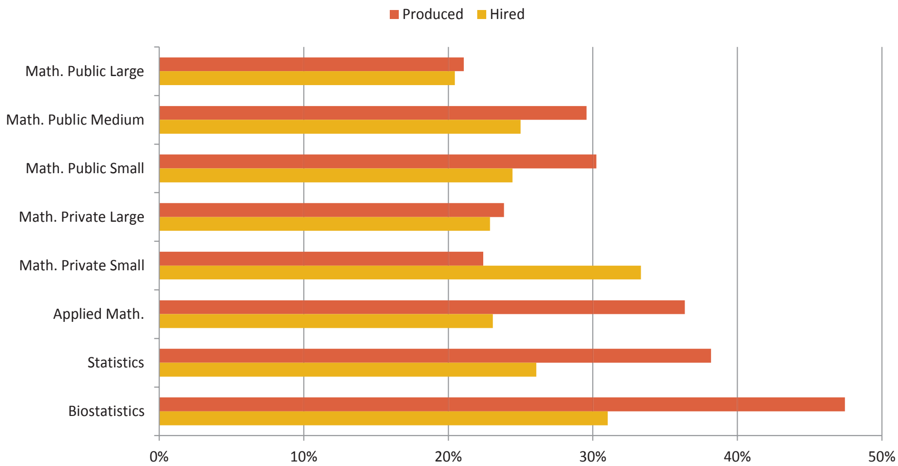
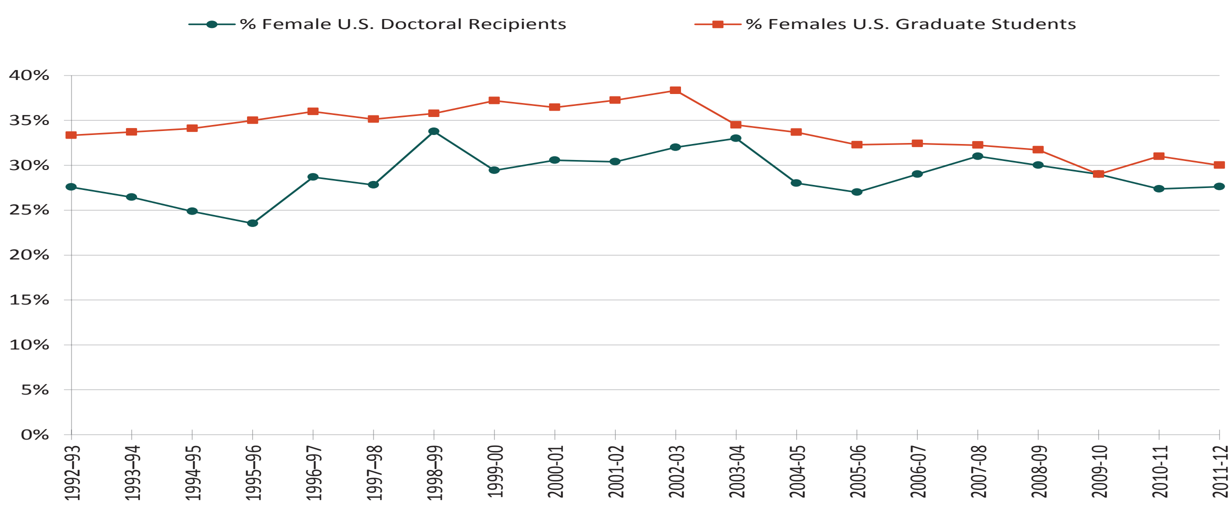


Table F.1: Number of Female New Doctoral Recipients Produced by and Hired by Department Groupings

Department Grouping	Females Produced	Females Hired
Math. Public Large	83	18
Math. Public Medium	76	15
Math. Public Small	62	11
Math. Private Large	47	19
Math. Private Small	13	9
Applied Math.	44	3
Statistics	105	12
Biostatistics	65	9

- 36% of those hired by the Bachelors Group were women (the same as last year) and 30% of those hired by the Masters Group were women (the same as last year).
- 25% of those reporting having postdoc positions (518) are women.
- 59% of the women employed in Ph.D.-granting departments are in postdoc positions (down slightly from 60% last year).

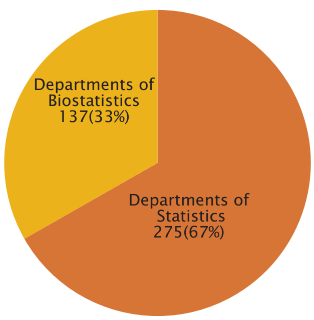
Figure F.2: Females as a Percentage of U.S. Citizen Doctoral Recipients



Ph.D.'s Awarded by Statistics or Biostatistics Departments

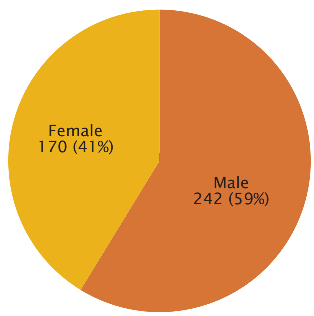
This section contains information about doctoral degrees awarded by Statistics or Biostatistics departments. These departments produced 412 new doctorates, of which all but 11 had dissertations in statistics or biostatistics. This is a 44% increase over the preliminary number reported for fall 2011 of 287. In addition, all Mathematics Groups combined had 72 Ph.D. recipients with dissertations in statistics. In Statistics or Biostatistics, 144 (35%) of the new doctoral recipients are U.S. citizens (while in the other groups 53% are U.S. citizens). While the unemployment rate for new Ph.D.'s with dissertations in statistics or probability has increased to 6.3%, the unemployment among the Statistics or Biostatistics new Ph.D.'s is 6.0%.

Figure S.1: Ph.D.s Awarded by Statistics/Biostatistics Departments



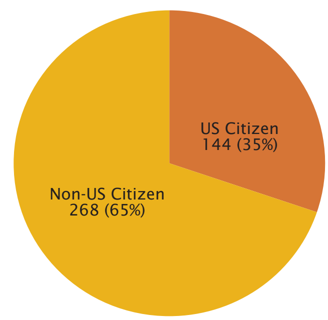
- 25% of all Ph.D.'s awarded were in Statistics/Biostatistics.
- Females account for 38% of statistics and 47% of biostatistics Ph.D.'s awarded.

Figure S.2: Gender of Ph.D. Recipients from Statistics/Biostatistics Departments



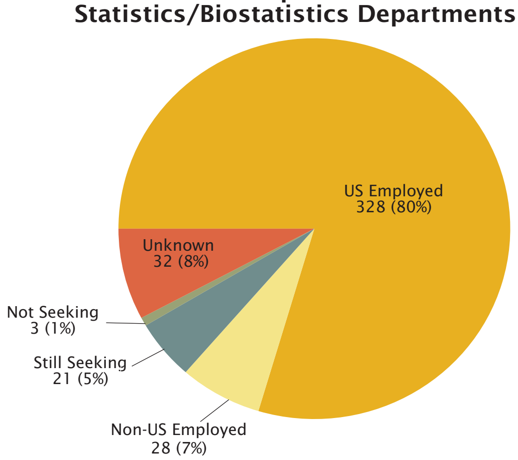
- Females accounted for 41% of the 412 Ph.D.'s in statistics/biostatistics, compared to all other groups combined, where 25% (325) are female.

Figure S.3: Citizenship of Ph.D. Recipients from Statistics/Biostatistics Departments



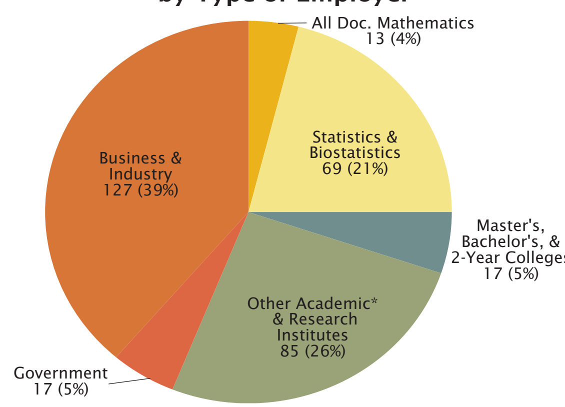
- 38% of Statistics/Biostatistics U.S. citizens are females, while in all other groups 25% are females.

Figure S.4: Employment Status of Ph.D. Recipients from Statistics/Biostatistics Departments



- 6.0% of Statistics/Biostatistics Ph.D.'s are unemployed compared to 10.8% among all other groups. This is up from 2.9% last year.
- Unemployment among new Ph.D.'s with dissertations in statistics/probability is 6.3%, up from 3.1%. Among all other dissertation groupings 9.2% are unemployed, up from 4.6%.

Figure S.5: U.S.-Employed Ph.D. Recipients from Statistics/Biostatistics Departments by Type of Employer



*Other Academic consists of departments outside the mathematical sciences including numerous medical related units.

- 39% of Statistics/Biostatistics Ph.D.'s are employed in Business/Industry, compared to 20% in all other groups.
- 26% of those hired by Statistics and 31% of those hired by Biostatistics departments were females, compared to 24% in all other groups.

Departmental Groupings and Response Rates

Starting with reports on the 2012 AMS-ASA-IMS-MAA-SIAM Annual Survey of the Mathematical Sciences, the Joint Data Committee has implemented a new method for grouping the doctorate-granting mathematics departments. These departments are first grouped into those at public institutions and those at private institutions. These groups are further subdivided based on the size of their doctoral program as reflected in the average annual number of Ph.D.'s awarded between 2000 and 2010, based on their reports to the Annual Survey during this period. Furthermore, doctorate-granting departments which self-classify their Ph.D. program as being in applied mathematics will join with the other applied mathematics departments previously in Group Va to form their own group. The former Group IV will be divided into two groups, one for departments in statistics and one for departments in biostatistics.

For further details on the change in the doctoral department groupings see the article in the October 2012 issue of *Notices of the AMS* at `http://www.ams.org/notices/201209/rtx120901262p.pdf.`

Survey Response Rates by New Groupings

Doctorates Granted
Departmental Response Rates*

Math. Public Large	26 of 26 including	0 with no degrees
Math. Public Medium	37 of 40 including	0 with no degrees
Math. Public Small	62 of 64 including	9 with no degrees
Math. Private Large	24 of 24 including	0 with no degrees
Math. Private Small	26 of 28 including	5 with no degrees
Applied Math.	27 of 30 including	2 with no degrees
Statistics	53 of 59 including	5 with no degrees
Biostatistics	24 of 36 including	2 with no degrees
Total	277 of 307 including	21 with no degrees

*A list of the departments yet to respond with their doctoral degrees awarded is on page 324.

Acknowledgements

The Annual Survey attempts to provide an accurate appraisal and analysis of various aspects of the academic mathematical sciences scene for the use and benefit of the community and for filling the information needs of the professional organizations. Every year, college and university departments in the United States are invited to respond. The Annual Survey relies heavily on the conscientious efforts of the dedicated staff members of these departments for the quality of its information. On behalf of the Data Committee and the Annual Survey Staff, we thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

Group Descriptions

Math. Public Large consists of departments with the highest annual rate of production of Ph.D.'s, ranging between 7.0 and 24.2 per year.

Math. Public Medium consists of departments with an annual rate of production of Ph.D.'s, ranging between 3.9 and 6.9 per year.

Math. Public Small consists of departments with an annual rate of production of Ph.D.'s of 3.8 or less per year.

Math. Private Large consists of departments with an annual rate of production of Ph.D.'s, ranging between 3.9 and 6.9 per year.

Math. Private Small consists of departments with an annual rate of production of Ph.D.'s of 3.8 or less per year.

Applied Mathematics consists of doctoral degree granting applied mathematics departments.

Statistics consists of doctoral degree granting statistics departments.

Biostatistics consists of doctoral granting biostatistics departments.

Group M contains U.S. departments granting a master's degree as the highest graduate degree.

Group B contains U.S. departments granting a baccalaureate degree only.

Listings of the actual departments which compose these groups are available on the AMS website at `www.ams.org/annual-survey/groups`.

Doctoral Degrees Not Yet Reported

The following mathematical sciences, statistics, biostatistics, and applied mathematics departments have not yet responded with their doctoral degrees awarded. Every effort will be made to collect this information for inclusion in the New Doctoral Recipients Report which will be published in August 2013 issue of *Notices of the AMS.*

Departments yet to respond can obtain copies of the Doctorates Granted survey forms on the AMS website at `www.ams.org/annual-survey/surveyforms`, by sending email to `ams-survey@ams.org`, or by calling 1-800-321-4267, ext. 4189.

Math. Public Large

All departments responded.

Math. Public Medium

Bowling Green State University
Virginia Polytechnic Institute and State University

Math. Public Small

College of William & Mary
University of Nevada, Las Vegas

Math. Private Large

All departments responded.

Math. Private Small

Lehigh University
Stevens Institute of Technology

Applied Mathematics

Columbia University
Naval Postgraduate School
Stony Brook University

Statistics

Colorado State University
University of California, Los Angeles
University of Iowa
University of Minnesota-Twin Cities
University of North Carolina at Chapel Hill
University of Pittsburgh

Biotatistics

LSU Health Science Center, New Orleans
The University of Albany, SUNY
Tulane University
University of California, Los Angeles
University of Cincinnati, Medical College
University of Colorado, Denver
University of Illinois at Chicago
University of Massachusetts, Amherst
University of Michigan
University of Minnesota-Twin Cities
University of South Carolina
Virginia Commonwealth University

About the Annual Survey

The Annual Survey series, begun in 1957 by the American Mathematical Society, is currently under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Mathematical Association of America, and the Society of Industrial and Applied Mathematics. The current members of this committee are Pam Arroway, Richard Cleary (chair), Steven R. Dunbar, Sue Geller, Boris Hasselblatt, Ellen Kirkman, Peter March, David R. Morrison, James W. Maxwell (ex officio), Bart S. Ng, and William Velez. The committee is assisted by AMS survey analyst Colleen A. Rose. In addition, the Annual Survey is sponsored by the Institute of Mathematical Statistics. Comments or suggestions regarding this Survey Report may be emailed to the committee at `ams-survey@ams.org`

About the Cover

Simulating the development of a brain tumor

This month's cover was suggested by Rick Durrett's article on cancer in this issue. The images are still frames taken from an animation simulating 180 days of tumor growth in a 1cm x 1cm section of brain tissue. The simulation was produced by Paul Macklin and John Lowengrub at the University of California at Irvine. Macklin (now at the University of Southern California) is also responsible for Figure 3 in Durrett's article.

Each frame advances the simulation by 10 days. The top image of each pair shows the developing tumor. Red marks the region of growing tumor tissue, blue tumor tissue behind this growing front is oxygen-starved (hypoxic), and brown regions behind these are dying (necrotic) tumor cells. The tumor plot is laid over the original brain tissue, in which the white region is the cranium, light gray is white matter, dark gray is gray matter, and black is cerebrospinal fluid. The tumor grows at noticeably different rates within each environment. Indeed, the principal feature of this simulation is its ability to deal with heterogeneous tissues.

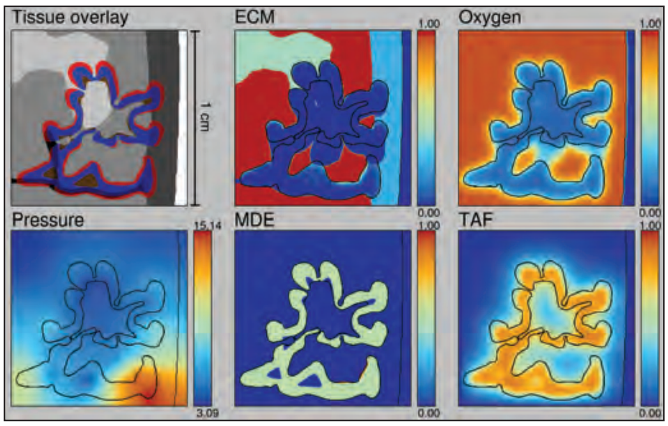
The bottom image of each pair shows the distribution of pressure generated by the growing tumor, ranging from low pressure (blue) to high pressure (oranges and reds).

It is pressure that causes the first symptoms felt by the patient, such as headaches, dizziness, or vision impairment.

The full animation can be found at

`http://MathCancer.org/Multimedia.php`

It also tracks several other features of the tumor development. Here is the full frame for the last day:



Macklin commented on this simulation, "There is extensive nonlinear feedback between the extracellular matrix (ECM) density and its degradation by the tumor, the tissue's biomechanical properties, the resulting tumor growth profile, and the distribution of oxygen and hypoxia in and around the tumor. As the simulation progresses, the blue region in the ECM frame enlarges. This is due to the secretion of matrix degrading enzymes (MDEs) by the tumor (lower middle). Oxygen is released by the pre-existing vasculature (blood circulation system) in non-degraded tissue, which perfuses through the tissue domain. Necrosis provides mechanical stress relief. The tissue's mechanical compliance is directly dependent upon the ECM density. Hypoxic regions of the tumor secrete tumor-angiogenic growth factors (TAFs). These stimulate the cancer's construction of its own blood circulation system, called angiogenesis.

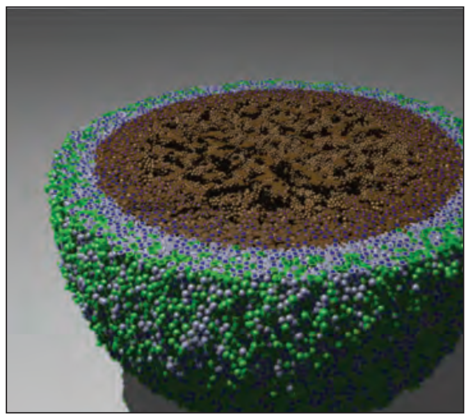
"In the simulation, oxygen gradients emerge that drive nonuniform growth on the outer tumor edges toward better oxygenated regions. This growth outpaces cell adhesion, increasing the magnitude of the oxygen gradients and thus also the nonuniformity of the tumor growth. This leads to the morphological instabilities seen here: invasive fingering growth and tumor fragmentation in regions of cell death. This is another example of a nonlinear feedback in the tumor-microenvironment system. Both these types of shape instabilities can be observed in real tumors."

The principal reference for the cover simulation is the paper "A New Ghost Cell/Level Set Method for Moving Boundary Problems: Application to Tumor Growth", by Macklin and John Lowengrub, in volume 35 of the *Journal of Scientific Computing*. More references can be found at

`http://www.MathCancer.org/Publications.php`

`http://math.uci.edu/~lowengrb`

Macklin's laboratory projects at USC have become more ambitious in recent times. Here is a frame from a 3D animation:



You can see more of this type of graphic at

`http://MathCancer.org/AMS2013`

We were intrigued by the great complexity and potential impact of this work, and asked Macklin to tell us more.

• *What are the long term goals of your project?*

In the long term, we'd like to create modeling tools that help oncologists to plan surgeries more accurately and choose better, patient-optimized therapies. We'd also like to create *in-silico* tools that help biologists to understand and extrapolate their *in-vitro* experimental findings to

(Continued on page 370)

Book Review

A Wealth of Numbers

Reviewed by Andy R. Magid

A Wealth of Numbers
Benjamin Wardhaugh
Princeton University Press, April 2012
Hardcover, 388 pages, US$45.00
ISBN-13: 978-0691147758

When it comes to mathematical exposition, we mathematicians are diligent consumers. We buy non-textbook monographs, read *Notices* articles, and attend departmental colloquia, generally independent of whether the exposition is high quality (*Notices*), mixed (monographs), or low (most colloquia). Perhaps we are motivated by the hope that ideas and methods from other fields will inspire our work in our own specialty, or perhaps we feel the duty to be informed about the world of research mathematics in general. In any event, we devote time and effort to consuming mathematical exposition. Fortunately, some mathematicians are diligent producers of mathematical exposition, although the hard work of producing exposition is usually not rewarded as well, or even at all, compared to original research or earning funding for original research. The mathematical world would probably be better off if we were all better citizens in this regard, say, by accepting *Mathematical Reviews* assignments, but it's also true that there is some art to exposition, and not everyone who does it does it artfully. Those who do it well earn, if not the rewards their employers could offer, the respect of their fellow mathematicians who, after all, set the standards for what qualifies as excellent exposition.

When it comes to mathematical exposition for the nonmathematical public, however, mathematicians are at best interested bystanders. Popularizations of mathematics, like other publishing ventures, succeed or fail in the marketplace through coincidences of taste, timeliness, advertising, and fate—which may or may not have anything to do with the quality, or even correctness, of their mathematical content. For example, consider the Amazon Best Sellers rankings of the following: Constance Reid's excellent *From Zero to Infinity* is number 907,624, only slightly better than Marilyn vos Savant's execrable *The World's Most Famous Math Problem*, number 966,319, while Lancelot Hogben's venerable (first published in 1937) and valuable *Mathematics for the Million* substantially outranks both at 153,398. For further comparison, John Allen Paulos's 1980s classic *Innumeracy* ranks 16,221 (all ranks observed 16 November 2012). This highly unrepresentative sample of mathematics books for the general reader currently available consists of books this reviewer happened to read, either as a general reader himself before becoming a mathematician or, for the later ones, out of curiosity when the books became newsworthy (Paulos) or notorious (vos Savant). I suspect most mathematicians have similarly limited exposure to popular mathematics books. "Limited" includes limited in time: while I wouldn't be surprised if my American coevals among the mathematical community are familiar with Reid, maybe even Hogben, our millennial successors probably aren't, and neither would be our prewar predecessors. For all any of us know, the general public is being offered, and buying, mathematical exposition that is erroneous in content, logically opaque, and gracelessly written.

Fortunately, Benjamin Wardhaugh has had the happy idea to anthologize selections of writings about mathematics for the general reader. Wardhaugh, a postdoctoral fellow at All Souls College specializing in the history of mathematics, assembled his selections ranging widely over topics (from Mathematical Tricks to Fiction and Humor) and time (1481 to 2004). With approximately one hundred excerpts, each with a brief introduction, comprising eleven chapters, each of which also has a short introduction, in some 370 pages, including index, the selections are necessarily brief. Nonetheless, Wardhaugh has certainly collected a representative sample of how people write when they are writing in English about mathematics for readers whose formal mathematics education

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DOI: http://dx.doi.org/10.1090/noti959

is only assumed to be "school-level". As such, this book belongs in every university library or similar places where mathematicians and others who are curious about the quality of mathematical popularizations can dip into it.

Here are some samples of the range of topics and times: from *A Path-way to Knowledge* by John Tapp, London, 1621, instructions about how to reduce fractions, presented as a dialogue between a teacher, Theodore, and a pupil, Junius; from *Sir Isaac Newton's Philosophy Explained for the Use of Ladies* by Francesco Algarotti, London, 1739, a description of Kepler's second law; from *Geometry without Axioms* by Thomas Perronet Thompson, 1833, an eccentric discussion of how to present Euclidean geometry without axioms or postulates, especially the fifth; from *Algebra for the Practical Man* by J. E. Thompson, London, 1931, the cookbook procedures for solving a cubic equation; and from the science fiction novel *Blue Mars* by Kim Stanley Robinson, London, 1996, a description of a twenty-third century physicist as viewed by an (extremely superannuated) scientist from our own era.

But the reader should be cautioned that the representative nature of this anthology means that it is definitely not a "greatest hits" collection. Wardhaugh warns his readers in the first paragraph of his preface that his collection is designed to answer the questions, "How did ordinary people think about mathematics in the past? How did they write about it? How did they learn and teach it?" And although he does later call his selections "a rambling garden of delights" (a point of view to which this reviewer will take exception), it is a fact that Wardhaugh has alerted us that this book is a sourcebook of historical mathematical popularization, not an invitation-to-mathematics collection for the general reader.

Unfortunately, the copywriters who prepared the cover blurbs for the volume failed to get the message. They write, "A treasure-house of popular mathematics, *A Wealth of Numbers* will provide many hours of fun and learning to anyone who loves math or science." No, it won't. Some examples:

From the selection *Napier's Rules* by Alan Clive Gardner, 1956 [Gardner is discussing a spherical triangle with angles $A = 90^o, B, C$ and opposite sides a, b, c]: "Draw a circle and divide it into five sectors ([figure indicated]). Starting from the right angle, which is indicated by a heavy line [drawn center to 12 o'clock], give each sector the name of one part of the triangle, naming the parts in order round the circle. The two parts next to the right angle are named normally [clockwise b, c], but the other three parts are replaced by their complements [clockwise $90^o - B, 90^o - A, 90^o - C$].

"Two Rules must be memorized in connection with the Circular Parts. They are as follows:

(1) Sine Middle Part = Product of Cosines of Opposite Parts.
(2) Sine Middle Part = Product of Tangents of Adjacent Parts."

Examples follow. There is no further discussion of why these rules might be true.

From the selection *Making a Star Clock* by Roy Worvill, 1974 [this selection is about constructing a device to measure the angle the line containing Dubne and Merak (unnamed in the selection) makes with the celestial parallel through Polaris. Worvill has instructed his readers to assemble materials (cardboard and a paper fastener) and tools (compasses, scissors, and knife) and to cut the cardboard into two 8-inch squares]: "On the other cardboard square draw…five concentric circles …the largest one of radius four inches and the others, proceeding inwards, of three and a half inches, three inches, two and a half inches and two inches. Draw a diameter in the outer circle and mark off angles of thirty degrees so that there are twelve spaces or sectors. On the outer circle these are marked with two-hourly divisions from twelve o'clock to midnight throughout the twenty-four hours, although of course the nocturnal can only be used when it is dark enough to see the stars."

The selection continues in this vein, including instructions for use.

From the selection *Turtle Fun* by Serafim Gascoigne, 1985 [The first two paragraphs of the selection, in their entirety]: "The world of microcomputers is forever changing. There is always something new to learn and find out. How can you keep up? Will you be able to program the computers of the future? And what about 'intelligent machines' and robots, especially the LOGO turtle?

"This book will help you to keep up with events by introducing you to a very powerful control language of the future, called LOGO. LOGO has in fact been developed by computer scientists working in a new science called Artificial Intelligence. LOGO has been written for young programmers. It comes from another language called LISP, which is one of the main languages used to control 'intelligent' computers and robots. Using such commands as STARTROBOT or REPEAT [FORWARD 50 LEFT 120] for example, you can either drive a small mechanical device called the floor turtle or control the screen turtle, a movable cursor on your TV screen. You can also teach the turtle your own commands, called 'procedures', which can include graphics text and sound."

The historical value of these examples is obvious. The common thread of these selections, of course, is their lack of mathematical content, at least as far as mathematicians would be concerned.

There are also selections from Euler, Polya, van der Waerden, Sylvester, Feynman, and others, with real mathematical content. But even in those the selections are so brief that mathematics must be interrupted midconcept. This well serves the purpose of a historical sourcebook, although "anyone who loves math or science" lured by the cover copywriter's blurb into looking at this book for "many hours of learning and fun," may well be disappointed.

Does this matter? Readers lured into buying a book by false advertising can always return it and get their money back. More generally, should mathematicians care about books on popular mathematics sold to the general public? I think so.

Consider the greatest years for popular support for mathematics (and science) in the United States, arguably from the Sputnik launch to the Mansfield Amendment. That was also the era of two colossal achievements in the area of mathematical popularization: Martin Gardner's *Scientific American* column "Mathematical Games", and James R. Newman's anthology *The World of Mathematics*, published in 1956. To quote Wikipedia, the latter is "a four volume library on the literature of mathematics from A'h-mos the Scribe to Albert Einstein, presented with commentaries and notes,…[it] covers many branches of mathematics and represents a 15-year effort by Newman to collect what he felt were the most important essays in the field…from a biography of Srinivasa Ramanujan by Newman to Bertrand Russell's Definition of Number. [*The World of Mathematics*] is often praised as suitable for any level of mathematical skill." It is still available new (Amazon rank 553,586).

Whether America's choice to generously support mathematical research in those years—unparalleled, I believe, before or since—was encouraged by Gardner and Newman or whether the popularity of Gardner and Newman was an artifact of the prestige with which America held its mathematical community in those years is open for debate. But we could certainly use figures like them now, making by example the public case for mathematics in the intellectual life of all Americans. Benjamin Wardhaugh's anthology is a useful tool for historians of mathematics, professional and amateur, who would like to know what forms mathematical popularization has taken. But the mathematical community could also use an updated *The World of Mathematics*, presenting the public with an anthology of the best writing about the best mathematics. It would certainly deliver the insight and entertainment the cover blurb of *A Wealth of Numbers* falsely promises. Who knows, it might even inspire a resurgence of the liberal funding of mathematics we once knew.

Book Review

Paradoxes in Probability Theory

Reviewed by Olle Häggström

Paradoxes in Probability Theory
William Eckhardt
Springer, September 2012
Paperback, 94 pages, US$39.95
ISBN-13: 978-9400751392

William Eckhardt's recent book, *Paradoxes in Probability Theory*, has an appetizing format with just xi+79 pages. Some might say it's a booklet rather than a book. Call it what you will, this thought-provoking text treats the following seven delightful problems or paradoxes.

The Doomsday Argument

Let a given human being's *birth rank* be defined as the number of human beings born up to and including his or her birth. Consider the scenario that humanity has a bright future, with a population of billions thriving for tens of thousands of years or more. In such a scenario, our own birth ranks will be very small as compared to the "typical" human. Can we thus conclude that Doomsday is near?

The Betting Crowd

You are in a casino together with a number of other people. All of you bet on the roll of a pair of fair dice *not* giving double sixes; either all of you win or all of you lose, depending on the outcome of this single roll. You seem to have probability 35/36 of winning, but there's a catch. The casino first invites one person to play this game. If the casino wins, then the game is played no more; otherwise, another ten people are invited to play. If the casino wins this time, play closes; otherwise, one hundred new players are invited. And so on, with a tenfold increase in the number of players in each round. This ensures that, when the whole thing is over, more than 90 percent of all players will have lost. Now what is your probability of winning?

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DOI: http://dx.doi.org/10.1090/noti958

The Simulation Argument

Assume that computer technology continues to develop to the extent that eventually we are able to run, at low cost, detailed simulations of our entire planet, down to the level of atoms or whatever is needed. Then future historians will likely run plenty of simulations of world history during those interesting transient times of the early twenty-first century. Hence the number of people living in the real physical world in 2012 will be vastly outnumbered by the number of people who believe themselves to do so but actually live in computer simulations run in the year 2350 or so. Can we thus conclude that we probably live in a computer simulation?

Newcomb's Paradox

An incredibly intelligent donor, perhaps from outer space, has prepared two boxes for you: a big one and a small one. The small one (which might as well be transparent) contains $1,000. The big one contains either $1,000,000 or nothing. You have a choice between accepting both boxes or just the big box. It seems obvious that you should accept both boxes (because that gives you an extra $1,000 irrespective of the content of the big box), but here's the catch: The donor has tried to predict whether you will pick one box or two boxes. If the prediction is that you pick just the big box, then it contains $1,000,000, whereas if the prediction is that you pick both boxes, then the big box is empty. The donor has exposed a large number of people before you to the same experiment and predicted correctly 90 percent of the time, regardless of whether subjects chose one box or two.[1] What should you do?

The Open Box Problem

This is the same as Newcomb's Paradox except that you get to see the contents of the big box before deciding.

[1] *Eckhardt forgets to mention this last condition ("regardless of…"), but it is clear that he intended it.*

The Hadron Collider Card Game

Physicists at CERN are looking for a hitherto undetected particle X.[2] A radical physical theory Y has been put forth[3] that particle X can in principle be produced, except that "something in the future is trying by any means available to prevent the production of [particle X]." A way to test theory Y is as follows. Prepare and shuffle a deck with a million cards, including one ace of spades. Pick one card at random from the deck after having made international agreements to abandon the search for particle X provided the card picked turns out to be the ace of spades. If the ace of spades is picked, this can be seen as evidence in favor of theory Y. Does this make sense?

The Two-Envelopes Problem

Two envelopes are prepared, one with a positive amount of money and the other with twice that amount. The envelopes are shuffled, and you get to pick one and open it. You may then decide whether you wish to keep that amount or switch to the other envelope. If the amount you observe is X, then the amount in the other envelope is either $X/2$ or $2X$, with probability $1/2$ each, for an expectation of $\frac{X/2+2X}{2} = \frac{5X}{4}$, which is greater than X, so it seems that you should switch envelopes. But this is true regardless of the value of X, so it seems that you have incentive to switch even before you open the envelope. This, however, seems to clash with an obvious symmetry between the two well-shuffled envelopes. What is going on here?

Of these seven paradoxes, two are new, whereas the other five are known from the literature, such as the Simulation Argument, which was put forth by Bostrom [B] in 2003 and has been the topic of intense discussion in the philosophy literature ever since.[4] The two new ones, the Betting Crowd and the Open Box Problem, were invented by Eckhardt, mainly as pedagogical vehicles to help one think more clearly about the other paradoxes.

Eckhardt has no ambition to provide complete coverage of the literature on the five previously known paradoxes. Rather, the task he sets himself is to resolve them, once and for all, and the review of previous studies that he does provide is mostly to set the stage for his own solutions. He claims to be successful in his task but realizes that not everyone will agree about that: in the introductory paragraph of his chapter on Newcomb's Paradox, he writes that "there exist a variety of arguments both for and against one-boxing but, in keeping with the design of this book, I search for an incontrovertible argument. (Of course it will be controverted.)" The book is a pleasure to read, not so much for Eckhardt's solutions (which, indeed, I find mostly controvertible) but for the stimulus it provides for thinking about the problems.

Eckhardt is a financial trader with a background in mathematical logic, a keen interest in philosophy, and a few academic publications in the subject prior to the present one. Hence it is not surprising that he may have a different view of what is meant by probability theory, as compared to an academic mathematician and probabilist such as I, who considers the title *Paradoxes in Probability Theory* to be a bit of a misnomer. To me, probability theory is the study of internal properties of given probability models (or classes of probability models) satisfying Kolmogorov's famous axioms from 1933 [Ko], the focus being on calculating or estimating probabilities or expectations of various events or quantities in such models. In contrast, issues about how to choose a probability model suitable for a particular real-world situation (or for a particular philosophical thought experiment) are part of what we may call applied probability but not of probability theory proper. This is not to say that we probabilists shouldn't engage in such modeling issues (we should!), only that when we do so we step outside the realms of probability theory.

In this strict sense of probability theory, all seven problems treated by Eckhardt fall outside of it. Take for instance the Two-Envelopes Problem, which to the untrained eye may seem to qualify as a probability problem. But it doesn't for the following reason. Write Y and $2Y$ for the two amounts put in the envelopes. No probability distribution for Y is specified in the problem, whereas in order to determine whether you increase your expected reward by changing envelopes when you observe $X = \$100$ (say), you need to know the distribution of Y or at least the ratio $P(Y = 50)/P(Y = 100)$. So a bit of modeling is needed. The first thing to note (as Eckhardt does) is that the problem formulation implicitly assumes that the symmetry $P(X = Y) = P(X = 2Y) = \frac{1}{2}$ remains valid if we condition on X (i.e., looking in the envelope gives no clue about whether we have picked the larger or the smaller amount). This assumption leads to a contradiction: if $P(Y = y) = q$ for some $y > 0$ and $q > 0$, then the assumption implies that $P(Y = 2^k y) = q$ for all integers k, leading to an improper probability distribution whose total mass sums to ∞ (and it is easy to see that giving Y a continuous distribution doesn't help). Hence the uninformativeness assumption must

[2] *In Eckhardt's account, X is the Higgs boson, which unfortunately (for his problem formulation) has been detected since the time of writing.*

[3] *It really has; see* [NN].

[4] *Even I have found reason to discuss it in an earlier book review in the* Notices [Hä].

be abandoned. Some of the paradoxicality can be retained in the following way. Fix $r \in (0,1)$ and give Y the following distribution:

$$P(Y = 2^k) = (1-r)r^k \quad \text{for } k = 0, 1, 2, \dots .$$

For $r > \frac{1}{2}$, it will always make sense (in terms of expected amount received) to switch envelopes upon looking in one. Eckhardt moves quickly from the general problem formulation to analyzing this particular model. I agree with him that the behavior of the model is a bit surprising. Note, however, that $r > \frac{1}{2}$ implies $E[Y] = \infty$, so the paradox can be seen as just another instance of the familiar phenomenon that if I am about to receive a positive reward with infinite expected value, I will be disappointed no matter how much I get.

Consider next Newcomb's Paradox. Here, Eckhardt advocates one-boxing, i.e., selecting the big box only. The usual argument against one-boxing is that since the choice has no causal influence on the content of the big box, one-boxing is sure to lose \$1,000 compared to two-boxing no matter what the big box happens to contain. On the other hand, one-boxers and two-boxers alike seem to agree that, if the observed correlation between choice and content of the big box reflected a causal effect of the choice on the box content, then one-boxing would be the right choice. Eckhardt's argument for one-boxing, in the absence of such causality, is an appeal to what he calls the Coherence Principle, which says that decision problems that can be put in *outcome alignment* should be played in the same way. Here outcome alignment is a particular case of what probabilists call a *coupling* [L]. Two decision problems with the same set of options to choose from are said to be outcome alignable if they can be constructed on the same probability space in such a way that any given choice yields the same outcome for the two problems. Eckhardt tweaks the original problem formulation NP to produce a causal variant NPc, where the choice does influence the box content causally in such a way that a one-boxer gets the \$1,000,000 with probability 0.9, and a two-boxer gets it with probability 0.1. He also stipulates the same probabilities for NP and notes that NP and NPc can be coupled into outcome alignment. Since everyone agrees that one-boxing is the right choice in NPc, we get from the Coherence Principle that one-boxing is the right choice also in NP.

The trouble with Eckhardt's solution, in my opinion, is that his stipulation of the probabilities in NP for getting the million dollars, given one-boxing or two-boxing, glosses over the central difficulty of Newcomb's Paradox. Suppose I find myself facing the situation given in the problem formulation. If I accept that I have a 0.9 probability of getting the million in case of one-boxing and a 0.1 probability in case of two-boxing, then the decision to one-box is a no-brainer. But why should I accept that those conditional probabilities apply to me just because they arise as observed frequencies in a large population of other people? It seems that most people would resist such a conclusion and that there are (at least) two psychological reasons for this. One is our intuitive urge to believe in something called free will, which prevents even the most superior being from reliably predicting whether we will one-box or two-box.[5] The other is our notorious inability to take into account base rates (population frequencies) in judging uncertain features of ourselves, including success rates of future tasks [Ka]. The core issue in Newcomb's Paradox is whether we should simply overrule these cognitive biases and judge, based on past frequencies, our conditional probabilities of getting the \$1,000,000 given one-boxing or two-boxing to be as stipulated by Eckhardt or if there are other, more compelling, rational arguments to think differently.

The story is mostly the same with the other problems and paradoxes treated in this book. The real difficulty lies in translating the problem into a fully specified probability model. Once that is done, the analysis becomes more or less straightforward. My main criticism of Eckhardt's book is that he tends to put too little emphasis on the first step (model specification) and too much on the second (model analysis). The few hours needed to read the book are nevertheless a worthwhile investment.

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[5] *This intuitive urge is so strong that, in a situation like this, it tends to overrule a more intellectual insight into the problem of free will, such as my own understanding (following, e.g., Hofstadter* [Ho] *and Harris* [Har]*) of the intuitively desirable notion of free will as being simply incoherent.*

What Is New in LaTeX? V. LaTeX on an iPad. Foundation

G. Grätzer

I wanted to write an article on how to typeset math on an iPad. It soon became clear that I have to cover a lot of ground on the iPad as a computer before I can discuss LaTeX on an iPad. So this “Foundation” lays the groundwork for “Empire”, coming soon in the *Notices*.

Post-PC Revolution

A few years back, computing was desktop-centric. To update the operating system, for back up, and for many other tasks, you had to connect your smartphone and tablet with a computer.

Tim Cook (Apple’s CEO) coined the term “post-PC revolution” to describe the trend that a tablet is no longer a younger brother to a PC but an equal partner; in fact, for many users, it may be the only computer they will ever need.

Why the iPad? Let Me Count the Ways

There are three reasons why the iPad is the only tablet I’ll discuss.

1. The iPad’s market share is 68 percent. It is clearly the dominant tablet of more than a hundred on the market. (The market share of Android tablets is about 20 percent.)

2. Today the iPad is the only tablet that is in an *ecosystem*. (Microsoft’s Surface has just joined this exclusive club.) The iPad is just one device under iCloud, along with the iPhone, Mac desktops, and Mac notebooks. I own an iPad, an iPhone, an iMac, and a MacBook Air. A picture I take on my iPhone instantly appears on my iPad. I work on a TeX article on my iMac, and when I am away from home, I continue my work on my MacBook Air—there is no interruption; they are fully synchronized.

3. I am not familiar with any other tablet.[1]

Isn’t the iPad Designed for Email, to Read News, and Enjoy Entertainment?

Certainly. While it has a dual-core CPU, it has a quad-core graphics chip, so viewing videos and complex webpages is quick.

The operating system (iOS 6) is designed to make performing these basic tasks very easy and intuitive. iOS masks the complexities of the underlying computer.

When She Was Good

To work on an article, Roth sits in front of his computer. In the complex folder hierarchy he finds article.tex, double clicks it to start the LaTeX implementation, edits and typesets the article. Then he prints article.pdf, proofreads it, and then goes back to editing…

On the iPad there is only a rectangular array of apps; no documents are visible. There may be folders containing more apps, but no folder in a folder. There are no Library folders, no Download folder. And no File menu containing the Print command! I have article.tex on my desktop, but how do I transfer it to the iPad? Roth plugs in his thumb drive, but it does not work.

In the Mac operating system, there are always features missing, and we can be certain that a future version will incorporate a solution. But this is different; these features are missing on purpose.

Here is what Steve Jobs said about the file system:

“You don’t keep your music in the file system, that would be crazy. You keep it in this app that

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DOI: http://dx.doi.org/10.1090/noti957

[1] At the TeX User Group conference in Boston this summer, there was a talk about Android pads by Boris Veytsman, “TeX and friends on a pad”.

knows about music and knows how to find things in lots of different ways. Same with photos…

"And eventually, the file system management is just gonna be an app for pros, and consumers aren't gonna need to use it."

In this article I will cover the file system and sandboxing, file transfers, and printing. Finally, I will briefly introduce text editing.

File System or Lack Thereof, Sandboxing, File Transfers

The iPad starts up by displaying a rectangular array of icons and folders for apps. There are no icons for documents.

There is no familiar Desktop for documents and folders. No Applications folder. No multiple users. The screen is always occupied by a single window, creating difficulties with Help screens that crowd out the screens they are supposed to help with.

The file system, as we know it from desktop computers, is gone. In its place is an app-centric starting point. Touch the icon of an app and you are in business. When the app opens, you get access to the documents and settings of the app.

For security reasons, the apps are sandboxed, limiting an app's access to files, preferences, network resources, hardware, and so on. Ars Technica's John Siracusa described the goal of sandboxing as follows:

"Running an application inside a sandbox is meant to minimize the damage that could be caused if that application is compromised by a piece of malware. A sandboxed application voluntarily surrenders the ability to do many things that a normal process run by the same user could do. For example, a normal application run by a user has the ability to delete every single file owned by that user. Obviously, a well-behaved application will not do this. But if an application becomes compromised, it may be coerced into doing something destructive."

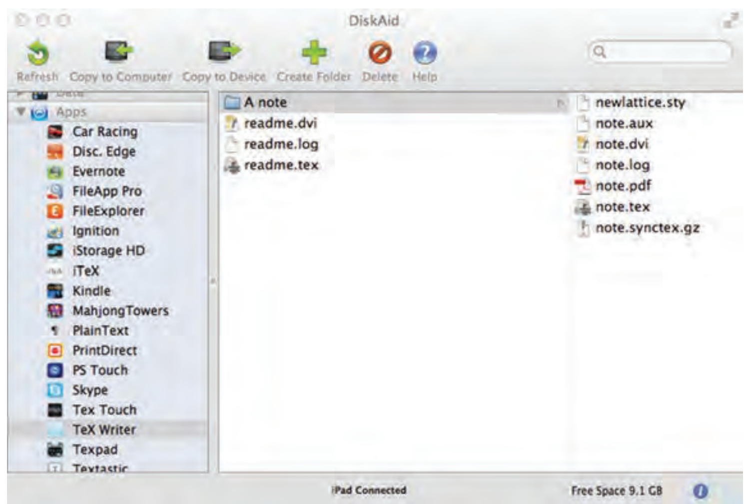
Of course, the iPad is a computer, and it has a file system; we just do not see it. But it is important to visualize it. To help us along, we will use an app.

FileApp Pro

If you search the iPad's App Store for "file" apps, there are more than one thousand of them. Many of them could be used to help us understand the iPad file system. I choose FileApp Pro (DigiDNA).

To get started, plug the iPad into a desktop computer, download and start DiskAid on the computer, download and start FileApp Pro on the iPad. On the left panel of DiskAid, click on Apps, then on FileApp. The second pane now shows Imported Files; the right pane shows the files imported to the iPad. In FileApp navigate to Imported Files. Anything you drag into the right pane of DiskAid is copied to FileApp's Imported Files. So much for file transfer.

To see the file structure of the various iPad apps, click on their names. I choose TeX Writer.



(File App Pro is the Swiss Army knife of utilities. It can zip files, open zip files, create and edit text documents, record sound, and sing lullabies.)

Of course, for file transfers I should also mention the ubiquitous Dropbox. Download it for the iPad, sign in (as you did for your desktop Dropbox), and that's it.

Printing

When I first wanted to print from my iPhone, I realized that there is no print command; however, lots of apps would do the job. In fact, searching for "print" in the App Store, I discovered over six hundred apps; many of them print, utilizing my desktop computer.

Typical of these apps is PrintDirect (EuroSmartz) and Printer Pro (Readdle Productivity). They can use any printer connected with your desktop computer.

They wirelessly connect to your computer and print with its help.

If so many apps can help me with printing, why can't iOS? Read the comments to articles about iOS printing; I was not the only one confused.

If the iPad is the poster child of the post-PC revolution, its printing solution cannot involve desktop computers. Apple introduced the appropriate technology; they named it AirPrint. The idea is simple: the iPad collaborates with the printer.

Of course, for this you need a wireless printer that is AirPrint aware. Apple lists all the AirPrint-aware printers:
`http://support.apple.com/kb/ht4356+`
as of this writing, over three hundred.

If you are lucky and have one of these printers, test it. Open an email and touch the Action icon (here it is the Reply icon); this offers you the options Reply, Forward, and Print. Touch Print, Printer Options appears, and you can choose how many copies and on which printer. (Lots of apps provide more choices, such as page range.) Choose the printer and print. For a second test, open a webpage in Safari. There is only one difference: the action icon is a curved arrow in a rectangle.

As a third test, open the Drudge Report. It has the familiar Action icon; we are in business. Finally, open the Politico app, read the news, and look for an Action icon. There is none.

So, to use AirPrint, you need an AirPrint-aware printer and an AirPrint-aware app! For the time being, these are rather severe restrictions.

Text Editors

Many of us edit LaTeX documents in text editors more sophisticated than the text editor that comes with the LaTeX implementation. Some thoughts on iPad text editors.

First, writing about apps is like shooting at a moving target. While I was writing about an app, it went through four versions: adding features, removing defective ones. This is especially true of the LaTeX implementations I will write about in the next article. Some have no documentation. One has a single page, explaining why it can only do TeX, not LaTeX. In fact, it can do LaTeX.

Second, there are so many text editors, well over two hundred. Take a look at the table at
`http://brettterpstra.com/ios-text-editors/`
This table is a 50×31 matrix, each row representing a text editor, each column representing a feature (such as Search and Replace). The entries are Yes or No. Hovering over the name of a text editor, you get a listing of additional features and the App Store information.

Third, keeping the iPad horizontal, the keyboard gobbles up too much real estate. Keeping it vertical, the keyboard is less intrusive, but the keys are smaller. If you want to do serious work on the iPad, buy a keyboard.

Fourth, the iOS's touch text editing is nice, but it lacks a feature crucial for text editing: moving the cursor a character ahead or back. (Of course, Bluetooth keyboards have cursor keys!) Text editors offer a variety of solutions, for instance, finger swiping.

I will discuss briefly a very sophisticated text editor: Textastics. If you want Syntax Highlighting, Search and Replace, and Text Expander, this is your only choice.

Here you see me editing this article:

You can see the extra keyboard row and the cursor navigation wheel (which appears with a two finger tap; finger swipe also moves the cursor). It comes with an excellent user manual. (Textastics can also perform a number of nonediting tasks, such as zipping and unzipping files.)

Textastics has no Mac version, and if you spend time shaping it to your liking, then you would like the same tamed editor for all your work. The good news is, it's coming. I can hardly wait to see it.

Onward

I hope I have convinced you that the iPad is a computer. So what we need now are some LaTeX implementations on the iPad computer.

Acknowledgments

Drafts of this article were read and commented on by a number of experts. I am grateful, in particular, to Alexander Blach, Richard Koch, Scot Mcphee, and Jonathan Weisberg.

John G. Hocking

Som Naimpally

John G. Hocking (Gib), emeritus professor of mathematics at Michigan State University, passed away on March 23, 2011, at the age of ninety. He left behind Judy, his wife of sixty-seven years, four children, five grandchildren, and four great-grandchildren. Gib was a versatile individual with a wide variety of interests and hobbies. Besides his lifelong passion for mathematics, he was adept at many activities, including fencing, racing cars, tennis, sailing, and carpentry. During WWII he worked in aerial reconnaissance and flew planes along the India-Burma border. As a person he was always upbeat and enlivened any gathering with interesting anecdotes and his "positive-definite" attitude.

Gib received his Ph.D. from the University of Michigan in 1953 under Gail S. Young. His dissertation title was "On Approximations to Monotone Mappings on Two-Dimensional Manifolds" [1]. He joined MSU in 1951 and remained there until his retirement in 1987. During 1962–63, Gib went to Tübingen on sabbatical as a Fulbright scholar. He lectured and wrote a paper [12] in German. He also lectured in London (1970–71), Oxford (1971), Dublin (1977–78), and Shanghai (1981).

I first encountered Gib in the fall of 1961 when he gave a colloquium talk at MSU. I had just arrived from India as a graduate student, desiring to work in fluid mechanics, with no knowledge of abstract mathematics. Yet Gib's talk completely engaged not only me but the entire audience as well. I immediately decided to work with him. In the winter quarter of 1962 I took Gib's introductory topology course based on the well-known book *Topology*, which he wrote with his teacher, Gail Young [2]. His teaching style was superb, and within just two weeks he had taught us the latest research he had done on "invertible spaces" with Pat Doyle [3], [4]). It was about the simplest characterization of an n-sphere as an invertible manifold. They continued their investigations on invertible spaces in several papers, some with graduate students [5], [6], [7], [8], [9], [10], [11].

Later, when he became my thesis advisor, the first thing he told me was, "The office hours posted on the door don't apply to you. You are welcome to meet me at any time." Whenever I gave him my work, he gave it his immediate attention, setting aside his own, and returned the material with suggestions. Several years after I graduated, Gib worked with me and my undergraduate student, Phil Cameron, on using the concept of "near and far" of Frederick Riesz in teaching calculus [13]. In 2009, Gib worked with me again on writing a booklet on the same topic [14]. Even at the age of eighty-eight he was as prompt in his replies (via emails) as he was in his younger days. His enthusiasm for mathematics and for new research was still just as vivid. On March 22, just a day before he passed away, my wife, Sudha, and I visited Gib and Judy, who were taken care of by their daughters, Megan and Wendell, in Michigan. In spite of being physically weak, his lively spirit shone through, which is how he will always be remembered.

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DOI: http://dx.doi.org/10.1090/noti960

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Presidential Views: Interview with David Vogan

Every other year when a new AMS president takes office, the *Notices* publishes interviews with the outgoing and incoming presidents. What follows is an edited version of an interview with David Vogan, whose two-year term as president began on February 1, 2013. Vogan is professor of mathematics at the Massachusetts Institute of Technology. The interview was conducted in fall 2012 by *Notices* senior writer and deputy editor Allyn Jackson. An interview with past president Eric M. Friedlander appeared in the February 2013 issue of the *Notices*.

Notices: *Communication in mathematics is something you are very interested in. What do you see as the challenges here?*

Vogan: There are a lot of wonderful ideas for using new technology to support communication. For example, MathOverflow takes advantage of collective expertise and makes it available to the community in ways that were unthinkable without the technology. It's a powerful way to solicit information widely and at the same time to provide information about the reliability of answers you are getting. A lot of young and not-so-young people are using it very effectively. Some of these things are replacing or supplementing things that the AMS has been involved with, like book publication and MathSciNet. Can we learn from what's happening at MathOverflow and similar places to make books and MathSciNet more useful?

David Vogan

The MathOverflow model is maybe most appealing to me in connection with changes in the way mathematics is taught. Students are taking enormous advantage of information on the Web to learn about mathematics—sometimes just to look up answers to their problem sets, but sometimes to get new understanding. Usually that information does not come with the certification of "this is reliable" that MathOverflow can provide. I've wondered whether the AMS could provide a framework for giving access to online mathematics and somehow accumulating evaluative information, such as: this is a really clear account or this is the right account to read if all you know is beginning linear algebra. MathSciNet indexes the math literature in a fantastically useful way. The literature is being extended by online material, such as the notes we write and post for students in our classes. If that material could be indexed in some of the useful and effective ways that MathSciNet and MathOverflow do, that could be wonderful.

All this is related to the issue of MOOCs: massively open online courses. Whether or not we participate in them directly, they are out there on the Web, freely available to some extent, and our students use them, even in traditional courses. If we can help find ways for our students to use those tools effectively, that's a great thing.

The books that have been written over the past centuries are still a tremendous resource, and they haven't been integrated into the online Web as well as they could be. Some books are out there and possible to get at, legally or illegally. One thing the AMS could think about is how to make the AMS catalogue of books available to be part of the resources that people can get at online. It's easy to make things available for free, and that's not necessarily the right idea for a complicated institution that wants to continue to exist.

Notices: *In contrast to the idea of indexing what is out there on the Web, there have been efforts to collect together essays that cover wide swaths of mathematics. What do you think of this?*

Vogan: It's an interesting idea. Tim Gowers's book[1] was a fantastic achievement in that direction. It's a book, unfortunately, and one that's not easy to carry in your briefcase! It's certainly possible for one

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DOI: http://dx.doi.org/10.1090/noti965

[1]The Princeton Companion to Mathematics, *edited by Timothy Gowers, was reviewed in the November 2009 issue of the* Notices.

committed person to ask experts in many directions to contribute. That can succeed wonderfully. Twenty years ago I would have said that's the way you ought to go. But I've been amazed at how successful the more democratic, grassroots approaches have been.

Notices: *Are young mathematicians of today working in a very different way from the way people worked when you were starting out?*

Vogan: I think they are. The way they learn about things and what constitutes learning are somewhat different. In the old days, if there was some important bit of mathematics that was hard to find good references for, what was needed was a good textbook that would make the material available to students. Sometimes that's still absolutely the right thing to do. But today, students don't want, for example, the right book about the entire theory of Lie groups; they want the section of a chapter in that book that deals with the problem they need to do right now. That's been an effective way for people to work. Since the AMS is partly in the business of providing information in books, we need to think about how to provide these smaller chunks too.

Notices: *A very general question: How would you assess the overall health of the mathematics profession today?*

Vogan: I think it's very good. But there are also enormous problems. A great deal of what we are about is conveying mathematics, as opposed to creating it. Conveying mathematics is some of the greatest work mathematicians do. Nevertheless, it's clear that there is a fairly widespread perception that we are all terrible at it. This perception leads to difficulties: difficulties about funding within universities and from the federal government, difficulties with respect to bringing people into the field. Mathematics is both growing in its internal wonderfulness and growing in the ways that it interacts with the rest of science and the world. Those are great things and very healthy. We need to work on not looking at our shoes as much and explaining to people how great these things are.

Notices: *How did the perception develop that mathematicians are terrible at communicating?*

Vogan: The easy answer is that it's hard stuff. If you want to understand modern biology, you can spend most of your time on things that have been done in the last eighty years. If you want to learn enough mathematics to be an engineer, you have to understand work that was done over a period of thousands of years. Mathematics has a hierarchical character, and it is deep. If there is any piece of it that you don't get straight in your head, that makes it difficult or impossible to understand the pieces that come after that. It's very demanding material that we're trying to get across to the world.

Notices: *What can the AMS do to help?*

Vogan: All the things that we are already doing are wonderful. MathSciNet makes it possible, at least for us experts, to find material in this impenetrable mass of the journal literature. The hour lectures at the meetings of the Society make serious and difficult mathematics accessible to a lot of people. Sometimes that succeeds brilliantly, sometimes less than brilliantly. But I think everybody involved is working hard on doing it as well as we can.

Notices: *And how about reaching out beyond the world of mathematicians?*

Vogan: I went a week or so ago to one of the congressional briefings that Sam Rankin [director of the AMS Washington Office] organizes in Washington. It's for members of Congress, but in practice it's mostly for their aides. Sam does a great job at finding bits of mathematics that are accessible and appealing and giving hints of what the subject is about. Some things the AMS has had nothing to do with are quite amazing. For example, the play *Truth Values*, by Gioia De Cari,[2] is, among many other things, a beautiful window into what mathematics is like.

The physicists do a great job of making people feel the excitement of the exploration that they do. Lots of people were excited to hear about the Higgs boson without knowing anything about it. The physicists showed that this is unexplored territory and has new and wonderful things. There is a lot of mathematics that is like that too. We can do a better job of writing adventure novels about it.

Notices: *You were involved in the great public interest that developed around E_8.*[3]

Vogan: That was a confluence of many happy accidents. I think in fact that the most important feature was a beautiful picture that Coxeter dreamed up from his work on geometry. Another mathematician, Peter McMullen, managed to draw this picture, and it appeared in some of Coxeter's books and papers. Then mathematician John Stembridge took that old black-and-white, pen-and-ink drawing and made a Postscript file. Then he could make the black lines whatever colors he wanted. The result was just gorgeous. A lot of media outlets, especially online ones, were happy to pick up this story that came with a gorgeous picture. If you just get people's attention, they are happy to hear an adventure story.

Notices: *Do you have thoughts about the situation for federal funding of mathematics?*

Vogan: There is a great deal of strong mathematical research in the United States that is not supported by the funding agencies. One big reason is limitations on how much money is available. But there have also been disagreements about the way the available money should be spent. There

[2] *"The mathematical dramatist: Interview with Gioia De Cari", by Julie Rehmeyer, appeared in the June/July 2010 issue of the* Notices.

[3] *See "The character table for E_8", by David Vogan,* Notices, *October 2007; and the April 2007 installment of the column "Tony's Take", by Tony Phillips, on the AMS Math in the Media website,* `http://www.ams.org/news/math-in-the-media`.

have been efforts through the AMS over the years to try to push the National Science Foundation to consider funding some smaller grants. I think this is a conversation worth continuing. Certainly it is valuable to provide a large grant that can support several graduate students, travel, etc. But if there is a limited amount of money, one has to ask whether a large grant is more valuable than providing a little support for work of several people. Those are always complicated questions, but I think maybe the prejudices of the funding agencies have been a little too much in the direction of large grants.

Notices: *Are there specific projects you hope to work on as president?*

Vogan: I would certainly like us to think about changes in teaching. These changes are taking place at every university, one course at a time, with a lot of individual mathematicians just having good ideas and making things happen. That's the best way for those changes to go forward. The big role of the AMS is to make sure these local things are visible so that when somebody sits down in a committee in Washington to think about whether mathematics education is a complete failure and is the reason for the bust in 2008, they are aware of all the good stuff that goes on. The AMS can also help with making mathematicians aware of good ideas that have been tried in institutions other than their own.

What the AMS is doing about electronic publishing and access with respect to journals is fantastic. The AMS is on top of that and staying ahead of the curve as much as possible. I think with respect to books, we're not so successful. The people in the AMS who are thinking about this understand what the difficulties are—and there are huge difficulties. But we haven't succeeded as well as we've got to. I've learned enough to know that I don't know exactly what should happen with electronic books. I've seen some other big mathematical publishers completely screw up electronic books. Some have put books on the Kindle, for example, without understanding mathematics, and the result was very poor. The AMS has not made those mistakes, which is wonderful. But we need to find a way to *do* something and not make mistakes. I'd be happy if we could do better with electronic distribution of books than we have.

I am also very concerned about archiving, about the library of books and journals that has existed on paper in university libraries. For that material to be useful, more and more of it needs to get into an electronic format that can evolve with technology. These are really complicated problems. Again, the AMS and the mathematical community in general have done wonderful things with electronic archiving for journals. But with books, we are not there yet. I think the AMS could be a part of that, because the AMS publications people are so good at everything they do.

Notices: *Is there anything else you wanted to talk about?*

Vogan: One issue which many people have thought about is what happens to the membership of the AMS in the future? The membership has declined slowly, although the mathematical world is still growing quite seriously. The reason the membership declines, I believe, is that some of the best things the AMS does are either freely available to everybody or at least easily available to anybody inside a university. Most young mathematicians understand very well that they need MathSciNet to live—more than they need air—but they don't have to belong to the AMS to get it. I don't want to change the fact that you don't need to be an AMS member to get MathSciNet, but I would like young mathematicians to understand that joining the AMS is their civic duty. It would be good if they also understood that joining the AMS has a lot of tangible benefits for them. There are a lot of ideas out there for addressing this. One good change is that the meetings of the AMS have become much more useful and accessible for students. At the Joint Meetings in Boston in 2012, there were huge numbers of undergraduate as well as graduate students, and I think they had a great time. I am not sure how we translate that into actual membership, but it is certainly a step in the right direction.

Notices: *One last question. What was the experience of running for AMS president like for you?*

Vogan: The running part is kind of surreal. The great thing about the experience of becoming president, especially in the last year as I have been sitting on some committees, is learning about what people are up to and how things are going. It's fascinating. My most serious involvement with the AMS previously was in the 1980s. That's when I knew more about the organization. And it was a very different organization then.

Notices: *What is the difference?*

Vogan: It's hard to say. In the 1980s the biggest thing the AMS did was Math Reviews. It's still true now that the biggest thing the AMS does is MathSciNet. And yet these feel like very different operations. Younger people are much more involved in the AMS than twenty or thirty years ago. A lot of the big policy committees of the AMS are run by fairly young people, and the membership involves lots of fairly young people. These young people are tremendously sophisticated in their understanding of the work they are doing. When I was involved in the past—well, it was a bunch of smart old people who were running everything. I like the picture of smart young people better.

Notices: *That seems to give a lot of hope for the future of the organization.*

Vogan: Absolutely.

New From the

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Explorations in Complex Analysis

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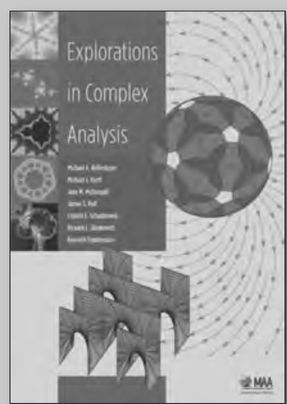

This book is written for mathematics students who have encountered basic complex analysis and want to explore more advanced project and/or research topics. Research topics in the book include complex dynamics, minimal surfaces, fluid flows, harmonic, conformal, and polygonal mappings, and discrete complex analysis via circle packing. The focus is on student-driven and technology-enhanced investigation. Interlaced in the reading for each chapter are examples, exercises, explorations, and projects, nearly all linked explicitly with computer applets for visualization and hands-on manipulation.

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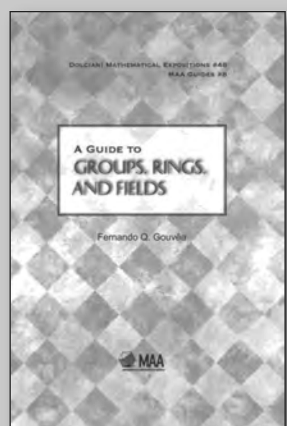
A Guide to Groups, Rings, and Fields

By Fernando Gouvêa



This *Guide* offers a concise overview of the theory of groups, rings, and fields at the graduate level, emphasizing those aspects that are useful in other parts of mathematics. It focuses on the main ideas and how they hang together. It will be useful to both students and professionals. In addition to the standard material on groups, rings, modules, fields, and Galois theory, the book includes discussions of other important topics that are often omitted in the standard graduate course, including linear groups, group representations, the structure of Artinian rings, projective, injective and flat modules, Dedekind domains, and central simple algebras. All of the important theorems are discussed, without proofs but often with a discussion of the intuitive ideas behind those proofs.

Catalog Code:
DOL-48

325 pp., Hardbound, 2012
ISBN 978-0-88385-355-9
List: $49.95
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How Content Matters

Alain Schremmer

Nowadays, about half of the college student population is in two-year colleges, and as they enter, the overwhelming majority of these students are totally unprepared for whatever college-level courses they have to take. Unfortunately, the belief that all that "unprepared students" need is to learn "mathematical facts" and acquire computational skills, together with the concomitant belief that, to that end, better pedagogy is all that is needed has caused a complete atomization of the contents and thus complete reliance on memorization. Also, it is unrealistic to expect that even two semesters of Developmental Mathematics can remedy so many lost years. It is thus rather unsurprising that during the near forty years of its existence, Developmental Mathematics has never worked.[1]

The premise for what is being proposed here is, as physicist Hestenes, of Geometric Algebra fame, wrote in his Oersted Medal lecture, that "[*That*] *course content is taken* [*by many*] *as given* [...] *ignores the possibility of improving pedagogy by reconstructing course contents.*" The aim is to call for mathematicians to engage in such reconstructions and to show that it can be interesting.

What follows is just one—very sparse—example of how a reconstruction of the contents of Developmental Arithmetic and Algebra, together with a corresponding reconstruction of the contents of Precalculus and Differential Calculus, could lead to a three-semester, 5-4-4 sequence realistically accessible to developmental students. In total opposition to what is to be found in *all* currently available commercial texts, the idea is merely to use systematically a few powerful concepts with one thing flowing smoothly into the next.

Arithmetic

We start with the construction of a symbolic system for representing on paper collections of real-world items. We use number phrases such as 3 *apples*, consisting of a numerator to represent the *number* of items and a denominator to represent the *kind* of items. The point here is twofold: (i) This is something completely self-contained that can be dealt with to the complete satisfaction of the students, and (ii) this sets the stage for future distinctions such as between $\frac{3}{7} + \frac{2}{7}$, which is equal to $\frac{5}{7}$; and $\frac{3}{5} + \frac{2}{7}$, which is a (linear) combination (aka vector);[2] and as between $3x^7 + 2x^7$, which is equal to $5x^7$; and $3x^5 + 2x^7$, which is a combination.

In fact, we immediately use combinations to construct the Decimal Numeral System: 42.75 *Dollars* is introduced as shorthand for the combination 4 DEKA*Dollars* + 2 *Dollars* + 7 DECI*Dollars* + 5 CENTI*Dollars*.

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[1] *At least when measured in terms of subsequent success instead of throughput. For instance, at my institution less than one quarter of one percent (0.24%) of the students starting on the route Arithmetic—Basic Algebra—Intermediate Algebra—Precalculus I—Precalculus II—Calculus I ever complete Calculus I.*

DOI: http://dx.doi.org/10.1090/noti961

[2] *+ being read here as "and".*

A further stage is to discuss operations which we see the old way, that is, as *unary*. Here again, this has two purposes: (i) to stick to the real world, where, for instance, we attach a collection *to* a collection, and (ii) to turn the concept of unary operation into that of a function.

The discussion of reverse problems leads naturally to the introduction of signed numbers in the case of addition and to decimal numbers in the case of multiplication. We thus arrive at $\mathbb{D}$, the set of signed decimal numbers.

However, if multiplication is introduced as dilation, we also look at it as "co-multiplication", as in $-3\,\cancel{apples} \odot -5\,\frac{cents}{\cancel{apple}}$, which, given that nobody has ever objected to the fact that getting rid of bad apples is a plus, immediately gives $+15\,cents$.

We introduce fractions as code for division as in $\frac{1}{3} = 0 + [\dots] = 0.3 + [\dots] = 0.33 + [\dots]$, where **[...]** is read "something too small to matter here".[3] Eventually, *quarter* is defined as "of which it takes 4 to exchange for 1 *dollar*", from which the rest follows naturally, e.g., $\frac{7}{4}$*dollar* is equivalent to the combination $1\,dollar + 3\,quarters$. Then, if *dimes* can be exchanged at the rate of $2\,\frac{nickels}{dime}$ and *quarters* at $5\,\frac{nickels}{quarter}$, then $3\,dimes - 2\,quarters$ can be exchanged for

$$(+3\,dimes, -2\,quarters)\ @\ \begin{bmatrix} +2\,\frac{nickels}{dime} \\ +5\,\frac{nickels}{quarter} \end{bmatrix}$$
$$= -4\,nickels,$$

with *nickels* in the underlying field. In other words, we get $\frac{3}{10} - \frac{2}{4} = -\frac{4}{20}$.

Algebra

We now deal with the mechanics of solving reverse problems. After the relation symbols $=, \neq, >, <, \geqq, \leqq$ have been introduced, we introduce "(in)equations" as open sentences sifting a solution subset out of a data set. We discuss the differences between the case of data sets consisting of whole numbers and that of data sets consisting of decimal numbers. Hence to specify a solution subset, we use the notion of an inequation problem, i.e., of a data set together with an inequation. We then spend a considerable amount of time dealing successively, mostly in the case of decimal data sets, with basic problems (e.g., $x \leqq -352.94$), translation problems (e.g., $x \oplus -37.183 > -352.94$), dilation problems (e.g., $x \odot -23.1327 \neq -822.08$), and affine problems, using *exclusively* the standard approach: (i) Find the boundary points by solving the associate equation. (ii) Test the boundary points against the given inequation. (iii) In each one of the intervals determined by the boundary points, test a point against the inequation and use the Pasch Theorem, which says that "whatever is true of the test point is true of all points in the interval." We then spend time with double problems, i.e., problems involving two inequations bound by one of three connectors: BOTH, EITHER ONE OR BOTH, EITHER ONE BUT NOT BOTH. We start with double basic problems and work our way up to double affine problems.[4]

Finally, with an unfortunate hiatus, we move to the notion of power with monomial functions; i.e., instead of multiplying the coefficient a by a single copy of the input x, as with dilation functions, we either

- multiply a by n copies of the input x:

$$x \xrightarrow{a\,\text{MONOMIAL}_{+n}} a\,\text{MONOMIAL}_{+n}(x)$$
$$= a \cdot \underbrace{x \cdot x\ \cdot\cdot\cdot\cdot\ x \cdot x}_{n \text{ copies of } x} \quad \text{aka} \quad ax^{+n}$$

or

- divide a by n copies of the input x:

$$x \xrightarrow{a\,\text{MONOMIAL}_{-n}} a\,\text{MONOMIAL}_{-n}(x)$$
$$= \frac{a}{\underbrace{x \cdot x\ \cdot\cdot\cdot\cdot\ x \cdot x}_{n \text{ copies of } x}} \quad \text{aka} \quad ax^{-n}.$$

In other words, $x^{\pm n}$ is just code to be read as "multiplied (resp. divided) by n copies of x" and generalizes the code 10^n that we used with decimal numbers and initially read as "1 followed/preceded by n zeros".

Computing with monomials, we find that:

1. From the multiplicative viewpoint, the code lets us write $3x^{+2} \cdot 4x^{+3} = 3 \cdot x \cdot x \cdot 4 \cdot x \cdot x \cdot x = 3 \cdot 4 \cdot x \cdot x \cdot x \cdot x \cdot x = 12x^{+5}$. Similarly, we have $3x^{+2} \cdot 4x^{-3} = 3 \cdot x \cdot x \cdot \frac{4}{x \cdot x \cdot x} = 3 \cdot 4 \cdot \frac{\cancel{x} \cdot \cancel{x}}{\cancel{x} \cdot \cancel{x} \cdot x} = 12x^{-1}$. Eventually we discover that "o-plussing (resp. o-minussing) the exponents" does the job automatically for the multiplication (resp. division) of monomials.

2. From the additive viewpoint, $x^{\pm n}$ behaves like a denominator, e.g., $5x^{-4} + 2x^{-4} = 7x^{-4}$, but $5x^{+3} + 2x^{-4}$ is a combination with Laurent polynomials generalizing decimal numbers: $3x^2 + 4x^1 + 5x^0 + 6x^{-1} + 7x^{-2}\,\big|_{x \leftarrow 10} = 345.67$.

We end with "the four operations" for Laurent polynomials. When adding and subtracting, the controlling fact is that $x^{\pm n}$ behaves just like a denominator. Multiplication is easily dealt with by reading the code and, eventually, by using $\oplus$. After that we make a small detour to get $(x_0 + h)^n = x_0^n + nx_0^{n-1}h + \frac{n(n-1)}{2}x_0^{n-2}h^2 + [\dots]$ (usually not much further). The most important operation for us will be division, using $[\dots]$ to stop it, as in

$$\frac{-12x^3 + 11x^2 - 17x + 1}{-3x^2 + 5x - 2} = +4x + 3 + 8x^{-1} + [\dots]$$

[3] *[...] can thus be seen as an undifferentiated precursor of Landau's o[h^n].*

[4] *Initially, students have a terrible time with even double* basic *problems.*

and

$$\frac{-12 + 23h - h^2 - 2h^3}{-3 + 2h} = +4 - 5h - 3h^2 + [\dots].$$

Conclusion

I have reasons to believe that the contents sketched above: (i) can be absorbed by developmental students in a 5-hour course and (ii) can prepare developmental students for a two-semester (4-4) integrated alternative to the conventional (3-3-4) Precalculus I–Precalculus 2–Calculus 1 sequence that I developed under a 1988 NSF calculus grant:

- I am currently using part of the materials I developed for arithmetic along with the materials on inequations and on Laurent polynomial functions in a 3-hour developmental algebra course. The arithmetic materials which lead up to it should be doable with an additional 2 hours.
- The NSF sequence was based on Lagrange's approach, in which the nth derivative of f at x_0 is defined (modulo $n!$) as the coefficient of x^n in the polynomial approximation of $f(x_0 + h)$. As such, it does not require anything more than an Arithmetic-Algebra course along the lines sketched above.

So, given that

- The Office of Institutional Research at my institution found that "Of those attempting the first course in each sequence, 12.5% finished the [conventional three-semester, 10-hour] sequence while 48.3% finished the [integrated two-semester, 8-hour] sequence."[5]
- Having passed the Arithmetic-Algebra course and thus having already learned to take advantage of "mathematical compression", as well as having acquired precisely the necessary prerequisites, these formerly "unprepared students" ought now to hit the ground running in the first semester of the integrated alternative sequence and thus perform there at least as well as the students who entered the NSF sequence.

it would seem that, in contrast with the number given at the outset, 0.24 percent, such a three-semester (5-4-4) sequence should work for anywhere from about 5 percent to 20 percent of incoming "unprepared students".[6]

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[5] *The passing rates in Calculus 2 were the same, but this was not really significant because of the low numbers of the students involved.*

[6] *The percentage would essentially depend on the extent to which the institution's placement test would be able to ascertain, instead of the students' "level of preparation", which is demonstrably meaningless in any case, their likely degree of commitment.*

Mathematics People

Reed Awarded 2013 CRM-Fields-PIMS Prize

Bruce Reed of McGill University has been awarded the CRM-Fields-PIMS Prize for 2013 "for his profound contributions to difficult and important problems in the areas of graph minors, graph colouring, algorithmic graph theory, random graphs, and the probabilistic analysis of algorithms." He has made contributions in such areas as discrete mathematics and theoretical computer science and is best known for his work on a broad range of areas within graph theory, with many of his most important contributions being in random structures, graph minors, and graph coloring.

The CRM-Fields-PIMS Prize recognizes exceptional achievement in the area of mathematical sciences. It is awarded by the Centre de Recherches Mathématiques (CRM), the Fields Institute, and the Pacific Institute for Mathematical Sciences (PIMS).

—From a CRM announcement

Bhargava Awarded Infosys Prize

Manjul Bhargava of Princeton University has been awarded the 2012 Infosys Prize for Mathematical Sciences "for his extraordinarily original work in algebraic number theory. His work has revolutionized the way in which various fundamental arithmetic objects, such as number fields and elliptic curves, are understood." The prize citation reads: "Professor Bhargava has made several highly original contributions to algebraic number theory. He has introduced brilliant new ideas which have turned a subject that had been largely stuck for forty years into one of the most active areas in number theory today. He has also proved a series of beautiful theorems that greatly enhance our understanding of number fields and algebraic curves, two of the most studied topics in number theory. In particular, he showed how to count quartic and quintic number fields and proved that the average rank of elliptic curves over the rational numbers is less than 1." The award is given annually to honor outstanding achievements of contemporary researchers and scientists across six categories: engineering and computer sciences, humanities, life sciences, mathematical sciences, physical sciences, and social sciences. It carries a cash award of US$90,000.

—From an Infosys Science Foundation announcement

Leverhulme Prizes Awarded

Five mathematicians have been awarded Leverhulme Prizes by the Leverhulme Trust. They are Toby Gee, Imperial College London, number theory; Jonathan Marchini, University of Oxford, statistical genetics; Andre Neves, Imperial College London, geometric analysis; Christoph Ortner, University of Warwick, numerical analysis and applied analysis; and Lasse Rempe-Gillen, University of Liverpool, complex dynamics. The Leverhulme Prizes carry a cash award of £70,000 (approximately US$112,800) each and are awarded to outstanding scholars who have made a substantial and internationally recognized contribution to their particular field of study and who are expected to achieve greater things in the future. The prizes commemorate the contribution to the work of the trust made by Philip Leverhulme, the Third Viscount Leverhulme and grandson of the founder.

—From a Leverhulme Trust announcement

Matui Awarded Operator Algebra Prize

Hiroki Matui of Chiba University has been awarded the fourth Operator Algebra Prize for his outstanding contributions to the interaction between topological dynamical systems and C^*-algebras and classification of group actions on C-algebras. The prize consists of a cash award of about US$4,000, a prize certificate, and a medal. The Operator Algebra Prize was established in 1999 by initiatives and contributions from some senior Japanese researchers in operator algebra theory and related fields to encourage young researchers in these fields. The prize is awarded every four years to a person under forty years of age either of Japanese nationality or principally based in a Japanese institution for outstanding contributions to operator algebra theory and related areas.

—Yasuyuki Kawahigashi, Chair,
Operator Algebra Prize Committee

Prizes of the Mathematical Society of Japan

The Mathematical Society of Japan (MSJ) has announced a number of prizes for 2012.

The Analysis Prize is awarded to researchers who have contributed to the progress of analysis in a broad sense by obtaining outstanding results. The 2012 Analysis Prize has been awarded to Yoshiyuki Kagei of Kyushu University for work on stability analysis for parallel flow of the compressible viscous fluid, to Shigeru Sakaguchi of Tohoku University for work on geometry on the domain via the isothermic set for diffusion equations, and to Masanobu Taniguchi of Waseda University for studies on optimal statistical inference in time series analysis.

The Geometry Prize is awarded to researchers who have contributed to the development of geometry in a broad sense by obtaining outstanding results. The 2012 Geometry Prize has been awarded to Ken'ichi Oshika of Osaka University for the affirmative solution of the Bers-Sullivan-Thurston density conjecture and to Yukinobu Toda of the University of Tokyo for the study of the Donaldson-Thomas invariants by stability conditions in derived categories.

The Autumn Prize for 2012 has been awarded to Mitsuhiro Nakao of Sasebo National College of Technology for outstanding contributions to research on validated computation and its applications to partial differential equations. The Autumn Prize is awarded without age restriction to people who have made exceptional contributions in their fields of research.

The Fujiwara Award was given to Kenji Fukaya of Kyoto University for outstanding contributions to mathematical foundation and geometric realization of topological field theory.

—From MSJ announcements

Isidori Receives 2012 IEEE Control Systems Award

Alberto Isidori of Sapienza University, Rome, Italy, has been named the recipient of the 2012 Control Systems Award of the Institute of Electrical and Electronics Engineers (IEEE) for his groundbreaking work in nonlinear control. According to the prize citation, his "research in the early 1970s focused on systems realization, resulting in the first complete theory of minimal realization for a class of nonlinear systems. He then extended the geometric theory used for feedback design in multivariable linear systems to general classes of nonlinear systems. This work is considered a milestone in the study of nonlinear feedback systems. Dr. Isidori also developed the concept of nonlinear zero dynamics, which has had fundamental impact on designing feedback laws for nonlinear systems. His contributions to regulation and tracking in nonlinear systems resulted in the design of a feedback law that solves the nonlinear equivalent of the servomechanism problem in linear control."

—From an IEEE announcement

Hendy Awarded Shorland Medal

Michael Hendy of Otago University has been awarded the Shorland Medal of the New Zealand Association of Scientists for "an outstanding body of research into mathematical phylogeny—the set of mathematical tools for reconstructing evolutionary relationships between species using DNA sequences," according to the prize citation. The award recognizes major and continued contribution to basic or applied research that has added significantly to scientific understanding or produced significant benefits to society.

—From a New Zealand Association of Scientists announcement

AAAS Fellows 2012

Seven researchers have been elected fellows of the Section on Mathematics of the American Association for the Advancement of Science (AAAS). They are: Susanne C. Brenner, Louisiana State University; Robert Calderbank, Duke University; L. Pamela Cook-Ioannidis, University of Delaware; Susan Friedlander, University of Southern California; Carolyn Gordon, Dartmouth College; Deborah Frank Lockhart, National Science Foundation; and Susan Montgomery, University of Southern California.

—From an AAAS announcement

2012 Siemens Competition

Several high school students whose work involves the mathematical sciences have won prizes in the 2012 Siemens Competition in Math, Science, and Technology.

Kensen Shi of A&M Consolidated High School, College Station, Texas, won a scholarship worth US$100,000 for his computer science project "Lazy Toggle PRM: A Single-Query Approach to Motion Planning". He was mentored by Nancy Amato of Texas A&M University, who invited him to join her laboratory focusing on the motion-planning problem, which involves finding a safe path for a moveable object among obstacles, such as an assembly-line robot in a factory. Shi developed a new algorithm that could compute safe paths for virtually any type of robot more efficiently than other methods. The strategy, called Lazy Toggle PRM, is effective in a wide range of scenarios, including those with narrow passages and highly complex environments. Shi has won honors in a variety of mathematics and science competitions. As Texas American

Regional Mathematics League Gold Team captain, he led his team to thirteenth place nationally. A senior, he is captain of his school's Science Bowl team, which placed second regionally for two consecutive years. As president of the Math Club, he presented a series of seminars on advanced topics and qualified for the USA Junior Mathematical Olympiad.

Jiayi Peng of Horace Greeley High School, Chappaqua, New York, was awarded a US$50,000 scholarship for her physics project "A Cellular Automation Model for Critical Dynamics in Neuronal Networks". She was mentored by John M. Beggs of Indiana University. Peng said, "I like how interdisciplinary mathematical modeling can be. Its basis may be in mathematics and/or physics, yet it can be used to solve real-world problems." Peng built a cellular automation model that combined short-term synaptic plasticity with long-term metaplasticity to investigate how these two mechanisms contribute to attaining and maintaining operation at a critical point. Her research could help determine how distinct neurological mechanisms can differentiate a healthy brain from one with a devastating neurological disorder such as epilepsy, autism, or Alzheimer's disease. Peng became interested in mathematical modeling after reading an article in *Scientific American* about mathematicians and computer scientists modeling terrorist group structures and predicting their behavior. A senior, she is a member of the Cum Laude Honor Society and is her school's top scorer in the American Mathematics Competition. She is a National Merit Semifinalist and has received Moody's Math Challenge National Honorable Mention. She plans to major in physics or mathematics and aspires to be a researcher or professor in one of these fields.

The team of Daniel Fu of Park Tudor School, Indianapolis, Indiana, and Patrick Tan, Carmel High School, Carmel, Indiana, was awarded a US$50,000 scholarship for their mathematics project "Chaos and Robustness in a Single Family of Genetic Oscillatory Networks". They were mentored by Alexey Kuznetsov and Yaroslav Molkov of Indiana University-Purdue University Indianapolis. In their project, Fu and Tan researched new techniques for mathematically analyzing genetic oscillatory networks. They developed a method for reducing infinitely dimensional delay differential equations (DDEs) to three-dimensional systems of ordinary differential equations (ODEs). Their work could lead to better treatments of diseases with irregularities in the cell cycle, such as cancer, or the circadian rhythm, such as sleep disorders. Fu, a junior, is a member of the USA Computing Olympiad Silver Division and won fourth place in the American Chemistry Society exam, Indiana section. He volunteers in cancer clinics and mentors other students in STEM. He is considering a major in computer science or political science and hopes to be either a research professor or a politician. In the near future, he is most excited about attending The Hague International Model United Nations in the Netherlands. Tan, a junior, is secretary of the Key Club, president of the Chemistry Club, and a member of the Top Symphonic Band. He cofounded the DPY Math Contest for middle school students, which helps prepare them for the MATHCOUNTS competition. He plans to study biochemistry, applied mathematics, and finance in college and aspires to a career in which he can combine math and science with his desire to help people.

The team of Jonathan Tidor and Rohil Prasad of Lexington High School, Lexington, Massachusetts, was awarded a US$20,000 scholarship for their mathematics project "New Results in Staged Self-Assembly of Wang Tiles". They were mentored by Jesse Geneson of the Massachusetts Institute of Technology. Tidor and Prasad said, "We decided on this research topic not only because of the interesting math involved but also because of its potential to be used beneficially in the real world." Their mathematics research explores self-assembly, which deals with the spontaneous appearance of order out of simple parts and is often applied in the field of nanotechnology. They looked at a self-assembly model and developed a method to build arbitrary shapes that is optimal in most situations. They found faster ways to create systems of particles that assemble themselves into particular structures, which could make it easier to assemble a large variety of nanostructures, such as nanoscale biomedical devices. They are looking forward to the possibility of their research being published in the next few months. Tidor, a junior, is captain of his school's math team and Science Bowl team, which was a winner at the national Science Bowl. He expects to pursue a career related to mathematics or physics. Prasad, also a junior, aspires to work in a mathematics-related field. "I enjoy the intense problem-solving aspects of it, in addition to how beautiful many things are in mathematics," he said. He is a member of the Science Bowl team and volunteers with his middle school's math team.

—From a Siemens Competition announcement

Mathematics Opportunities

Call for Nominations for Prizes of the Academy of Sciences for the Developing World

The Academy of Sciences for the Developing World (TWAS) prizes are awarded to individual scientists in developing countries in recognition of outstanding contributions to knowledge in eight fields of science.

Eight awards are given each year in the fields of mathematics, medical sciences, biology, chemistry, physics, agricultural sciences, earth sciences, and engineering sciences. Each award consists of a prize of US$15,000 and a plaque. Candidates for the awards must be scientists who have been working and living in a developing country for at least ten years.

The deadline for nominations for the 2013 prizes is **February 28, 2013**. Nomination forms should be sent to: TWAS Prizes, International Centre for Theoretical Physics (ICTP) Campus, Strada Costiera 11, 1-34151 Trieste, Italy; fax: 39 040 2240 7387; email: `prizes@twas.org`.

Further information is available on the World Wide Web at `http://www.twas.org/`.

—From a TWAS announcement

Call for Nominations for Graham Wright Award

The Canadian Mathematical Society (CMS) is seeking nominations for the 2013 Graham Wright Award for Distinguished Service. This award recognizes individuals who have made sustained and significant contributions to the Canadian mathematical community and, in particular, to the Canadian Mathematical Society. Nominations should include a reasonably detailed rationale and be submitted by **March 31, 2013,** to `gwaward@cms.math.ca`. For more information see the website `http://cms.math.ca/Prizes/dis-nom`.

—From a CMS announcement

For Your Information

2013 Everett Pitcher Lectures

Gunnar Carlsson of Stanford University will deliver the 2013 Everett Pitcher Lectures, to be held March 18–20, 2013, on the campus of Lehigh University in Bethlehem, Pennsylvania. The title of his lecture series is "The Shape of Data". The lectures, which are open to the public, are held in honor of Everett Pitcher, who was secretary of the AMS from 1967 until 1988. Pitcher served in the mathematics department at Lehigh from 1938 until 1978, when he retired as Distinguished Professor of Mathematics. He passed away in December 2006 at the age of ninety-four.

For further information contact the Everett Pitcher Lecture Series, Department of Mathematics, Lehigh University, Bethlehem, PA 18015; telephone 610-758-3731; website `http://www.lehigh.edu/~math/pitcher.html`.

—Don Davis
Lehigh University

Correction

On page 1219 of the October 2012 issue of the *Notices* ("The influence of Benoît B. Mandelbrot on mathematics") we had misread a statement by Mandelbrot and incorrectly reported that in 1979 he formulated the local connectivity conjecture (MLC). Local connectivity was conjectured by John Hubbard and Adrien Douady. We thank Curtis McMullen for pointing out this error.

—Michael F. Barnsley and Michael Frame, article authors

Open Access

Donald E. McClure

The American Mathematical Society (AMS) is currently considering a proposal to start two new open access research journals. The proposal has been presented to the Committee on Publications, the Long Range Planning Committee, the Executive Committee and Board of Trustees (ECBT), and the Council. At its November 17 meeting, the ECBT recommended that the president appoint an ad hoc committee to advise the Council, Board of Trustees, and the executive director about the proposal and other open access alternatives. The committee members are Matthew Ando, John Ewing, Eric Friedlander, David Goss, Robert Guralnick, Bryna Kra, Donald McClure, and Ronald Stern.

The committee welcomes comments, questions, and suggestions about the proposal, which is described in this article. Comments sent to OpenAccess@ams.org will be shared with the committee. The committee plans to report to the Council and Board of Trustees in mid-March, about a month before the April 20 Council meeting.

Background

The proposal to expand the options for open access publishing in AMS research journals is motivated by AMS publication policy, open access mandates from research sponsors, encouragement from research libraries, and the need to create a path for the future of AMS publishing.

AMS Publication Policy. At the January 2012 Council meeting in Boston, the following statement of AMS policy was adopted:

> ***The American Mathematical Society strongly endorses and adheres to the principle that a paper in the mathematical sciences should have an opportunity to be evaluated and possibly published without regard to the financial circumstances of its authors.***

Donald E. McClure is the executive director of the AMS. His email address is dem@ams.org.

DOI: http://dx.doi.org/10.1090/noti978

The policy simply states that the AMS will not discriminate against any author because of his or her financial circumstances.

Currently, the AMS does not have a method of accommodating an author who wishes to publish under an open access model that makes the *version of record* of an article freely available. This constraint will be explained more fully below, but to provide an example: if an author happens to be required by their funding agency or institution to give preference to publishing in an open access journal or if he or she simply wants their paper to be freely available in its final published form immediately upon publication, the AMS has no way to address that author's needs or wishes.

Community Pressures. The movement toward open access publishing is rapidly shifting beneath our feet. Funding agencies and academic institutions are taking steps to promote open access publishing of research. The Research Councils UK and the European Commission made major policy announcements in July 2012. For some time, U.S. funding agencies, Congress, and the Executive Office of Science and Technology Policy (OSTP) have been formulating plans for an open access mandate for public access to federally sponsored research.

Government Mandates. On July 16, 2012, Research Councils UK (RCUK) announced that, starting in April 2013, all publicly funded "research outputs", including refereed articles in journals and conference proceedings, must be published under one of two acceptable open access models.[1] (1) Under the "gold" open access model, a journal provides immediate unrestricted access to the publisher's final version of the paper (the version of record) and allows immediate deposit of the version of record in other repositories. RCUK also established a mechanism for supporting payment to the publisher of an Article Processing Charge (APC), recognizing that there are costs of publication. (2) Under the "green" open access model, publishers must allow an author's final peer-reviewed manuscript to be deposited in an online repository within six months of publication (twelve months for arts, humanities, and social sciences). While all of the AMS research journals

[1] http://www.rcuk.ac.uk/documents/documents/RCUK%20_Policy_on_Access_to_Research_Outputs.pdf

already offer green open access,[2] the UK Government explicitly expressed a preference for the "gold" over the "green" model.

One day later, on July 17, the European Commission (EC) announced a similar policy for all research outputs sponsored under a program funded at US$98 billion over the years 2014 to 2020.[3]

Over the four-year period 2006–2009, 40 percent of the articles published in *Transactions* and 36 percent of the articles published in *Proceedings* had a corresponding author who was domiciled in Europe. These percentages both exceed the percentages of corresponding authors domiciled in the United States.

Increased Commitment of Academic Institutions to Open Access. In the gold open access model, it is generally assumed that an Article Processing Charge will be paid **by a funding agency or by the author's institution**. APCs are not expected to be paid by the author personally.

In an organized effort to support a transition of scholarly publishing to open access, more than thirty institutions have established funds to support APCs on behalf of their affiliated authors. Seventeen institutions have signed a *Compact for Open-Access Publishing Equity*[4] to establish "durable mechanisms for underwriting reasonable publication charges."

In particular, institutional payment of APCs is restricted to truly open access journals and will not be paid to a so-called *hybrid* journal that enables an isolated article to be made open access by payment of a fee.

We anticipate that the proposed new journals will be welcomed by the library community.

The need for society publishers to publish more. Society publishers and other non-commercial publishers are not keeping up with *commercial* publishers in terms of market share. In the ten-year period 2000–2009, the number of research articles in the mathematical sciences grew by 37 percent. Over the same period, the proportion of articles published by commercial publishers grew from 44 percent in 2000 to 56 percent in 2009.

The research and library communities would be better served if society publishers could publish more of the high-quality literature in low-cost journals. This cannot be achieved solely with subscription journals. Open access provides an opportunity for society publishers to publish more.

Laying the Foundation for the Future of AMS Publishing. Proponents of open access publishing predict phenomenal growth for open access and the eventual demise of subscription journals. Even if such predictions are exaggerated, the move to open access publishing forces us to think carefully about adapting to the change. The proposal below starts to pave a path, if it is necessary, toward the partial replacement of the subscription model by open access.

Proposal

It is proposed that the AMS establish two new open access journals to start publication in 2014 or 2015. The journals would be managed editorially as *companion journals* of *Proceedings of the AMS* (PAMS) and of *Transactions of the AMS* (TAMS). I shall refer to the new journals as

> *Proceedings of the American Mathematical Society, Series B*, and
>
> *Transactions of the American Mathematical Society, Series B*,

or by the short names *Proceedings B* and *Transactions B*. Both of the journals would be supported by Article Processing Charges. The APCs would be designed to cover the Society's costs of publication.

1. The new journals will have distinct ISSNs (**I**nternational **S**tandard **S**erial **N**umbers). Each one will be distinct from its companion. The proposed model avoids the pitfalls of a hybrid journal; see, for example, item 6.

2. The *Series B* journals will be electronic-only and will be freely available online.

3. PAMS and its companion, *Proceedings B, w*ould have a common editorial board. The same would hold for TAMS and *Transactions B*. This will assure the high editorial standard of each new journal. The editorial boards will be expanded as necessary.

4. Editorial decisions will be independent of "business" decisions. The editor handling a paper will not need to know whether a paper is intended for the open access journal or its subscription counterpart.

5. Upon acceptance of a paper, the author(s) will choose which of the two companion journals would publish it; the decision can well be postponed that long. Publication in *Series B* of either companion pair would be dependent on payment of the APC by a research sponsor or the author's home institution.

6. The two subscription journals will not change their respective budgeted number of pages, and they will continue to publish all of the budgeted pages. Thus the value received by a subscriber will not be diminished.

7. In the first years of publication, we would plan for a modest number of pages for both of the *Series B* journals. The creation of the new journals does enable the AMS to work toward the goal of publishing more.

The new journals will also enable the AMS to adapt gracefully to shifts toward open access publishing in the future. This is a huge benefit of establishing the new journals as companions of our primary research journals.

[2] `http://www.ams.org/publications/journals/AMS-Views-on-Journal-Publishing`

[3] `http://europa.eu/rapid/press-release_IP-12-790_en.htm`

[4] `http://www.oacompact.org/compact/`

Reference and Book List

*The **Reference** section of the* Notices *is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.*

Contacting the *Notices*

The preferred method for contacting the *Notices* is electronic mail. The editor is the person to whom to send articles and letters for consideration. Articles include feature articles, memorial articles, communications, opinion pieces, and book reviews. The editor is also the person to whom to send news of unusual interest about other people's mathematics research.

The managing editor is the person to whom to send items for "Mathematics People", "Mathematics Opportunities", "For Your Information", "Reference and Book List", and "Mathematics Calendar". Requests for permissions, as well as all other inquiries, go to the managing editor.

The electronic-mail addresses are `notices@math.wustl.edu` in the case of the editor and `smf@ams.org` in the case of the managing editor. The fax numbers are 314-935-6839 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Information for *Notices* Authors

The *Notices* welcomes unsolicited articles for consideration for publication, as well as proposals for such articles. The following provides general guidelines for writing *Notices* articles and preparing them for submission. Contact information for *Notices* editors and staff may be found on the *Notices* website, `http://www.ams.org/notices`.

Upcoming Deadlines

February 25, 2013: Applications for EDGE Summer Program. See `http://www.edgeforwomen.org/`.

February 28, 2013: Nominations for TWAS Prizes. See "Mathematics Opportunities" in this issue.

March 1, 2013: Applications for 2013 Summer Program for Women in Mathematics (SPWM). Contact the director, Murli M. Gupta, email: `mmg@gwu.edu`; telephone: 202-994-4857; or see the website `http://www.gwu.edu/~spwm/`.

March 18, 2013: Registration for CRM International School and Research Workshop on Complex Systems. See the website `http://www.crm.cat/en/Activities/Pages/ActivityDescriptions/International-School-and-Research-Workshop-on-Complex-systems.aspx`.

March 31, 2013: Nominations for CMS Graham Wright Award for Distinguished Service. See "Mathematics Opportunities" in this issue.

March 31, 2013: Applications for AMS-Simons Travel Grants. See `www.ams.org/programs/travel-grants/AMS-SimonsTG` or contact Steven Ferrucci, email: `ams-simons@ams.org`, telephone: 800-321-4267, ext. 4113.

March 31, 2013: Applications for IPAM graduate summer school on computer vision. See `www.ipam.ucla.edu`.

April 1, 2013: Letters of intent for proposals for one-semester programs at the Bernoulli Center (CIB). See the website `http://cib.epfl.ch/`.

April 15, 2013: Applications for fall 2013 semester of Math in Moscow. See `http://www.mccme.ru/mathinmoscow`, or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; e-mail: `mim@mccme.ru`. Information and application forms for the AMS scholarships are available on the AMS website at `http://www.ams.org/programs/travel-grants/mimoscow`, or by writing to: Math in Moscow Program, Membership

Where to Find It

A brief index to information that appears in this and previous issues of the *Notices*.

and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email student-serv@ams.org.

May 1, 2013: Applications for May review for National Academies Research Associateship Programs. See the website http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email rap@nas.edu.

May 1, 2013: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; or telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

August 1, 2013: Applications for August review for National Academies Research Associateship Programs. See the website http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email rap@nas.edu.

October 1, 2013: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; or telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

October 4, 2013: Letters of intent for NSF Program ADVANCE Institutional Transformation and Institutional Transformation Catalyst awards. See http://www.nsf.gov/pubs/2012/nsf12584/nsf12584.htm?WT.mc_id=USNSF_36&WT.mc_ev=click.

November 1, 2013: Applications for November review for National Academies Research Associateship Programs. See the website http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email rap@nas.edu.

November 12, 2013: Full proposals for NSF Program ADVANCE Institutional Transformation and Institutional Transformation Catalyst awards. See http://www.nsf.gov/pubs/2012/nsf12584/nsf12584.htm?WT.mc_id=USNSF_36&WT.mc_ev=click.

Board on Mathematical Sciences and Their Applications, National Research Council

The Board on Mathematical Sciences and Their Applications (BMSA) was established in November 1984 to lead activities in the mathematical sciences at the National Research Council (NRC). The mission of BMSA is to support and promote the quality and health of the mathematical sciences and their benefits to the nation. Following are the current BMSA members.

Gerald G. Brown, Naval Postgraduate School

L. Anthony Cox Jr., Cox Associates, Inc.

Brenda Dietrich, IBM Thomas J. Watson Research Center

Constantine Gatsonis, Brown University

Darryll Hendricks, UBS Investment Bank

Andrew W. Lo, Massachusetts Institute of Technology Sloan School of Management

David Maier, Portland State University

James C. McWilliams, University of California, Los Angeles

Juan C. Meza, University of California, Merced

John W. Morgan, Stony Brook University

Vijayan N. Nair, University of Michigan

Claudia Neuhauser, University of Minnesota

J. Tinsley Oden, University of Texas at Austin

Fred S. Roberts, Rutgers University

Donald Saari, Chair, University of California at Irvine

Carl P. Simon, University of Michigan

J. B. Silvers, Case Western Reserve University

Eva Tardos, Cornell University

Karen L. Vogtmann, Cornell University

Bin Yu, University of California, Berkeley

The postal address for BMSA is: Board on Mathematical Sciences and Their Applications, National Academy of Sciences, Room K974, 500 Fifth Street, NW, Washington, DC 20001; telephone: 202-334-2421; fax: 202-334-2422; email: bms@nas.edu; website: http://sites.nationalacademies.org/DEPS/BMSA/DEPS_047709.

Book List

The Book List highlights recent books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. Suggestions for books to include on the list may be sent to notices-booklist@ams.org.

*Added to "Book List" since the list's last appearance.

Algorithmic Puzzles, by Anany Levitin and Maria Levitin. Oxford University Press, October 2011. ISBN-13: 978-01997-404-44.

American Mathematicians as Educators, 1893–1923: Historical Roots of the "Math Wars", by David Lindsay Roberts. Docent Press, July 2012, ISBN-13: 978-09837-004-49.

The Beginning of Infinity: Explanations That Transform the World, by David Deutsch. Viking Adult, July 2011. ISBN-13: 978-06700-227-55. (Reviewed April 2012.)

The Best Writing on Mathematics 2012, edited by Mircea Pitici. Princeton University Press, November 2012. ISBN-13: 978-06911-565-52.

Bibliography of Raymond Clare Archibald, by Scott Guthery. Docent Press, April 2012. ISBN-13: 978-0983700425.

The Big Questions: Mathematics, by Tony Crilly. Quercus, April 2011. ISBN: 978-18491-624-01. (Reviewed October 2012.)

Calculating Curves: The Mathematics, History, and Aesthetic Appeal of T. H. Gronwall's Nomographic Work, by Thomas Hakon Gronwall, with contributions by Ron Doerfler and Alan Gluchoff, translation by Paul Hamburg, and bibliography by Scott Guthery. Docent Press, April 2012. ISBN-13: 978-09837-004-32.

Classic Problems of Probability, by Prakash Gorroochurn. Wiley, May 2012. ISBN: 978-1-1180-6325-5.

The Crest of the Peacock: Non-European Roots of Mathematics, by George Gheverghese Joseph. Third edition. Princeton University Press, October 2010. ISBN-13: 978-0-691-13526-7.

The Crossing of Heaven: Memoirs of a Mathematician, by Karl Gustafson. Springer, January 2012. ISBN-13: 978-36422-255-74.

Elliptic Tales: Curves, Counting, and Number Theory, by Avner Ash and Robert Gross. Princeton University Press, March 2012. ISBN-13: 978-06911-511-99.

Excursions in the History of Mathematics, by Israel Kleiner. Birkhäuser, 2012. ISBN-13: 978-08176-826-75.

Experimental and Computational Mathematics: Selected Writings, by Jonathan Borwein and Peter Borwein. PSIpress, 2011. ISBN-13: 978-19356-380-56.

The Foundations of Geometry And Religion From An Abstract Standpoint, by Salilesh Mukhopadhyay. Outskirts Press, July 2012. ISBN: 978-1-4327-9424-8.

**The Fractalist: Memoir of a Scientific Maverick,* by Benoit Mandelbrot. Pantheon, October 2012. ISBN-13: 978-03073-773-57.

Galileo's Muse: Renaissance Mathematics and the Arts, by Mark Austin-Peterson. Harvard University Press, October 2011. ISBN-13: 978-06740-597-26. (Reviewed November 2012.)

Game Theory and the Humanities: Bridging Two Worlds, by Steven J. Brams. MIT Press, September 2012. ISBN-13: 978-02625-182-53.

Games and Mathematics: Subtle Connections, by David Wells. Cambridge University Press, November 2012. ISBN-13: 978-11076-909-12.

Gösta Mittag-Leffler: A Man of Conviction, by Arild Stubhaug (translated by Tiina Nunnally). Springer, November 2010. ISBN-13: 978-36421-167-11.

Guesstimation 2.0: Solving Today's Problems on the Back of a Napkin, by Lawrence Weinstein. Princeton University Press, September 2012. ISBN: 978-06911-508-02.

**Henri Poincaré: A Scientific Biography* by Jeremy Gray. Princeton University Press, November 2012. ISBN-13: 978-06911-527-14.

Henri Poincaré: Impatient Genius, by Ferdinand Verhulst. Springer, August 2012. ISBN: 978-14614-240-62.

In Pursuit of the Traveling Salesman: Mathematics at the Limits of Computation, by William J. Cook. Princeton University Press, December 2011. ISBN-13: 978-06911-527-07.

**I Died for Beauty: Dorothy Wrinch and the Cultures of Science*, by Marjorie Senechal. Oxford University Press, December 2012. ISBN-13:978-01997-325-93.

In Pursuit of the Unknown: 17 Equations That Changed the World, by Ian Stewart. Basic Books, March 2012. ISBN-13: 978-04650-297-30. (Reviewed December 2012.)

In Service to Mathematics: The Life and Work of Mina Rees, by Amy Shell-Gellasch. Docent Press, December 2010. ISBN-13: 978-0-9837004-1-8.

Infinity: New Research Frontiers, edited by Michael Heller and W. Hugh Woodin. Cambridge University Press, February 2011. ISBN-13: 978-11070-038-73.

The Infinity Puzzle: Quantum Field Theory and the Hunt for an Orderly Universe, by Frank Close. Basic Books, November 2011. ISBN-13: 978-04650-214-44. (Reviewed September 2012.)

Introduction to Mathematical Thinking, by Keith Devlin. Keith Devlin, July 2012. ISBN-13: 978-06156-536-31.

The Irrationals: A Story of the Numbers You Can't Count On, by Julian Havil. Princeton University Press, June 2012. ISBN-13: 978-0691143422.

The Joy of x: A Guided Tour of Math, from One to Infinity, by Steven Strogatz. Eamon Dolan/Houghton Mifflin Harcourt, October 2012. ISBN-13: 978-05475-176-50.

Late Style: Yuri I. Manin Looking Back on a Life in Mathematics. A DVD documentary by Agnes Handwerk and Harrie Willems. Springer, March 2012. ISBN NTSC: 978-3-642-24482-7; ISBN PAL: 978-3-642-24522-0. (Reviewed January 2013.)

Lemmata: A Short Mathematical Thriller, by Sam Peng. CreateSpace, December 2011. ISBN-13: 978-14681-442-39.

The Logician and the Engineer: How George Boole and Claude Shannon Created the Information Age, by Paul J. Nahin, Princeton University Press, October 2012. ISBN: 978-06911-510-07.

Lost in a Cave: Applying Graph Theory to Cave Exploration, by Richard L. Breisch. National Speleological Society, January 2012. ISBN-13: 978-1-879961-43-2.

The Lost Millennium: History's Timetables Under Siege, by Florin Diacu. Johns Hopkins University Press (second edition), November 2011. ISBN-13: 978-14214-028-88.

Magical Mathematics: The Mathematical Ideas That Animate Great Magic Tricks, by Persi Diaconis and Ron Graham. Princeton University Press, November 2011. ISBN-13: 978-06911-516-49. (Reviewed August 2012.)

The Man of Numbers: Fibonacci's Arithmetic Revolution, by Keith Devlin. Walker and Company, July 2011. ISBN-13: 978-08027-781-23. (Reviewed May 2012.)

Math Girls, by Hiroshi Yuki (translated from the Japanese by Tony Gonzalez). Bento Books, November 2011. ISBN-13: 978-09839-513-15. (Reviewed August 2012.)

Math Goes to the Movies, by Burkard Polster and Marty Ross. Johns Hopkins University Press, July 2012. ISBN-13: 978-14214-048-44.

Math is Murder, by Robert C. Brigham and James B. Reed. Universe, March 2012. ISBN-13: 978-14697-972-81.

The Mathematical Writings of Évariste Galois, edited by Peter M. Neumann. European Mathematical Society, October 2011. ISBN-13: 978-3-03719-104-0. (Reviewed December 2012.)

Mathematical Excursions to the World's Great Buildings, by Alexander J. Hahn. Princeton University Press, July 2012. ISBN-13: 978-06911-452-04.

A Mathematician Comes of Age, by Steven G. Krantz. Mathematical Association of America, December 2011. ISBN-13: 978-08838-557-82.

Mathematicians in Bologna 1861-1960, edited by Salvatore Coen. ISBN: 978-30348-022-60.

Mathematics in Popular Culture: Essays on Appearances in Film, Fiction, Games, Television and Other Media, edited by Jessica K. Sklar and Elizabeth S. Sklar. McFarland, February 2012. ISBN-13: 978-07864-497-81.

Mathematics in Victorian Britain, by Raymond Flood, Adrian Rice, and Robin Wilson. Oxford University Press, October 2011. ISBN-13: 978-019-960139-4.

Meaning in Mathematics, edited by John Polkinghorne. Oxford University Press, July 2011. ISBN-13: 978-01996-050-57.

Measurement, by Paul Lockhart. Belknap Press of Harvard University Press, September 2012. ISBN-13: 978-06740-575-55.

Nine Algorithms That Changed the Future: The Ingenious Ideas That Drive Today's Computers, by John MacCormick. Princeton University Press, December 2011. ISBN-13: 978-06911-471-47.

Number-Crunching: Taming Unruly Computational Problems from Mathematical Physics to Science Fiction, by Paul J. Nahin. Princeton University Press, August 2011. ISBN: 978-06911-442-52.

On the Formal Elements of the Absolute Algebra, by Ernst Schröder (translated and with additional material by Davide Bondoni; with German parallel text). LED Edizioni Universitarie, 2012. ISBN: 978-88-7916-516-7.

Our Days Are Numbered: How Mathematics Orders Our Lives, by Jason Brown. Emblem Editions, April 2010. ISBN-13: 978-07710-169-74. (Reviewed October 2012.)

Paradoxes in Probability Theory, by William Eckhardt. Springer, September 2012. ISBN-13: 978-94007-513-92. (Reviewed in this issue.)

Pricing the Future: Finance, Physics, and the 300-Year Journey to the Black-Scholes Equation, by George G. Szpiro. Basic Books, November 2011. ISBN-13: 978-04650-224-89.

Proving Darwin: Making Biology Mathematical, by Gregory Chaitin. Pantheon, May 2012. ISBN: 978-03754-231-47.

Scientific Reflections: Selected Multidisciplinary Works, by Richard Crandall. PSIpress, 2011. ISBN-13: 978-19356-380-87.

**The Search for Certainty: A Journey Through the History of Mathematics*, 1800-2000, edited by Frank J. Swetz. Dover Publications, September 2012. ISBN-13: 978-04864-744-27.

Secrets of Triangles: A Mathematical Journey, by Alfred S. Posamentier and Ingmar Lehman. Prometheus Books, August 2012. ISBN-13: 978-16161-458-73.

Seduced by Logic: Emilie Du Châelet, Mary Somerville and the Newtonian Revolution, by Robyn Arianrhod. Oxford University Press, September 2012. ISBN: 978-01999-316-13.

Selected Papers: Volume II: On Algebraic Geometry, including Correspondence with Grothendieck, by David Mumford. Edited by Amnon Neeman, Ching-Li Chai, and Takahiro Shiota. Springer, July 2010. ISBN-13: 978-03877-249-11. (Reviewed February 2013.)

**The Signal and the Noise: Why So Many Predictions Fail—but Some Don't* by Nate Silver. Penguin Press, September 2012. ISBN-13:978-15942-041-11.

Simon: The Genius in My Basement, by Alexander Masters. Delacorte Press, February 2012. ISBN-13: 978-03853-410-80.

Six Gems of Geometry, by Thomas Reale. PSIpress, 2010. ISBN-13: 978-19356-380-25.

Sources in the Development of Mathematics: Series and Products from the Fifteenth to the Twenty-first Century, by Ranjan Roy. Cambridge University Press, June 2011. ISBN-13: 978-05211-147-07.

A Strange Wilderness: The Lives of the Great Mathematicians, by Amir D. Aczel. Sterling, October 2011. ISBN-13: 978-14027-858-49.

Taking Sudoku Seriously: The Math behind the World's Most Popular Pencil Puzzle, by Jason Rosenhouse and Laura Taalman. Oxford University Press, January 2012. ISBN-13: 978-01997-565-68.

The Theory That Would Not Die: How Bayes' Rule Cracked the Enigma Code, Hunted Down Russian Submarines, and Emerged Triumphant from Two Centuries of Controversy, by Sharon Bertsch McGrayne. Yale University Press, April 2011. ISBN-13: 978-03001-696-90. (Reviewed May 2012.)

**Thinking Statistically,* by Uri Bram. CreateSpace Independent Publishing Platform, January 2012. ISBN-13: 978-14699-123-32.

Transcending Tradition: Jewish Mathematicians in German Speaking Academic Culture, edited by Birgit Bergmann, Moritz Epple, and Ruti Ungar. Springer, January 2012. ISBN: 978-36422-246-38. (Reviewed February 2013.)

Turbulent Times in Mathematics: The Life of J. C. Fields and the History of the Fields Medal, by Elaine McKinnon Riehm and Frances Hoffman. AMS, November 2011. ISBN-13: 978-08218-691-47.

Uneducated Guesses: Using Evidence to Uncover Misguided Education Policies, by Howard Wainer. Princeton University Press, August 2011. ISBN-13: 978-06911-492-88. (Reviewed June/July 2012.)

The Universe in Zero Words: The Story of Mathematics as Told through Equations, by Dana Mackenzie. Princeton University Press, April 2012. ISBN-13: 978-06911-528-20. (Reviewed in this issue.)

Vilim Feller, istaknuti hrvatsko-americki matematicar/William Feller, Distinguished Croatian-American Mathematician, by Darko Zubrinic. Bilingual Croatian-English edition, Graphis, 2011. ISBN-13: 978-953-279-016-0.

A Wealth of Numbers: An Anthology of 500 Years of Popular Mathematics Writing, edited by Benjamin Wardhaugh. Princeton University Press, April 2012. ISBN-13: 978-06911-477-58. (Reviewed March 2013.)

Who's #1?: The Science of Rating and Ranking, by Amy N. Langville and Carl D. Meyer. Princeton University Press, February 2012. ISBN-13: 978-06911-542-20. (Reviewed January 2013.)

Why Beliefs Matter: Reflections on the Nature of Science, by E. Brian Davies. Oxford University Press, June 2010. ISBN-13: 978-01995-862-02. (Reviewed April 2012.)

Why Cats Land on Their Feet (and 76 Other Physical Paradoxes and Puzzles), by Mark Levi. Princeton University Press, May 2012. ISBN-13: 978-0691148540.

Mathematics Calendar

Please submit conference information for the Mathematics Calendar through the Mathematics Calendar submission form at http://www.ams.org/cgi-bin/mathcal-submit.pl. The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at http://www.ams.org/mathcal/.

March 2013

* 1–3 **History and Pedagogy of Mathematics (HPM) Americas Section 2013 East Coast Meeting**, United States Military Academy, West Point, New York.
Description: Special features of this meeting include a visit to the Academy's rare book collections. This is the only call for papers to be presented at the meeting. HPM seeks a variety of talks on relations between the history and pedagogy of mathematics. Talks will be about 30 minutes long. Prospective speakers should send a title and abstract, as well as their own contact information, to Fred Rickey at fred.rickey@me.com by February 15, 2013. Contact Amy Ackerberg-Hastings, aackerbe@verizon.net, for information on registration.
Information: http://www.hpm-americas.org.

1–3 **2013 Spring Southeastern Section Meeting**, University of Mississippi, Oxford, Mississippi. (Sept. 2012, p. 1170)

2–3 **36th Annual Texas Partial Differential Equations Conference**, The University of Texas at El Paso, El Paso, Texas. (Dec. 2012, p. 1591)

4–6 **The First International Conference on Green Computing, Technology and Innovation (ICGCTI2013)**, The Asia Pacific University of Technology and Innovation (APU), Kuala Lumpur, Malaysia. (Dec. 2012, p. 1591)

4–6 **The Second International Conference on e-Technologies and Networks for Development (ICeND 2013)**, The Asia Pacific University of Technology and Innovation (APU), Kuala Lumpur, Malaysia. (Dec. 2012, p. 1591)

4–8 **Forty-Fourth Southeastern International Conference on Combinatorics, Graph Theory and Computing**, Florida Atlantic University, Boca Raton, Florida. (Oct. 2012, p. 1302)

4–8 **ICERM Workshop: Whittaker Functions, Schubert Calculus and Crystals**, ICERM, Providence, Rhode Island. (Sept. 2012, p. 1170)

* 9–10 **3rd Ohio River Analysis Meeting (ORAM-III)**, University of Cincinnati, Cincinnati, Ohio.
Description: This is the third edition of an annual meeting hosted in alternation by the University of Cincinnati and the University of Kentucky. The program traditionally covers a broad spectrum of topics in analysis and partial differential equations.
Featured speakers: Rodrigo Banuelos (Purdue), Tanya Christiansen (Missouri), Robert Hardt (Rice), Steve Hofmann (Missouri), Alexei Poltoratski (Texas A&M). In addition to the featured speakers there will be contributed half-hour talks.
Funding: From the National Science Foundation is available for junior participants.
Information: http://math.uc.edu/ORAM/index.html.

* 11–June 14 (NEW DATE) **Dynamics of Groups and Rational Maps**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.
An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.
In general, announcements of meetings and conferences carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. If there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to notices@ams.org or mathcal@ams.org.
In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.
The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June/July, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.
The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: http://www.ams.org/.

Description: In recent years, dynamical properties of group actions have seen many applications to areas as diverse as rational maps, geometry, low dimensional and geometric topology, number theory. Such applications have motivated a rapid development of new tools within the area of dynamical systems, which in turn were used as essential ingredients in solutions to long-standing open conjectures in seemingly unrelated areas of mathematics. The most recent such application is the solution of the virtual fibred conjecture for closed hyperbolic 3-manifolds. The goal of the workshop is to bring together leading contributors to these recent developments in the theory of dynamical systems as well as young researchers who are interested in exploring the interplay between different fields from the viewpoint of dynamical systems.
Information: `http://www.ipam.ucla.edu/programs/iagws2/`.

11–14 **Interactions between Analysis and Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2011, p. 1325)

12–15 **Interactions Between Analysis and Geometry Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2013, p. 113)

13–15 **IAENG International Conference on Operations Research 2013 (ICOR'13)**, Royal Garden Hotel, Hong Kong, China. (Sept. 2012, p. 1170)

15–16 **29th Southeastern Analysis Meeting (SEAM 2013)**, Virginia Tech, Blacksburg, Virginia. (Dec. 2012, p. 1591)

18–22 **Analysis on Metric Spaces**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2013, p. 113)

18–22 **84th Annual Meeting of GAMM (The International Association of Applied Mathematics and Mechanics)**, University of Novi Sad, Novi Sad, Serbia. (Sept. 2012, p. 1170)

* 18–22 **Hot Topics: Surface subgroups and cube complexes**, Mathematical Sciences Research Institute (MSRI), Berkeley, California.
Description: Recently there has been substantial progress in our understanding of the related questions of which hyperbolic groups are cubulated on the one hand, and which contain a surface subgroup on the other. The most spectacular combination of these two ideas has been in 3-manifold topology, which has seen the resolution of many long-standing conjectures. In turn, the resolution of these conjectures has led to a new point of view in geometric group theory, and the introduction of powerful new tools and structures. The goal of this conference will be to explore the further potential of these new tools and perspectives, and to encourage communication between researchers working in various related fields.
Organizers: Ian Agol (University of California, Berkeley), Danny Calegari (University of Chicago), Ursula Hamenstdt (University Bonn), Vlad Markovic (California Institute of Technology).
Information: `https://www.msri.org/web/msri/scientific/show/-/event/Wm9922`

18–22 **Masterclass: Soergel bimodules and Kazhdan-Lusztig conjectures by Williamson and Elias**, QGM, Aarhus University, Aarhus, Denmark. (Dec. 2012, p. 1591)

* 18–28 **MECC 2013—International Conference and Advanced School Planet Earth, Mathematics of Energy and Climate Change**, Calouste Gulbenkian Foundation (FCL) and Faculdade de Ciências, Universidade Lisboa (FCUL), Lisbon, Portugal.
Description: The first two volumes of the CIM Series in Mathematical Sciences published by Springer-Verlag will consist of selected works presented in the conferences Mathematics of Planet Earth (CIM-MPE). The editors of these first two volumes are Jean-Pierre Bourguignon, Rolf Jeltsch, Alberto Pinto, and Marcelo Viana.
Keynote speakers and school lecturers: Inês Azevedo, Carnegie Mellon University, USA; Richard James, University of Minnesota, USA; Christopher K. R. T. Jones, University of North Carolina, USA; Pedro Miranda, Universidade de Lisboa, Portugal; Keith Promislow, Michigan State University, USA; Richard L. Smith, University of North Carolina, USA; José Xavier, Universidade de Coimbra, Portugal; David Zilberman, University of California, Berkeley, USA.
Information: `http://sqig.math.ist.utl.pt/cim/mpe2013/MECC`.

20–22 **17th International Conference on Discrete Geometry for Computer Imagery (DGCI 2013)**, Escuela Tecnica Superior de Ingenieria Informatica, Univ. de Sevilla, Seville, Spain. (Sept. 2012, p. 1170)

25–27 **7th IMA Conference on Quantitative Modelling in the Management of Health and Social Care**, Central London College, London, United Kingdom. (Sept. 2012, p. 1170)

25–29 **4th International conference "Function spaces. Differential operators. General topology. Problems of mathematical education"**, Peoples' Friendship University of Russia (PFUR), Moscow, Russia. (Jan. 2013, p. 113)

25–29 **AIM Workshop: Mathematical problems arising from biochemical reaction networks**, American Institute of Mathematics, Palo Alto, California. (Sept. 2012, p. 1170)

25–29 **Master class on geometry and Teichmüller theory**, Erwin Schrödinger Institute, Vienna, Austria. (Jan. 2013, p. 113)

25–29 **Teichmüller theory: A quantization and relations with physics**, Erwin Schrödinger Institute, Vienna, Austria. (Feb. 2013, p. 261)

29 **Columbia-Princeton Probability Day 2013**, Princeton University, Princeton, New Jersey. (Feb. 2013, p. 261)

April 2013

1–5 **AIM Workshop: Gromov-Witten invariants and number theory**, American Institute of Mathematics, Palo Alto, California. (Jan. 2013, p. 113)

1–26 **Modular Representation Theory of Finite and p-adic Groups**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jan. 2013, p. 113)

3–6 **Recreational Mathematics Colloquium III**, University of Azores, Ponta Delgada, Portugal. (Jan. 2013, p. 113)

4–6 **38th Arkansas Spring Lecture Series in the Mathematical Sciences: "Extension and Interpolation of Functions"**, University of Arkansas, Fayetteville, Arkansas. (Nov. 2012, p. 1480)

5–6 **3rd International Conference on E-Learning and Knowledge management Technology (ICEKMT 2013)**, Hotel Ramada, Bangkok, Thailand. (Dec. 2012, p. 1592)

* 6–7 **11th Annual Graduate Student Topology and Geometry Conference**, University of Notre Dame, Notre Dame, Indiana.
Description: This conference provides a space for graduate students to present their work in topology and geometry to each other.
Talks: Talks by graduate students will make up the majority of the conference—students are invited to submit proposals for talks by February 10, 2013. Previous versions of this conference have been large, diverse and fun, and we expect 2013 to be no different. We will also have presentations by David Ayala (Harvard), Clark Barwick (MIT), Alessio Figalli (UT Austin), Dan Freed (UT Austin), Fernando Galaz-García (Münster), Ana Rita Pires (Cornell), Gábor Székelyhidi (Notre Dame) and Burkhard Wilking (Múnster).
Support: We expect to be able to provide some funding to students without alternative resources, thanks to an award from the National Science Foundation.

Information: Apply for funding or submit a talk proposal by February 10, 2013, at our website: `http://www.nd.edu/~conf/gstgc13`.

6–7 **2013 Spring Eastern Sectional Meeting**, Boston College, Chestnut Hill, Massachusetts. (Sept. 2012, p. 1170)

8–9 **IMA Mathematics in Finance**, Edinburgh Conference Centre, Heriot-Watt University, Edinburgh, United Kingdom (Sept. 2012, p. 1170)

8–10 **Fourteenth International Conference on Numerical Combustion (NC13)**, Holiday Inn Riverwalk, San Antonio, Texas. (Sept. 2012, p. 1170)

8–12 **AIM Workshop: Geometric perspectives in mathematical quantum field theory**, American Institute of Mathematics, Palo Alto, California. (Sept. 2012, p. 1171)

8–12 **Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2011, p. 1014)

8–13 **International School and Research Workshop on Complex Systems**, Centre de Recerca Matemática, Bellaterra, Barcelona. (Feb. 2013, p. 261)

12–14 **Graduate Research Conference in Algebra and Representation Theory**, Kansas State University, Manhattan, Kansas. (Feb. 2013, p. 261)

13–14 **2013 Spring Western Section Meeting**, University of Colorado Boulder, Boulder, Colorado. (Sept. 2012, p. 1171)

13–14 **3rd IIMA International Conference on Advanced Data Analysis, Business Analytics and Intelligence**, Indian Institute of Management, Ahmedabad, India. (Apr. 2012, p. 593)

15–17 **Geomathematics 2013**, Hotel Haus am Weinberg, Sankt Martin, Palatinate, Germany. (Nov. 2012, p. 1480)

15–19 **ICERM Workshop: Combinatorics, Multiple Dirichlet Series and Analytic Number Theory**, ICERM, Providence, Rhode Island. (Sept. 2012, p. 1171)

* 17–20 **Fifth Discrete Geometry and Algebraic Combinatorics Conference**, South Padre Island, Texas.
Description: The event is partially supported by the National Security Agency. This conference is a unique opportunity for Geometry and Combinatorics researchers to meet, share their specialized knowledge and learn from others.
Information: `http://blue.utb.edu/dg2013/`.

19–20 (NEW DATE) **New Frontiers in Numerical Analysis and Scientific Computing**, Kent State University, Kent, Ohio. (Nov. 2012, p. 1172. Formerly listed under April 12–13.)

19–21 **Underrepresented Students in Topology and Algebra Research Symposium**, Purdue University, West Lafayette, Indiana. (Jan. 2013, p. 113)

20 **2013 Great Lakes SIAM conference on "Computational Mathematics: Modeling, Algorithms and Applications"**, Central Michigan University, Mount Pleasant, Michigan. (Dec. 2012, p. 1592)

20–21 **Great Lakes Geometry Conference 2013**, Northwestern University, Evanston, Illinois. (Feb. 2013, p. 261)

22–25 **The Cape Verde International Days on Mathematics 2013 (CVIM'2013)**, University of Cape Verde, Praia, Cape Verde. (Feb. 2013, p. 261)

24–28 **Algebra, Combinatorics and Representation Theory: a conference in honor of the 60th birthday of Andrei Zelevinsky**, Northeastern University, Boston, Massachusetts. (Jan. 2013, p. 113)

26 **Philosophy of Information: The Value of Information**, American University, Washington, DC. (Oct. 2012, p. 1302)

* 26–28 **International Conference on Recent Trends in Applied Sciences with Engineering Applications**, Truba Institute of Engineering & Information Technology, Bhopal (M.P.), India.
Description: RTASEA 2013 is intended to provide a common platform for researchers, scientists, engineers, and practitioners throughout the world to present their latest research findings, ideas, developments, and applications in the field of applied sciences, humanities, management, & engineering.
Important dates: Submission of manuscript up to February 20, 2013. Acceptance of manuscript up to February 28, 2013. Camera ready paper submission with copyright form: March 15, 2013. Manuscript submit to: `rtasea@trubainstitute.ac.in`, `ramakant.bhardwaj@trubainstitute.ac.in`.
Information: `http://rtasea.trubainstitute.ac.in`.

27–28 **2013 Spring Central Section Meeting**, Iowa State University, Ames, Iowa. (Sept. 2012, p. 1171)

29–May 1 **Mathematics of Planet Earth 2013. Establishing the scientific foundation for Quantitative Public Health Decision-Making: Linking surveillance, disease modeling, and simulation at the Fields Institute**, FIELDS, Toronto, Canada. (Sept. 2012, p. 1171)

29–May 3 **Non-Smooth Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2013, p. 114)

29–May 10 **J-holomorphic Curves in Symplectic Geometry, Topology and Dynamics**, Centre de Recherches Mathématiques, Montréal, Canada. (Dec. 2012, p. 1592)

30–May 3 **Third Buea International Conference on the Mathematical Sciences**, University of Buea, Cameroon. (Dec. 2012, p. 1592)

May 2013

3–5 **Atkin Memorial Lecture and Workshop: Cohen-Lenstra Heuristics**, University of Illinois at Chicago, Chicago, Illinois. (Jan. 2013, p. 114)

5–9 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Major and Neglected Diseases in Africa**, Ottawa, Canada. (Sept. 2012, p. 1171)

6–10 **AIM Workshop: Algorithms for lattices and algebraic automorphic forms**, American Institute of Mathematics, Palo Alto, California. (Sept. 2012, p. 1171)

6–10 **The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1171)

7–11 **Analysis, Complex Geometry, and Mathematical Physics: A Conference in Honor of Duong H. Phong**, Columbia University, New York, New York. (Jan. 2013, p. 114)

9–11 **The International Conference on Technological Advances in Electrical, Electronics and Computer Engineering (TAEECE2013)**, Mevlana University, Konya, Turkey. (Feb. 2013, p. 261)

* 10–12 **Southeastern Lie Theory Workshop: Nocommutative Algebraic Geometry and Representation Theory**, Louisiana State University, Baton Rouge, Louisiana.
Description: The workshop will emphasize the interactions between representation theory of Lie algebras and groups and noncommutative algebraic geometry. In addition to invited talks, there will be two sessions of contributed talks.
Support: Modest support from the conference grant and LSU will be available to graduate students, postdocs, junior faculty, women, and members of underrepresented minority groups. Please contact one of the organizers before April 10, 2013, to apply for support. Graduate students are encouraged to share a hotel room with another participant.
Information: `http://www.math.lsu.edu/~brselie/`.

12–17 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program- Impact of climate change on biological invasions and population distributions**, BIRS, Banff, Canada. (Sept. 2012, p. 1172)

13–17 **AIM Workshop: Nonhomogeneous boundary-value problems for nonlinear waves**, American Institute of Mathematics, Palo Alto, California. (Sept. 2012, p. 1172)

19–23 **SIAM Conference on Applications of Dynamical Systems (DS13)**, Snowbird Ski and Summer Resort, Snowbird, Utah. (Oct. 2011, p. 1326)

19–24 **FEMTEC 2013 - 4th International Congress on Computational Engineering and Sciences**, Stratosphere Hotel, Las Vegas, Nevada. (Dec. 2012, p. 1592)

19–25 **15th International Conference on Functional Equations and Inequalities**, Ustron (near the borders with the Czech Republic and Slovakia), Poland. (Sept. 2012, p. 1172)

19–27 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Summer School on Mathematics of Infectious Disease**, York University, Toronto, Canada. (Sept. 2012, p. 1172)

* 20–24 **NSF/CBMS Regional Conference in the Mathematical Sciences: Solitons in Two-Dimensional Water Waves and Applications to Tsunami**, The University of Texas–Pan American, Edinburg, Texas.
Description: Professor Yuji Kodama, Ohio State University, delivers a self-contained and comprehensive exposition on the new developments in the subjects of solitons in two-dimensional water waves and applications to tsunamis. The conference will bring together a diverse group of researchers and students who are interested in nonlinear waves, water waves, solitons, integrable systems and tsunamis.
Invited speakers: Professor Yuji Kodama (Principal Lecturer), Professor Mark J. Ablowitz, Professor Sarbarish Chakravarty, Professor Philippe Guyenne, Professor Taro Kakinuma, Professor Alex Kasman, Professor Tetsu Mizumachi, Professor Harvey Segur, Professor Lauren K. Williams, Professor Harry Yeh.
Information: `http://faculty.utpa.edu/kmaruno/nsfcbms-tsunami.html`.

20–24 **Quasiconformal Geometry and Elliptic PDEs**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2013, p. 114)

21–24 **Questions, Algorithms, and Computations in Abstract Group Theory**, University of Braunschweig, Germany. (Jan. 2013, p. 114)

22–24 **Algebra and Topology: A conference celebrating Lionel Schwartz's 60th birthday**, University of Nantes, France. (Feb. 2013, p. 261)

25–27 **10th Hstam International Congress on Mechanics**, Technical University of Crete, Chania, Crete, Greece. (Sept. 2012, p. 1172)

26–30 **The 19th International Conference on Difference Equations and Applications**, Sultan Qaboos University, Muscat, Oman. (Sept. 2012, p. 1172)

26–June 27 **Topological, Symplectic and Contact Spring in Toulouse**, Université Paul Sabatier, Toulouse, France. (Jan. 2013, p. 114)

27–31 **Control, index, traces and determinants: The journey of a probabilist. A conference related to the work of Jean-Michel Bismut**, Amphithéâtre Lehman Bâtiment 200 Université Paris-Sud F-91405, Orsay, France. (Jan. 2013, p. 114)

27–31 **Introductory week to the Topological, Symplectic and Contact Spring in Toulouse**, Université Paul Sabatier, Toulouse, France. (Jan. 2013, p. 114)

27–31 **Summer School on Topics in Space-Time Modeling and Inference**, Aalborg University, Department of Mathematical Sciences, Aalborg, Denmark. (Nov. 2012, p. 1481)

27–June 7 **Masterclass: (u,v,w knots)x(topology, combinatorics, low and high algebra) by Dror Bar-Natan (University of Toronto)**, QGM, Aarhus Univrsity, Aarhus, Denmark. (Dec. 2012, p. 1593)

* 28–June 1 **Homotopical Methods in Algebraic Geometry**, University of Southern California, Los Angeles, California.
Organizers: Aravind Asok (USC), Eric Friedlander (USC), Christian Haesemeyer (UCLA), Mark Walker (UNL), and Chuck Weibel (Rutgers).
Speakers: Joseph Ayoub, Frederic Deglise, Jean Fasel, Thomas Geisser*, Uwe Jannsen, Bruno Kahn, Marc Levine, Alexander Merkurjev, Dmitri Orlov*, Pablo Pelaez, Shuji Saito, Vasudevan Srinivas, Andrei Suslin*, Goncalo Tabuada, Burt Totaro, Claire Voisin, Kirsten Wickelgren, Inna Zakharevich. * (pending confirmation).
Funding: Graduate students, post-docs, and others are encouraged to apply for funding, provided to us through an NSF grant.
Information: For additional information and to register, please visit `https://sites.google.com/site/hmag2013/`.

30 **"The first International Western Balkan Conference of Mathematical Sciences"**, Elbasan University, Elbasan, Albania. (Feb. 2013, p. 261)

30–June 1 **Dynamical systems and statistical physics (91th Encounter between Mathematicians and Theoretical Physicists)**, Institut de Recherche Mathématique Avancée, Strasbourg, France. (Dec. 2012, p. 1593)

* 30–June 1 **Geometry and Physics 2013 (GAP 2013)**, Centre de Recherches Mathématiques, Montréal, Québec, Canada,
Speakers: Philip Boalch (Ecole Normale Supérieure & CNRS), Sergey Cherkis (University of Arizona), Tamas Hausel (EPF Lausanne), Andrew Neitzke (University of Texas at Austin), Lauren Williams (UC Berkeley).
Organizers: Marco Gualtieri (Toronto), Spiro Karigiannis (Waterloo), Ruxandra Moraru (Waterloo), Johannes Walcher (McGill), McKenzie Wang (McMaster).
Information: `http://www.math.uwaterloo.ca/~gap/`.

* 30–June 2 **International Conference on Topological Algebras and their Applications (shortly ICTAA 2013)**, University of Tartu, Tartu, Estonia.
Description: The forthcoming conference will be the seventh in the series of international conferences on Topological Algebras and their Applications. The previous ones were held at Tartu (1999), Rabat (2000), Oulu (2001), Oaxaca (2002), Athens (2005) and Tartu (2008). The present international conference, dedicated to the 70th birthday of Professor Emeritus Mati Abel, will be organized in Tartu in the end of May by the Institute of Mathematics at the University of Tartu and the Estonian Mathematical Society.
Topics: The topics of the conference are all areas of mathematics, connected with (preferably general) topological algebras and their applications included every kind of topological-algebraic structures as topological linear spaces, rings, modules, groups and semigroups; bornological-algebraic structures as bornological linear spaces, algebras, groups, rings and modules; algebraical and topological K-theory; topological module bundles and others. The objective of the present conference is to bring together experts and young researchers on these fields of mathematics. The programme of the conference will consist of 30-minutes lectures and contributed 20-minutes talks if necessary, then also poster sessions as well as short presentations.
Information: `http://ictaa2013.ut.ee/`.

June 2013

* 2–5 **International Conference on Applied Analysis and Mathematical Modelling (ICAAMM2013)**, Yildiz Technical University, Davut Pasa Campus, Istanbul, Turkey.
Description: The international conference on Applied Analysis and Mathematical Modelling (ICAAMM2013) is jointly organized by Yildiz

Technical University, University Putra Malaysia and Malaysian Mathematical Sciences Soc.
Information: http://www.ica13.yildiz.edu.tr.

2–8 **8th Spring School on Analysis**, Paseky nad Jizerou, Czech Republic. (Jan. 2013, p. 114)

3–7 **GESTA 2013 (Topological, Symplectic and Contact Spring in Toulouse)**, Université Paul Sabatier, Toulouse, France. (Jan. 2013, p. 114)

3–7 **MEGA 2013: Effective Methods in Algebraic Geometry**, Goethe University, Frankfurt am Main, Germany. (Sept. 2012, p. 1172)

3–9 **Summer school on Finsler geometry with applications to low-dimensional geometry and topology**, Department of Mathematics, University of the Aegean, Karlovassi, Island of Samos, Greece. (Dec. 2012, p. 1593)

3–14 **Moduli Spaces and their Invariants in Mathematical Physics**, Centre de Recherches Mathématiques, Montréal, Canada. (Feb. 2013, p. 262)

3–July 12 **Nonlinear expectations, stochastic calculus under Knightian uncertainty, and related topics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Oct. 2012, p. 1303)

3–28 **Focus Program on Noncommutative Geometry and Quantum Groups**, Fields Institute for Research in Mathematical Sciences, Toronto, Ontario, Canada. (Sept. 2012, p. 1172)

4–14 **Conference on Nonlinear Mathematical Physics: Twenty Years of JNMP**, The Sophus Lie Conference Center, Nordfjordeid, Norway. (Sept. 2012, p. 1173)

5–9 **4th Novi Sad Algebraic Conference–NSAC 2013**, Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad, Novi Sad, Serbia. (Sept. 2012, p. 1173)

* 7–12 **XVth International Conference on Geometry, Integrability and Quantization**, Sts. Constantine and Elena Resort, near Varna, Bulgaria.
Description: This conference is next in a row of previous meetings on geometry and mathematical physics which took place in Bulgaria — Zlatograd (1995) and the annual conferences under the same title held in Varna from 1998 to 2012.
Aim: To bring together experts in classical and modern differential geometry, complex analysis, mathematical physics, and related fields to assess recent developments in these areas and to stimulate researches in related topics.
Principal speakers: George Bluman, Some Recent Developments in Finding Systematically Conservation Laws; and Nail H. Ibragimov, Group Analysis as a Microscope of Mathematical Modeling.
Information: http://www.bio21.bas.bg/conference/.

* 8–13 **39th International Conference "Applications of Mathematics in Engineering and Economics" — AMEE'13**, Technical University Leisure House, Sozopol, Bulgaria.
Description: The 39th International Conference AMEE'13 is organized by the Faculty of Applied Mathematics and Informatics at the Technical University of Sofia, Bulgaria. The aim of the conference is to provide an overview of the "hot topics" in Applied Mathematics and to bring together young researchers and senior scientists and at the same time to create a forum for exchange of new scientific ideas. The invited lectures will be presented in general sessions and the contributed talks in separate sessions on the following topics:
Topics: Mathematical analysis and applications, differential equations, differential geometry, numerical methods and mathematical modeling, statistics, probability theory, operations research, economics and financial mathematics, software innovations in scientific computing, E-learning. The conference post-proceedings will be published only after peer reviewing by the American Institute of Physics (AIP).
Information: http://tu-sofia.bg/eng_new/fpmi/amee/.

10–14 **AIM Workshop: Automorphic forms and harmonic analysis on covering groups**, American Institute of Mathematics, Palo Alto, California. (Nov. 2012, p. 1481)

10–14 **ApplMath13, 8th Conference on Applied Mathematics and Scientific Computing**, Sibenik, Croatia. (Sept. 2012, p. 1173)

10–14 **Computational Methods and Function Theory 2013**, Shantou University, Shantou, Guangdong, China. (Sept. 2012, p. 1173)

10–14 **Pde's, Dispersion, Scattering theory and Control theory**, University of Monastir, Monastir, Tunisia. (Dec. 2012, p. 1593)

10–20 **Recent Advances in Hodge Theory: Period Domains, Algebraic Cycles, and Arithmetic**, UBC Campus, Vancouver, B.C., Canada. (Dec. 2012, p. 1593)

11–13 **4th International Conference on Mathematical and Computational Applications**, Celal Bayar University, Applied Mathematics and Computation Center, Manisa, Turkey. (Dec. 2012, p. 1593)

11–14 **6th Chaotic Modeling and Simulation International Conference (CHAOS2013)**, Yeditepe University, Istanbul, Turkey. (Feb. 2013, p. 262)

12–14 **Tenth edition of the Advanced Course in Operator Theory and Complex Analysis**, Sevilla, Spain. (Dec. 2012, p. 1594)

* 16–21 **BIOMATH: International Conference of Mathematical Methods and Models in Biosciences and Young Scientists School**, Bulgarian Academy of Sciences, Sofia, Bulgaria.
Description: This annual event is devoted to recent research in life sciences based on applications of mathematics as well as mathematics applied to or motivated by biological studies. It is a multidisciplinary meeting forum for researchers who develop and apply mathematical and computational tools to the study of phenomena in the broad fields of biology, ecology, medicine, biotechnology, bioengineering, environmental science, etc.
Information: http://www.biomath.bg/2013.

16–23 **51st International Symposium on Functional Equations**, Rzeszów, Poland. (Dec. 2012, p. 1594)

17–21 **AIM Workshop: Exponential random network models**, American Institute of Mathematics, Palo Alto, California. (Sept. 2012, p. 1173)

* 17–21 **Fluid Mechanics and Singular Integrals**, Institute of Mathematics of the University of Seville (IMUS), Seville, Spain.
Description: This is an international conference organized by the Institute of Mathematics of the University of Seville (IMUS). The purpose of this conference is to gather experts in both Fluid Mechanics and Singular Integrals or more generally Harmonic Analysis. These areas of research are very active, there is a lot of interaction among them, and many questions and problems of interest can be found.
Information: http://www.imus.us.es/FMSI13/.

17–21 **Summer school on Donaldson hypersurfaces (in Topological, Symplectic and Contact Spring in Toulouse)**, La Llagonne, France. (Jan. 2013, p. 115)

17–23 **Numerical Computations: Theory and Algorithms (International conference and Summer School NUMTA2013)**, Eurolido Hotel, Falerna (CZ), Tyrrhenian Sea, Italy. (Feb. 2013, p. 262)

17–28 **Algebraic Graph Theory**, University of Wyoming, Laramie, Wyoming. (Jan. 2013, p. 115)

17–28 **Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1481)

17–August 9 **SUMMERICERM: 2013 Undergraduate Summer Research Program Geometry and Dynamics**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 115)

18–20 **The 9th East Asia SIAM (EASIAM) Conference & The 2nd Conference on Industrial and Applied Mathematics (CIAM)**, Bandung Institute of Technology, Bandung, Indonesia. (Feb. 2013, p. 262)

19–21 **Nonlinear Elliptic and Parabolic Partial Differential Equations**, Dipartimento di Matematica, Politecnico di Milano, Italy. (Jan. 2013, p. 115)

19–22 **4th International conference "Nonlinear Dynamics-2013"**, Sevastopol, Ukraine. (Jan. 2013, p. 115)

* 20–21 **DIMACS Workshop on Big Data Integration**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey.

Short Description: The Big Data era is upon us: data is being generated, collected, and analyzed at an unprecedented scale, and data-driven decision making is sweeping through all aspects of technology and society. Since the value of data increases exponentially when it can be linked and fused with other data, addressing the big data integration challenge is critical to realizing the promise of Big Data—and conversely, Big Data techniques are critical to the goals of simplifying data integration. The convergence of Big Data and data integration is emerging in many forms, largely motivated by the goals of integrating structured data on the Web or across communities. Increasingly we are seeing problems where (i) the number of data sources, even for a single domain, has grown to be in the tens of thousands, (ii) many of the data sources are very dynamic, as large volumes of newly collected data are continuously made available, (iii) the data sources are extremely heterogeneous in their structure, with considerable variety even for conceptually similar entities, and (iv) the data sources are of widely differing quality, with significant differences in the coverage, accuracy, and timeliness of data provided.

Organizers: Xin Luna Dong, AT&T Labs-Research, `lunadong@research.att.com`; Zachary Ives, University of Pennsylvania, `zives@cis.upenn.edu`. Presented under the auspices of the DIMACS Special Focus on Information Sharing and Dynamic Data Analysis.

Workshop Coordinator: DIMACS Center, `workshop@dimacs.rutgers.edu`, 732-445-5928.

Information: `http://dimacs.rutgers.edu/Workshops/BigData/`.

21–24 **"Experimental and Theoretical Methods in Algebra, Geometry and Topology". Held in the honor of Alexandru Dimca and Stefan Papadima on the occasion of their 60th birthday**, Mangalia (near Constanta), Romania. (Sept. 2012, p. 1173)

22–29 **Physics and Mathematics of Nonlinear Phenomena 2013**, Hotel Le Sirene, Gallipoli, South of Italy. (Oct. 2012, p. 1303)

24–26 **Numerical Analysis and Scientific Comlputation with Applications (NASCA13)**, University of Littoral Cote d'Opale, Calais, France. (Jan. 2013, p. 115)

24–28 **EACA'S Second International School on Computer Algebra and Applications**, Faculty of Sciences, University of Valladolid, Spain. (Feb. 2013, p. 262)

24–28 **Low-dimensional Topology and Geometry in Toulouse**, Université Paul Sabatier, Institut de Mathématiques de Toulouse, Toulouse, France. (Jan. 2013, p. 115)

24–29 **5th Conference for Promoting the Application of Mathematics in Technical and Natural Sciences (AMiTaNS'13)**, Resort of Albena, Bulgaria. (Feb. 2013, p. 262)

24–July 5 **Seminaire de Mathematiques Superieures 2013: Physics and Mathematics of Link Homology**, Montreal, Canada. (Dec. 2012, p. 1594)

26–29 **International Symposium on Symbolic and Algebraic Computation (ISSAC)**, Northeastern University, Boston, Massachussetts. (Nov. 2012, p. 1481)

27 **5th National Dyscalculia and Maths Learning Difficulties Conference, UK**, Cumberland Hotel, London, England. (Nov. 2012, p. 1481)

28–30 **First International Conference on Smarandache Multispace and Multistructure**, Academy of Mathematics and Systems, Chinese Academy of Sciences, Beijing 100190, People's Republic of China. (Sept. 2012, p. 1173)

30–July 5 **British Combinatorial Conference 2013**, Royal Holloway, University of London, Egham, United Kingdom. (Feb. 2013, p. 262)

30–July 20 **IAS/PCMI Summer 2013: Geometric Analysis**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1481)

July 2013

1–4 **2nd IMA Conference on Dense Granular Flows**, Isaac Newton Institute of Mathematical Sciences, Cambridge, United Kingdom. (Oct. 2012, p. 1303)

1–5 **Erdös Centennial**, Budapest, Hungary. (Sept. 2012, p. 1173)

1–5 **International conference on Sampling Theory and Applications 2013**, Jacobs University, Bremen, Germany. (Sept. 2012, p. 1173)

1–5 **The 6th Pacific RIM Conference on Mathematics 2013**, Sapporo Convention Center, Sapporo City, Japan. (Nov. 2012, p. 1481)

1–5 **7th International Summer School on Geometry, Mechanics and Control (ICMAT School)**, La Cristalera, Miraflores de la Sierra, Madrid, Spain. (Feb. 2013, p. 262)

1–5 **Preconditioning of Iterative Methods—Theory and Applications 2013 (PIM 2013)**, Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic. (Oct. 2012, p. 1303)

* 1–12 **Advanced School and Workshop on Matrix Geometries and Applications**, The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy.

Description: Linear algebra is a fundamental topic in mathematics. It is used in almost all branches of mathematics and is among the most important mathematical disciplines for applications to science and technology.

Information: `http://agenda.ictp.it/smr.php?2470`.

1–12 **New Geometric Techniques in Number Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1481)

2–5 **The 4th International Conference on Matrix Analysis and Applications**, Konya, Turkey. (Nov. 2012, p. 1481)

3–5 **The 2013 International Conference of Applied and Engineering Mathematics**, Imperial College London, London, United Kingdom. (Nov. 2012, p. 1482)

3–6 **International Conference on Anatolian Communications in Nonlinear Analysis (ANCNA 2013)**, Abant Izzet Baysal University, Bolu, Turkey. (Feb. 2013, p. 263)

8–10 **SIAM Conference on Control and Its Applications (CT13)**, Town and Country Resort and Convention Center, San Diego, California. (Sept. 2012, p. 1174)

8–12 **AIM Workshop: Generalizations of chip-firing and the critical group**, American Institute of Mathematics, Palo Alto, California. (Sept. 2012, p. 1174)

8–12 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Climate Change and the Ecology of Vector-borne Diseases**, Fields Institute, CDM, Toronto, Canada. (Sept. 2012, p. 1174)

8–12 **2013 SIAM Annual Meeting (AN13)**, Town and Country Resort & Convention Center, San Diego, California (Jan. 2013, p. 116)

8–12 **Topics in Numerical Analysis for Differential Equations**, Instituto de Ciencias Matemáticas-ICMAT, campus de Cantoblanco, Madrid, Spain. (Jan. 2013, p. 116)

* 8–26 **RTG Summer School on Microlocal Analysis and Inverse Problems**, University of Washington, Seattle.
Description: The Research Training Group in the Department of Mathematics at the University of Washington will host a summer school on solving inverse problems via microlocal analysis, aimed at graduate students and advanced undergraduates who have the required background. Students will attend lectures in the morning and problem sessions in small groups with mentors in the afternoon. On-campus accommodation and meals will be provided, plus a travel allowance of up to $600. The Summer School is supported by an NSF Research Training Grant. Support is restricted to U.S. citizens/permanent residents; international students can be considered but will have to pay all their own expenses. The course will be taught by Mark Anastasio, Guillaume Bal, Francois Monard, Plamen Stefanov, and Gunther Uhlmann. Visit our website for the full course description and prerequisites.
Information: `http://www.math.washington.edu/ipde/summer/index2013.html`.

* 9–13 **Satellite Summer School to the 7th International Conference on Levy Processes: Theory and Applications**, Mathematical Research and Conference Center of the Institute of Mathematics of the Polish Academy of Sciences, Bedlewo, Poland.
Description: The summer school will be devoted to stochastic analysis and its applications. Its goal is to bring together young researchers interested in the theory and applications of stochastic processes.
Lecturers: Víctor Pérez Abreu (CIMAT), Nicolaus Privault (Nanyang Technological University), Jan Rosiński (University of Tennessee), Zoran Vondraček (University of Zagreb).
Topics: The following topics will be discussed: random matrices and free probability, Malliavin calculus for jump processes, analysis and representation of infinitely divisible distributions and processes, subordinators and potential theory.
Information: `http://bcc.impan.pl/13LevySchool/`.

14–19 **The Sixth International Congress of Chinese Mathematicians (ICCM)**, Opening ceremony on July 14 in the Big Hall of the Grand Hotel, Taipei, Taiwan. Lectures and invited talks from July 15–19 on the campus of National Taiwan University, Taipei, Taiwan. (Jan. 2013, p. 116)

15–19 **Finite Dimensional Integrable Systems 2013**, CIRM, Marseille, France. (Dec. 2012, p. 1594)

15–19 **ICERM IdeaLab 2013: Weeklong Program for Postdoctoral Researchers**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 116)

* 15–19 **7th International Conference on Lévy Processes: Theory and Applications**, University of Wroclaw and Wroclaw University of Technology, Wroclaw, Poland.
Description: The previous conferences in the series took place in Dresden (2010), Copenhagen (2007), Manchester (2005), Paris (2003) and Aarhus (2002, 1999). The aim of the conference is to bring together a wide range of researchers, practitioners and graduate students whose work is related to Lévy processes and infinitely divisible distributions. The scope of the conference: Fluctuation theory, Infinite divisibility with respect to nonclassical convolutions, Lévy trees, Numerical methods, Potential theory, Risk theory (including Finance and Insurance), Queues, Stable and self-decomposable processes, Stochastic analysis, Stochastic partial differential equations.
Information: `http://bcc.impan.pl/13Levy/`.

* 15–19 **Women in Shape (WiSh): Modeling Boundaries of Objects in 2- and 3-Dimensions (in cooperation with AWM)**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: This workshop is designed to strengthen the shape modeling community by bringing together women researchers at various stages in their careers (from graduate student to senior researcher) to foster research collaboration and mentorship. We welcome applications from women with active research programs from smaller teaching schools as well as from research-oriented institutions. Participants will spend one week working together in small groups to solve one of four open questions in shape modeling. Instead of the more typical workshop structure where participants watch presentations of established results, WiSh participants will begin generating new results in collaboration with other participants. Small Group Topics: Simultaneous spectral and spatial analysis of shape; Dimensionality reduction and visualization of data in tree-spaces; Geometric shape segmentation; Folding polygons and surface approximation. The application is available online and is due January 30, 2013.
Information: `http://www.ipam.ucla.edu/programs/awm2013/`.

15–19 **Workshop on Interactions between Dynamical Systems and Partial Differential Equations (JISD2013)**, School of Mathematics and Statistics, Universitat Politècnica de Catalunya, Barcelona, Spain. (Feb. 2013, p. 263)

15–20 **Stochasticity in Biology: Is Nature Inherently Random?**, Montreal, Canada. (Dec. 2012, p. 1595)

20–25 **European Meeting of Statisticians**, Eotvos Lorand University, Budapest, Hungary. (Sept. 2012, p. 1174)

21–27 **Applied Topology - Bedlewo 2013**, Bedlewo, near Poznan, Poland. (Feb. 2013, p. 263)

22–25 **MIP2013: Mixed Integer Programming Workshop**, University of Wisconsin-Madison, Madison, Wisconsin. (Sept. 2012, p. 1174)

22–26 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Biodiversity in a Changing World**, CRM, Cambam, Montréal, Canada. (Sept. 2012, p. 1174)

22–26 **Positivity VII**, Leiden University, Leiden, The Netherlands. (Dec. 2012, p. 1595)

29–August 2 **36th Conference on Stochastic Processes and their Applications**, Boulder, Colorado. (Sept. 2012, p. 1174)

29–August 9 **Introduction to the Mathematics of Seismic Imaging**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1482)

31–August 10 **Workshop and Conference on the Topology and Invariants of Smooth 4-Manifolds (First Announcement)**, University of Minnesota, Twin Cities, Minnesota. (Jan. 2013, p. 117)

August 2013

3–11 **Groups St. Andrews 2013**, University of St. Andrews, St. Andrews, Fife, Scotland, UK. (Sept. 2012, p. 1174)

5–9 **1st Mathematical Congress of the Americas**, Guanajuato, Mexico. (Sept. 2012, p. 1174)

* 5–9 **AIM Workshop: Sections of convex bodies**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the study of geometric properties of convex bodies based on information about sections of these bodies.
Information: `http://aimath.org/ARCC/workshops/sectionsconvex.html`.

* 5–9 **Quantum/Affine Schubert Calculus**, University of Oregon, Eugene, Oregon.
Description: The goal of this workshop will be to understand the ring isomorphism (after localization) between the quantum cohomology of the flag variety and the homology ring of the affine Grassmannian. This result was asserted in unpublished notes by Dale Peterson, and later formalized and proven by Thomas Lam and Mark Shimozono. Along the way, we will learn about Schubert calculus, equivariant

cohomology, quantum cohomology, the affine Grassmannian, and the Toda lattice, with an emphasis on concrete examples and computations. The workshop will be led by Allen Knutson.
Information: `http://pages.uoregon.edu/njp/qsc.html`.

5–9 **XXII Rolf Nevanlinna Colloquium**, Helsinki, Finland. (Aug. 2011, p. 1014)

* 11–12 **A quasiconformal life: Celebration of the legacy and work of F. W. Gehring**, University of Helsinki, Helsinki, Finland.
Description: In the memory of the distinguished mathematician Frederick William Gehring the conference "A quasiconformal life: Celebration of the legacy and work of F. W. Gehring" will be organized at the University of Helsinki, August 11–12, 2013.The Conference will take place at the downtown campus of the University of Helsinki on Sunday and Monday, August 11–12, after the XXIIth Rolf Nevanlinna Colloquium, which will be held at the same place August 5–9, 2013.
Lecturers: The following have already promised to give a lecture at the conference: Alan Beardon, Mario Bonk, Peter Jones, Pekka Koskela, Gaven Martin, Brad Osgood, Bruce Palka, Kai Rajala, Nageswari Shanmugalingam, Jussi Visl, and Jang-Mei Wu.
Registration: The registration and accommodation web pages will be available at the beginning of February 2013. There is no conference fee.
Information: `https://wiki.helsinki.fi/display/Gehring/Home|`.

11–17 **3rd Mile High Conference on Nonassociative Mathematics**, University of Denver, Denver, Colorado. (Dec. 2012, p. 1595)

12–15 **International Conference on Algebra in Honour of Patrick Smith and John Clark's 70th Birthdays**, Balikesir, Turkey. (Nov. 2012, p. 1482)

* 12–15 **12th International Workshop on Dynamical Systems and Applications**, Atilim University, Ankara, Turkey.
Description: The workshop is in honour of the 70th birthday of Professor A. Okay Celebi.
Theme: The main theme will be "Partial Differential Equations and Applications". Talks will not be restricted to this subject only. These workshops constitute the annual meetings of the series of dynamical systems seminars traditionally organized at Middle East Technical University throughout each academic year. The workshop is held every year to make it an ideal platform for people to share views and experiences in Dynamical Systems and Applications.
Information: `http://iwdsa2013.atilim.edu.tr/`.

12–16 **AIM Workshop: Computable stability theory**, American Institute of Mathematics, Palo Alto, California. (Dec. 2012, p. 1595)

12–16 **Branching Diffusions and Random Trees**, Montreal, Canada. (Dec. 2012, p. 1595)

12–16 **2nd Strathmore International Mathematics Conference (SIMC-2013)**, Strathmore University, Nairobi, Kenya. (Feb. 2013, p. 263)

19–September 13 **Infectious Disease Dynamics**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2012, p. 1595)

19–December 20 **Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1174)

19–December 20 **Optimal Transport: Geometry and Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)

22–23 **Connections for Women on Optimal Transport: Geometry and Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)

* 24–31 **Second International Conference "Mathematics in Armenia: Advances and Perspectives" dedicated to the 70th anniversary of thefoundation of Armenian National Academy of Sciences**, YSU Guesthouse, Tsaghkadzor, Armenia.
Description: The main objective of the conference is to bring together Armenian mathematicians and friends of Armenian mathematics from all over the world to share and discuss high-quality research results, to exchange new ideas and to explore new frontiers for collaboration.
Focus: Will be real and complex analysis, differential and integral equations, probability and statistics, algebra and geometry. The program of the conference will consist of invited 40-minute plenary lectures and contributed 15-20-minute talks. Selected contributed papers will be published in the special issues of *Journal of Contemporary Mathematical Analysis of Armenian Academy of Sciences* (distributed by Springer).
Deadline: For registration and abstract submission is June 30, 2013.
Information: `http://mathconf.sci.am`.

25–27 **The 7th Global Conference on Power Control and Optimization (PCO'2013)**, Prague, Czech Republic. (Feb. 2013, p. 263)

26–29 **2nd International Eurasian Conference on Mathematical Sciences and Applications**, Sarajevo, Bosnia and Herzegovina. (Feb. 2013, p. 263)

26–30 **Geometric Function Theory and Applications 2013**, Isik University, Campus of Sile, Istanbul, Turkey. (Jan. 2013, p. 116)

26–30 **International Conference AMMCS-2013 (Applied Mathematics, Modeling and Computational Science)**, Waterloo, Ontario, Canada. (Sept. 2012, p. 1175)

26–30 **Introductory Workshop on Optimal Transport: Geometry and Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)

* 26–September 7 **DGS 2013 — International Conference and Advanced School Planet Earth, Dynamics, Games and Science**, Calouste Gulbenkian Foundation (FCL) and Escola Superior de Economia e Gestão, Universidade Técnica de Lisboa (ISEG-UTL), Lisbon, Portugal.
Description: The first two volumes of the CIM Series in Mathematical Sciences published by Springer-Verlag will consist of selected works presented in the conferences Mathematics of Planet Earth (CIM-MPE). The editors of these first two volumes are Jean-Pierre Bourguignon, Rolf Jeltsch, Alberto Pinto, and Marcelo Viana.
Keynote speakers and school lecturers: Michel Benaim, Université de Neuchâtel, Switzerland; Jim Cushing, University of Arizona, USA; João Lopes Dias, Universidade Técnica de Lisboa, Portugal; Pedro Duarte, Universidade de Lisboa, Portugal; Diogo Gomes, Universidade Técnica de Lisboa, Portugal; Yunping Jiang, City University of New York, USA; Eric Maskin, Institute for Advanced Studies, USA (schedule permitting); Jorge Pacheco, Universidade do Minho, Portugal; David Rand, University of Warwick, UK; Martin Shubik, Yale University, USA (video lecture); Satoru Takahashi, Princeton University, USA; Marcelo Viana, Instituto de Matemática Pura e Aplicada IMPA, Brazil.
Information: `http://sqig.math.ist.utl.pt/cim/mpe2013/DGS`.

* 27–31 **The 9th William Rowan Hamilton Geometry and Topology Workshop, on Geometry and Groups after Thurston**, Hamilton Mathematics Institute, Trinity College, Dublin, Ireland.
Description: First announcement: The workshop will consist of a two day mini-course August 27–28, followed by a three day lecture series, August 29–31, 2013.
Topic: This year's topic for the workshop is Geometry and Groups after Thurston. This past year has seen the passing of William P. Thurston (1946–2012) whose work and conjectural program influenced much of the research in the fields of low-dimensional geometry and topology and geometric group theory. Also recent progress has seen most of Thurston's conjectural program now solved. This year's workshop aims to consider new directions of research and

new problems which will direct future research in the spirit of Thurston's original program.
Information: `http://www.hamilton.tcd.ie/events/gt/gt2013.htm`.

27–December 20 **Mathematical Challenges in Quantum Information**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2012, p. 1596)

28–September 2 **Gelfand Centennial Conference: A View of 21st Century Mathematics**, Massachusetts Institute of Technology, Cambridge, Massachusetts. (Jan. 2013, p. 116)

September 2013

* 1–5 **Motivic Galois Groups**, Alfréd Rényi Institute of Mathematics, Budapest, Hungary.
Description: Mini-courses by: Yves André (Institut de Mathématiques de Jussieu, Paris), Joseph Ayoub (Universität Zürich), Marc Levine (Universität Duisburg–Essen).
Invited Lecturers: Michael Dettweiler (Universität Bayreuth), Hélène Esnault (Freie Universität Berlin), Jochen Heinloth (Universität Duisburg–Essen), Annette Huber-Klawitter (Albert-Ludwigs-Universität Freiburg), Peter Jossen (Université de Paris-Sud, Orsay), Bruno Kahn (Institut de Mathématiques de Jussieu, Paris).
Organizers: Stefan Müller-Stach (Universität Mainz), Tamás Szamuely (Rényi Institute, Budapest).
Information: `http://renyi.mta.hu/~szamuely/mgg.html`.

1–6 **Kangro-100, Methods of Analysis and Algebra, International Conference dedicated to the Centennial of Professor Gunnar Kangro**, University of Tartu, Tartu, Estonia. (Feb. 2013, p. 264)

1–August 31, 2014 **Call for Research Programmes 2013-2014**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Sept. 2012, p. 1175)

1–December 20 **Research Program on Automorphisms of Free Groups: Algorithms, Geometry and Dynamics**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Dec. 2012, p. 1596)

* 2–5 **XXII International Fall Workshop on Geometry and Physics**, University of Évora, Évora, Portugal.
Description: The Fall Workshops on Geometry and Physics have been held yearly since 1992, and bring together Spanish and Portuguese geometers and physicists, along with an ever increasing number of participants from outside the Iberian peninsula. The meetings aim to provide a forum for the exchange of ideas between researchers of different fields in Differential Geometry, Applied Mathematics and Physics, and always include a substantial number of enthusiastic young researchers amongst the participants.
Information: `http://www.ifwgp2013.uevora.pt/`.

3–4 **Connections for Women: Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)

3–6 **CAI 2013: 5th Conference on Algebraic Informatics**, ERISCS and IML, Aix-Marseille University, IGESA, Porquerolles Island, France. (Dec. 2012, p. 1596)

8–14 **Combinatorial Methods in Topology and Algebra**, Il Palazzone, Cortona, Italy. (Feb. 2013, p. 264)

* 9–13 **European Conference on Combinatorics, Graph Theory and Applications—Eurocomb 2013**, National Research Council of Italy (CNR), Pisa, Italy.
Description: In the tradition of EuroComb'01 (Barcelona), Eurocomb'03 (Prague), EuroComb'05 (Berlin), Eurocomb'07 (Seville), Eurocomb'09 (Bordeaux), and Eurocomb'11 (Budapest), this conference will cover the full range of combinatorics and graph theory including applications in other areas of mathematics, computer science and engineering.
Topics: Include, but are not limited to: Algebraic combinatorics, combinatorial geometry, combinatorial number theory, combinatorial optimization, designs and configurations, enumerative combinatorics, extremal combinatorics, graph theory, ordered sets, random methods, topological combinatorics.
Information: `http://www.eurocomb2013.it/`.

9–13 **Introductory Workshop: Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)

9–December 6 **ICERM Semester Program on "Low-Dimensional Topology, Geometry, and Dynamics"**, Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, Rhode Island. (Sept. 2012, p. 1176)

11–13 **14th IMA Conference on Mathematics of Surfaces**, University of Birmingham, United Kingdom. (Sept. 2012, p. 1176)

15–20 **ICERM Workshop: Exotic Geometric Structures**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 116)

16–20 **Mathematics for an Evolving Biodiversity**, Montreal, Canada. (Dec. 2012, p. 1596)

16–20 **MatTriad'2013 - Conference on Matrix Aanalysis and its Applications**, Herceg-Novi, Montenegro. (Dec. 2012, p. 1596)

16–October 11 **Mathematics and Physics of the Holographic Principle**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2012, p. 1596)

23–27 **Mathematics of Sequence Evolution: Biological Models and Applications**, Montreal, Canada. (Dec. 2012, p. 1596)

28–29 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Mathematical Modeling of Indigenous Population Health**, BIRS, Banff, Canada. (Sept. 2012, p. 1176)

October 2013

5–6 **2013 Fall Southeastern Section Meeting**, University of Louisville, Louisville, Kentucky. (Sept. 2012, p. 1176)

7–11 **Coalescent Theory: New Developments and Applications**, Montreal, Canada. (Dec. 2012, p. 1596)

* 10–12 **International Conference on Statistical Distributions and Applications**, Mt. Pleasant, Michigan.
Description: This international conference is being organized to provide a platform for researchers and practitioners to share and discuss recent advancements on distribution theory and applications, and to provide opportunities for collaborative work. The scope includes, but is not limited to (1) new methodology for generating discrete and continuous (univariate and multivariate) distributions, (2) properties, estimation techniques, and goodness of fit tests on generalized distributions from both frequentist and Bayesian perspectives, (3) Bayesian priors using generalized distributions, (4) statistical modeling using generalized distributions, and (5) applications of generalized distributions in disciplines including biosciences, medical sciences, finance, insurance, and engineering.
Information: `http://people.cst.cmich.edu/lee1c/icosda/`.

12–13 **2013 Eastern Sectional Meeting**, Temple University, Philadelphia, Pennsylvania. (Sept. 2012, p. 1176)

14–18 **Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1176)

15–19 **VII Moscow International Conference on Operations Research (ORM2013)**, Dorodnicyn Computing Center of RAS (CC of RAS) and Lomonosov Moscow State University (MSU), Moscow, Russian Federation. (Jan. 2013, p. 117)

18–20 **2013 Fall Central Section Meeting**, Washington University, St. Louis, Missouri. (Sept. 2012, p. 1176)

21–25 **ICERM Workshop: Topology, Geometry and Group Theory, Informed by Experiment**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 117)

21–25 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Sustainability of Aquatic Ecosystem Networks**, AARMS, Fredericton, New Brunswick, Canada. (Sept. 2012, p. 1176)

21–December 20 **Mathematics for the Fluid Earth**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2012, p. 1597)

* 23–25 **International Conference in Modeling Health Advances ICMHA 2013**, Berkeley, California.
Description: Modeling is important because it gives important insight into the method of treatment. The conference ICMHA'13 is held under the World Congress on Engineering and Computer Science, WCECS 2013.
Organizer: The WCECS 2013 is organized by the International Association of Engineers (IAENG), a non-profit international association for the engineers and the computer scientists.
Information: `http://www.iaeng.org/WCECS2013`.

28–November 9 **Lévy Processes and Self-similarity 2013**, Tunis, Tunisia. (Feb. 2013, p. 264)

November 2013

2–3 **2013 Western Fall Section Meeting**, University of California Riverside, Riverside, California. (Sept. 2012, p. 1176)

4–8 **Biodiversity and Environment: Viability and Dynamic Games Perspectives**, Montreal, Canada. (Dec. 2012, p. 1597)

09–16 (NEW DATE) **International Conference on Fractals and Wavelets**, Rajagiri School of Engineering & Technology Kakkanad Cochin, Kerala, India. (Feb. 2013, p. 264)

10–15 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Current Challenges for Mathematical Modelling of Cyclic Populations**, BIRS, Banff, Canada. (Sept. 2012, p. 1176)

12–14 **The Second International Conference on Informatics Engineering & Information Science (ICIEIS2013)**, University Technology Malaysia (UTM), Kuala Lumpur, Malaysia. (Dec. 2012, p. 1597)

18–22 **Evolution Problems in General Relativity**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1176)

18–22 **ICERM Workshop: Geometric Structures in Low-Dimensional Dynamics**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 117)

19–21 **Gulf International Conference on Applied Mathematics (GICAM13)**, Mubarak Al-Abdullah Al-Jaber Area, Kuwait. (Feb. 2013, p. 264)

26–28 **International Conference on Pure and Applied Mathematics, ICPAM-LAE 2013**, Png University of Technology, Lae, Morobe Province, Papua New Guinea. (Sept. 2012, p. 1176)

December 2013

* 7–11 **"ATCM+TIME 2013": A joint session of 18th Asian Technology Conference in Mathematics and 6th Technology & Innovations in Mathematics Education**, Department of Mathematics, Indian Institute of Technology, Powai, Mumbai 400076, India.
Description: The ATCM conferences are international conferences addressing technology-based issues in all mathematical sciences. The 17th ATCM December 16–20, 2012, was held at SSR University, Bangkok, Thailand. About 400 participants coming from over 30 countries around the world participated in the conference. The TIME conferences are national (Indian) conferences held every two years. TIME conferences serve a dual role: as a forum in which mathematics educators and teachers will come together to discuss and to probe major issues associated with the integration of technology in mathematics teaching and learning, and as a place where they can share their perspectives, personal experiences, and innovative teaching practices.
Information: `http://atcm.mathandtech.org` and `http://www.math.iitb.ac.in/TIME2013`.

* 16–20 **Fundamental Groups in Arithmetic and Algebraic Geometry**, Centro di Ricerca Matematica Ennio De Giorgi, Pisa, Italy.
Description: The study of fundamental groups of algebraic varieties has been an important theme in algebraic geometry for a long time. With the introduction of purely algebraic-geometric variants, due to Grothendieck, Deligne, Nori, and others, it has become crucial in arithmetic geometry, revealing deep connections with Galois theory and algebraic number theory.
Purpose: Of this conference is to present a wide range of recent relevant advances, in complex geometry, algebraic geometry in positive characteristic and in arithmetic geometry. We aim at gathering experts in different aspects of this vast subject, thus painting a multifaceted yet unified picture of it.
Information: `http://www.crm.sns.it/event/281/`.

28–30 **3rd International Conference on Mathematics & Information Science (ICMIS 2013)**, Luxor, Egypt. (Oct. 2012, p. 1303)

January 2014

5–7 **ACM-SIAM Symposium on Discrete Algorithms (SODA14), being held with Analytic Algorithmics and Combinatorics (ANALCO14) and Algorithm Engineering and Experiments (ALENEX14)**, Hilton Portland & Executive Tower, Portland, Oregon. (Dec. 2012, p. 1597)

6–July 4 **Free Boundary Problems and Related Topics**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

20–May 23 **Algebraic Topology Program**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1482)

20–May 23 **Model Theory and Number Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)

23–24 **Connections for Women: Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)

27–31 **Introductory Workshop: Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)

February 2014

3–7 **Introductory Workshop: Model Theory, Arithmetic Geometry and Number Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1482)

3–May 9 **ICERM Semester Program on "Network Science and Graph Algorithms"**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 117)

10–11 **Connections for Women: Model Theory and its interactions with number theory and arithmetic geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

March 2014

* 24–April 17 **Mathematical, Statistical and Computational Aspects of the New Science of Metagenomics**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.
Description: Metagenomics is the study of the total genomic content of microbial communities. DNA material is sampled collectively from the microorganisms that populate the environment of

interest. The extracted DNA sequences are then used to profile the environment and its biodiversity, its dominant microbial classes or biological functions, and whether and how this profile differs from those of other environments. This research programme will bring together leading expertise in the multiple disciplines involved, including mathematics, computer science, probability and statistics, biomedical research and biology. The brief of the programme will be to explore the major current analytical and computational open problems in metagenomics, and to identify opportunities for application and development of theory and methods, with an emphasis on synergy between disciplines. Several workshops will take place during the programme. For full details please see: `http://www.newton.ac.uk/events.html`.

Information: `http://www.newton.ac.uk/programmes/MTG/index.html`.

April 2014

* 22–May 16 **Advanced Monte Carlo Methods for Complex Inference Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: In recent years there has been an explosion of complex data-sets in areas as diverse as Bioinformatics, Ecology, Epidemiology, Finance and Population genetics. In a wide variety of these applications, the stochastic models devised to realistically represent the data-generating processes are very high-dimensional and the only computationally feasible and accurate way to perform statistical inference is with Monte Carlo. The focus of this programme is on recent innovations in the field of Monte Carlo methods for inference in complex and intractable statistical problems. It will take up the following research threads: Approximate Bayesian Computation; SMC and Markov Chain Monte Carlo and their integration; and recent theoretical advancements underpinning these areas. Several workshops will take place during the programme. For full details please see `http://www.newton.ac.uk/events.html`.

Information: `http://www.newton.ac.uk/programmes/MCM/index.html`.

June 2014

* 9–July 4 **Interactions between Dynamics of Group Actions and Number Theory**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: In the last decade there have been several important breakthroughs in number theory and diophantine geometry, where progress on long-standing open problems has been achieved by utilising ideas originated in the theory of dynamical systems on homogeneous spaces. Dynamical systems techniques are applicable to a wide range of number-theoretic objects that have many symmetries.

Aim: Of this programme is to bring together researchers working in number theory and homogeneous dynamics to discuss the recent developments and open problems that lie at the crossroads of these fields and to encourage more interaction among people working in these diverse areas. Several workshops will take place during the programme. For full details please see: `http://www.newton.ac.uk/events.html`.

Information: `http://www.newton.ac.uk/programmes/GAN/index.html`.

January 2015

* 5–June 26 **Periodic and Ergodic Spectral Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: The main objective of the programme is to bring together specialists in three major themes: periodic, almost-periodic, and random operators, to discuss recent developments and deep connections between the methods intrinsic for each of these research areas. Operators on manifolds or graphs and more general ergodic operators will also be considered, as well as problems that lie at the interface of the main topics (e.g., "sheared" periodic operators), and applications in other areas of mathematics (e.g., geometry). At the beginning of the programme, there will be a two-week long instructional conference with six mini-courses of about ten lectures each, which will be designed for students and non-specialists. Further there will be three workshops evenly spread over the period of the programme to cover more advanced results, each centred on one of the main themes. Several workshops will take place during the programme. For full details please see `http://www.newton.ac.uk/events.html`.

Information: `http://www.newton.ac.uk/programmes/PEP/`.

* 12–July 3 **Random Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: A new frontier has emerged at the interface between probability, geometry, and analysis, with a central target to produce a coherent theory of the geometry of random structures. The principal question is the following: within a given structure, what is the interplay between randomness and geometry? More precisely, does the geometry appear to be random at every scale (i.e., fractal), or do fluctuations "average out" at sufficiently large scales? Can the global geometry be described by taking a suitable scaling limit that allows for concrete computations? The goal of the programme is to gather experts from probability, geometry, analysis, and other connected areas, in order to study aspects of this question in some paradigmatic situations. Several workshops will take place during the programme. For full details please see `http://www.newton.ac.uk/events.html`.

Information: `http://www.newton.ac.uk/programmes/RGM/index.html`.

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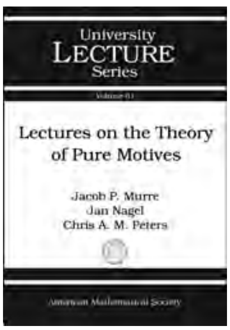
Algebra and Algebraic Geometry



Lectures on the Theory of Pure Motives

Jacob P. Murre, *Universiteit Leiden, The Netherlands*, **Jan Nagel**, *Université de Bourgogne, Dijon Cedex, France*, and **Chris A. M. Peters**, *Université Grenoble I, St. Martin d'Heres, France*

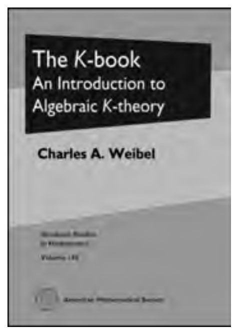
The theory of motives was created by Grothendieck in the 1960s as he searched for a universal cohomology theory for algebraic varieties. The theory of pure motives is well established as far as the construction is concerned. Pure motives are expected to have a number of additional properties predicted by Grothendieck's standard conjectures, but these conjectures remain wide open. The theory for mixed motives is still incomplete.

This book deals primarily with the theory of pure motives. The exposition begins with the fundamentals: Grothendieck's construction of the category of pure motives and examples. Next, the standard conjectures and the famous theorem of Jannsen on the category of the numerical motives are discussed. Following this, the important theory of finite dimensionality is covered. The concept of Chow-Künneth decomposition is introduced, with discussion of the known results and the related conjectures, in particular the conjectures of Bloch-Beilinson type. We finish with a chapter on relative motives and a chapter giving a short introduction to Voevodsky's theory of mixed motives.

Contents: Algebraic cycles and equivalence relations; Survey of some of the main results on Chow groups; Proof of the theorem of Voisin-Voevodsky; Motives: Construction and first properties; On Grothendieck's standard conjectures; Finite dimensionality of motives; Properties of finite dimensional motives; Chow-Künneth decomposition; The Picard and Albanese motive; Chow-Künneth decomposition in a special case; On the conjectural Bloch-Beilinson filtration; Relative Chow-Künneth decomposition; Surfaces fibered over a curve; Beyond pure motives; The category of motivic complexes; Bibliography; Index of notation; Index.

University Lecture Series, Volume 61

April 2013, 149 pages, Softcover, ISBN: 978-0-8218-9434-7, 2010 *Mathematics Subject Classification:* 14-02, 14C15, 14C25, 19E15, **AMS members US$35.20**, List US$44, Order code ULECT/61



The K-book

An Introduction to Algebraic K-theory

Charles A. Weibel, *Rutgers University, New Brunswick, NJ*

Informally, K-theory is a tool for probing the structure of a mathematical object such as a ring or a topological space in terms of suitably parameterized vector spaces and producing important intrinsic invariants which are useful in the study of algebraic and geometric questions. Algebraic K-theory, which is the main character of this book, deals mainly with studying the structure of rings. However, it turns out that even working in a purely algebraic context, one requires techniques from homotopy theory to construct the higher K-groups and to perform computations. The resulting interplay of algebra, geometry, and topology in K-theory provides a fascinating glimpse of the unity of mathematics.

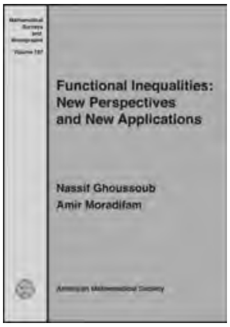
This book is a comprehensive introduction to the subject of algebraic K-theory. It blends classical algebraic techniques for K_0 and K_1 with newer topological techniques for higher K-theory such as homotopy theory, spectra, and cohomological descent. The book takes the reader from the basics of the subject to the state of the art, including the calculation of the higher K-theory of number fields and the relation to the Riemann zeta function.

Contents: Projective modules and vector bundles; The Grothendieck group K_0; K_1 and K_2 of a ring; Definitions of higher K-theory; The fundamental theorems of higher K-theory; The higher K-theory of fields; Nomenclature; Bibliography; Index.

Graduate Studies in Mathematics, Volume 145

May 2013, approximately 642 pages, Hardcover, ISBN: 978-0-8218-9132-2, LC 2012039660, 2010 *Mathematics Subject Classification:* 19-00, 19-01, **AMS members US$71.20**, List US$89, Order code GSM/145

Differential Equations



Functional Inequalities: New Perspectives and New Applications

Nassif Ghoussoub, *University of British Columbia, Vancouver, BC, Canada*, and **Amir Moradifam**, *Columbia University, New York, NY*

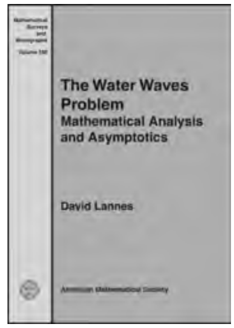
The book describes how functional inequalities are often manifestations of natural mathematical structures and physical phenomena, and how a few general principles validate large classes of analytic/geometric inequalities, old and new. This point of view leads to "systematic" approaches for proving the most basic inequalities, but also for improving them, and for devising new ones—sometimes at will—and often on demand. These general principles also offer novel ways for estimating best constants and for deciding whether these are attained in appropriate function spaces.

As such, improvements of Hardy and Hardy-Rellich type inequalities involving radially symmetric weights are variational manifestations of Sturm's theory on the oscillatory behavior of certain ordinary differential equations. On the other hand, most geometric inequalities, including those of Sobolev and Log-Sobolev type, are simply expressions of the convexity of certain free energy functionals along the geodesics on the Wasserstein manifold of probability measures equipped with the optimal mass transport metric. Caffarelli-Kohn-Nirenberg and Hardy-Rellich-Sobolev type inequalities are then obtained by interpolating the above two classes of inequalities via the classical ones of Hölder. The subtle Moser-Onofri-Aubin inequalities on the two-dimensional sphere are connected to Liouville type theorems for planar mean field equations.

Contents: *Hardy type inequalities:* Bessel pairs and Sturm's oscillation theory; The classical Hardy inequality and its improvements; Improved Hardy inequality with boundary singularity; Weighted Hardy inequalities; The Hardy inequality and second order nonlinear eigenvalue problems; *Hardy-Rellich type inequalities:* Improved Hardy-Rellich inequalities on $H_0^2(\Omega)$; Weighted Hardy-Rellich inequalities on $H^2(\Omega) \cap H_0^1(\Omega)$; Critical dimensions for 4th order nonlinear eigenvalue problems; *Hardy inequalities for general elliptic operators:* General Hardy inequalities; Improved Hardy inequalities for general elliptic operators; Regularity and stability of solutions in non-self-adjoint problems; *Mass transport and optimal geometric inequalities:* A general comparison principle for interacting gases; Optimal Euclidean Sobolev inequalities; Geometric inequalities; *Hardy-Rellich-Sobolev inequalities:* The Hardy-Sobolev inequalities; Domain curvature and best constants in the Hardy-Sobolev inequalities; *Aubin-Moser-Onofri inequalities:* Log-Sobolev inequalities on the real line; Trudinger-Moser-Onofri inequality on $\mathbb{S}^2$; Optimal Aubin-Moser-Onofri inequality on $\mathbb{S}^2$; Bibliography.

Mathematical Surveys and Monographs, Volume 187

March 2013, approximately 310 pages, Hardcover, ISBN: 978-0-8218-9152-0, 2010 *Mathematics Subject Classification:* 42B25, 35A23, 26D10, 35A15, 46E35, **AMS members US$78.40**, List US$98, Order code SURV/187



The Water Waves Problem

Mathematical Analysis and Asymptotics

David Lannes, *Ecole Normale Supérieure et CNRS, Paris, France*

This monograph provides a comprehensive and self-contained study on the theory of water waves equations, a research area that has been very active in recent years. The vast literature devoted to the study of water waves offers numerous asymptotic models. Which model provides the best description of waves such as tsunamis or tidal waves? How can water waves equations be transformed into simpler asymptotic models for applications in, for example, coastal oceanography? This book proposes a simple and robust framework for studying these questions.

The book should be of interest to graduate students and researchers looking for an introduction to water waves equations or for simple asymptotic models to describe the propagation of waves. Researchers working on the mathematical analysis of nonlinear dispersive equations may also find inspiration in the many (and sometimes new) models derived here, as well as precise information on their physical relevance.

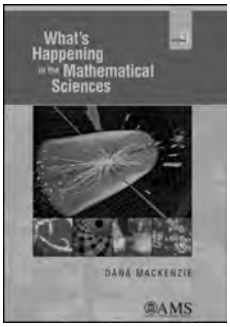
This item will also be of interest to those working in mathematical physics.

Contents: The water waves equations and its asymptotic regimes; The Laplace equation; The Dirichlet-Neumann operator; Well-posedness of the water waves equations; Shallow water asymptotics: Systems. Part 1: Derivation; Shallow water asymptotics: Systems. Part 2: Justification; Shallow water asymptotics: Scalar equations; Deep water models and modulation equations; Water waves with surface tension; Appendix A. More on the Dirichlet-Neumann operator; Appendix B. Product and commutator estimates; Appendix C. Asymptotic models: A reader's digest; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 188

May 2013, approximately 328 pages, Hardcover, ISBN: 978-0-8218-9470-5, 2010 *Mathematics Subject Classification:* 76B15, 35Q53, 35Q55, 35J05, 35J25, **AMS members US$78.40**, List US$98, Order code SURV/188

General Interest



What's Happening in the Mathematical Sciences, Volume 9

Dana Mackenzie

What's Happening in the Mathematical Sciences looks at some highlights of the most recent developments in mathematics. These include the mathematics behind stories that made headlines, as well as fascinating mathematical stories that never made it into the newspapers.

In 2009, a flu pandemic, the world's first in more than 40 years, tested a new generation of mathematical models that take some of the guesswork out of public health decisions. As health officials rushed to quell the outbreak of H1N1 flu, mathematicians were working just as hurriedly to answer questions like these: Was the epidemic serious enough to justify school closings or quarantines? Who should be vaccinated first, the elderly or the young? Their findings substantially affected the response of local governments, national governments, and the World Health Organization.

Mathematics can also help society prepare for other kinds of natural and manmade disasters. A major tsunami in 2011 in Japan, like the one seven years earlier in the Indian Ocean, highlighted flaws in our understanding of these catastrophic events and inadequacies in our early warning systems. Geoscientists are working together with mathematicians to improve our short-term forecasting ability and quantify the long-term risks of tsunamis. Meanwhile, in California, another group of mathematicians succeeded in adapting earthquake prediction algorithms to forecast criminal activity. Their "predictive policing" software was tested in Los Angeles and is being adopted by other cities across the United States.

Fortunately, not all mathematics has to do with emergencies. Pure mathematicians have been busy cleaning out their closets of long-standing open problems. In 2012, two conjectures about different kinds of minimizing surfaces were solved: the Willmore Conjecture (minimizing energy) and the Lawson Conjecture (minimizing area). Also in 2012, following up on the extraordinary proofs of the Poincaré Conjecture and Thurston's Geometrization Conjecture, topologists proved a collection of conjectures that ensure that three-dimensional spaces can all be constructed in a uniform way. Meanwhile, for the last ten years, a new way of understanding algebraic curves and surfaces has developed, leading to a subject now known as tropical geometry. With the new ideas, certain hard problems in algebraic geometry suddenly become easy and certain "mathematical mysteries" of string theory begin to make sense.

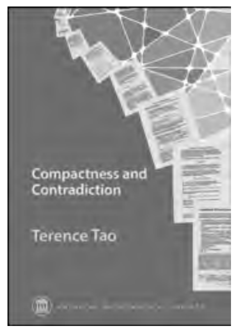
In physics, the nine-billion-dollar search for the elusive Higgs boson finally bagged its quarry in 2012. This discovery, one of the most widely publicized science stories of the year, provides experimental evidence for the "Higgs mechanism," a nearly 50-year-old mathematical argument that explains how certain subatomic particles acquire mass.

Rounding out this volume are chapters on a new statistical technique called topic modeling, which is breaking down the academic barriers between math and the humanities, and new discoveries about mathematicians' (and a lot of other people's) favorite toy: the Rubik's Cube.

Contents: A massive breakthrough (about the mathematics of the Higgs particle); Tubing through hyperspace (about the proofs of the Willmore conjecture, Lawson's conjecture, and the Pinkall-Sterling conjecture); Tsunamis: Learning from math, learning from the past (title is self explanatory); Today's forecast: Ten percent chance of burglary (about protective policing); Topologists cross four off "bucket list" (about the proof of the Virtual Haken Conjecture and three related conjectures); Speedcubing, anyone? (about the mathematics of the Rubik's cube); The right epidemic at the right time (about the 2009 flu epidemic and mathematical models of epidemics); Thinking topically: Latent Dirichlet allocation (about topic models); Thinking tropically (about tropical geometry).

What's Happening in the Mathematical Sciences, Volume 9

May 2013, approximately 136 pages, Softcover, ISBN: 978-0-8218-8739-4, 2010 *Mathematics Subject Classification:* 00A06, **AMS members US$20**, List US$25, Order code HAPPENING/9



Compactness and Contradiction

Terence Tao, *University of California, Los Angeles, CA*

There are many bits and pieces of folklore in mathematics that are passed down from advisor to student, or from collaborator to collaborator, but which are too fuzzy and nonrigorous to be discussed in the formal literature. Traditionally, it was a matter of luck and location as to who learned such "folklore mathematics". But today, such bits and pieces can be communicated effectively and efficiently via the semiformal medium of research blogging. This book grew from such a blog.

The articles, essays, and notes in this book are derived from the author's mathematical blog in 2010. It contains a broad selection of mathematical expositions, commentary, and self-contained technical notes in many areas of mathematics, such as logic, group theory, analysis, and partial differential equations. The topics range from the foundations of mathematics to discussions of recent mathematical breakthroughs.

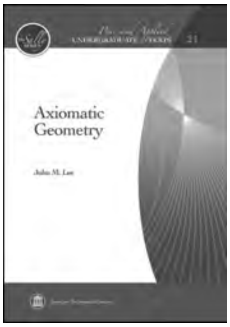
Lecture notes from the author's courses that appeared on the blog have been published separately in the *Graduate Studies in Mathematics* series.

This item will also be of interest to those working in analysis, algebra and algebraic geometry, and logic and foundations.

Contents: Logic and foundations; Group theory; Analysis; Nonstandard analysis; Partial differential equations; Miscellaneous; Bibliography; Index.

April 2013, approximately 262 pages, Softcover, ISBN: 978-0-8218-9492-7, 2010 *Mathematics Subject Classification:* 00B15, **AMS members US$35.20**, List US$44, Order code MBK/81

Geometry and Topology



Axiomatic Geometry

John M. Lee, *University of Washington, Seattle, WA*

The story of geometry is the story of mathematics itself: Euclidean geometry was the first branch of mathematics to be systematically studied and placed on a firm logical foundation, and it is the prototype for the axiomatic method that lies at the foundation of modern mathematics. It has been taught to students for more than two millennia as a model of logical thought.

This book tells the story of how the axiomatic method has progressed from Euclid's time to ours, as a way of understanding what mathematics is, how we read and evaluate mathematical arguments, and why mathematics has achieved the level of certainty it has. It is designed primarily for advanced undergraduates who plan to teach secondary school geometry, but it should also provide something of interest to anyone who wishes to understand geometry and the axiomatic method better. It introduces a modern, rigorous, axiomatic treatment of Euclidean and (to a lesser extent) non-Euclidean geometries, offering students ample opportunities to practice reading and writing proofs while at the same time developing most of the concrete geometric relationships that secondary teachers will need to know in the classroom.

This item will also be of interest to those working in general interest.

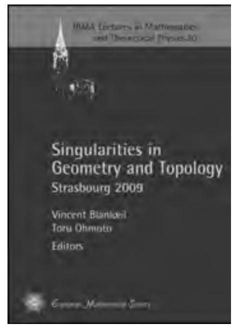
Contents: Euclid; Incidence geometry; Axioms for plane geometry; Angles; Triangles; Models of neutral geometry; Perpendicular and parallel lines; Polygons; Quadrilaterals; The Euclidean parallel postulate; Area; Similarity; Right triangles; Circles; Circumference and circular area; Compass and straightedge constructions; The parallel postulate revisited; Introduction to hyperbolic geometry; Parallel lines in hyperbolic geometry; Epilogue: Where do we go from here?; Hilbert's axioms; Birkhoff's postulates; The SMSG postulates; The postulates used in this book; The language of mathematics; Proofs; Sets and functions; Properties of the real numbers; Rigid motions: Another approach; References; Index.

Pure and Applied Undergraduate Texts, Volume 21

May 2013, approximately 472 pages, Hardcover, ISBN: 978-0-8218-8478-2, LC 2012043438, 2010 *Mathematics Subject Classification:* 51-01; 51M05, 51M10, **AMS members US$60**, List US$75, Order code AMSTEXT/21

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Singularities in Geometry and Topology—Strasbourg 2009

Vincent Blanlœil, *Université de Strasbourg, France*, and **Toru Ohmoto**, *Hokkaido University, Sapporo, Japan*, Editors

This volume arises from the Fifth Franco-Japanese Symposium on Singularities, held in Strasbourg in August 2009. The conference brought together an international group of researchers, mainly from France and Japan, working on singularities in algebraic geometry, analytic geometry and topology. The conference also featured the JSPS Forum on Singularities and Applications, which aimed to introduce some recent applications of singularity theory to physics and statistics.

This book contains research papers and short lecture notes on advanced topics on singularities. Some surveys on applications that were presented at the JSPS Forum are also included. Among the topics covered are splice surface singularities, b-functions, equisingularity, degenerating families of Riemann surfaces, hyperplane arrangements, mixed singularities, jet schemes, noncommutative blow-ups, characteristic classes of singular spaces, and applications to geometric optics, cosmology, and learning theory.

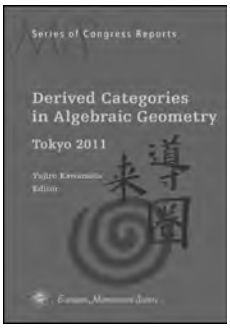
Graduate students who wish to learn about various approaches to singularities, as well as experts in the field and researchers in other areas of mathematics and science, will find the contributions to this volume a rich source for further study and research.

A publication of the European Mathematical Society. Distributed within the Americas by the American Mathematical Society.

Contents: **A. Joets**, Optical caustics and their modelling as singularities (JSPS Forum); **H. A. Hamm**, On local equisingularity; **S. Ishii**, **A. Sannai**, and **K.-i. Watanabe**, Jet schemes of homogeneous hypersurfaces; **T. Koike**, Singularities in relativity (JSPS Forum); **Y. Matsumoto**, On the universal degenerating family of Riemann surfaces; **Y. Nakamura** and **S. Tajima**, Algebraic local cohomologies and local b-functions attached to semiquasihomogeneous singularities with $L(f) = 2$; **T. Ohmoto**, A note on the Chern-Schwartz-MacPherson class; **M. Oka**, On mixed projective curves; **T. Okuma**, Invariants of splice quotient singularities; **O. Riemenschneider**, A note on the toric duality between $A_{n,q}$ and $A_{n,n-q}$; **J. Schürmann**, Nearby cycles and characteristic classes of singular spaces; **T. Suwa**, Residues of singular holomorphic distributions (lecture); **S. Watanabe**, Two birational invariants in statistical learning theory (JSPS Forum); **T. Yasuda**, Frobenius morphisms of noncommutative blowups; **S. Yokura**, Bivariant motivic Hirzebruch class and a zeta function of motivic Hirzebruch class (lecture); **M. Yoshinaga**, Minimality of hyperplane arrangements and basis of local system cohomology.

IRMA Lectures in Mathematics and Theoretical Physics, Volume 20

December 2012, 370 pages, Softcover, ISBN: 978-3-03719-118-7, 2010 *Mathematics Subject Classification:* 13A35, 14A22, 14B05, 14B07, 14B15, **AMS members US$49.60**, List US$62, Order code EMSILMTP/20



Derived Categories in Algebraic Geometry—Tokyo 2011

Yujiro Kawamata, *University of Tokyo, Japan*, Editor

The study of derived categories is a subject that attracts increasingly many mathematicians from various fields of mathematics, including abstract algebra, algebraic geometry, representation theory, and mathematical physics.

The concept of the derived category of sheaves was invented by Grothendieck and Verdier in the 1960s as a tool to express important results in algebraic geometry such as the duality theorem. In the 1970s, Beilinson, Gelfand, and Gelfand discovered that a derived category of an algebraic variety may be equivalent to that of a finite-dimensional non-commutative algebra, and Mukai found that there are non-isomorphic algebraic varieties that have equivalent derived categories. In this way, the derived category provides a new concept that has many incarnations. In the 1990s, Bondal and Orlov uncovered an unexpected parallelism between the derived categories and the birational geometry. Kontsevich's homological mirror symmetry provided further motivation for the study of derived categories.

This book contains the proceedings of a conference held at the University of Tokyo in January 2011 on the current status of the research on derived categories related to algebraic geometry. Most articles are survey papers on this rapidly developing field.

The book is suitable for mathematicians who want to enter this exciting field. Some basic knowledge of algebraic geometry is assumed.

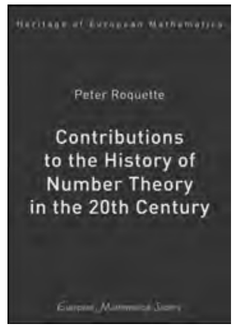
A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: **M. Bernardara** and **M. Bolognesi**, Categorical representability and intermediate Jacobians of Fano threefolds; **A. Canonaco** and **P. Stellari**, Fourier-Mukai functors: A survey; **S. Cautis**, Flops and about: A guide; **A. Ishii** and **K. Ueda**, A note on derived categories of Fermat varieties; **D. Kaledin**, Homology of infinite loop spaces; **B. Keller**, Cluster algebras and derived categories; **I. Mori**, Some derived equivalences between noncommutative schemes and algebras; **A. Polishchuk**, Lagrangian-invariant sheaves and functors for abelian varieties; **M. Popa**, Generic vanishing filtrations and perverse objects in derived categories of coherent sheaves; **C. Schnell**, The fundamental group is not a derived invariant; **Y. Toda**, Introduction and open problems of Donaldson–Thomas theory; **M. Van den Bergh**, Notes on formal deformations of abelian categories; List of contributors.

EMS Series of Congress Reports, Volume 8

December 2012, 354 pages, Hardcover, ISBN: 978-3-03719-115-6, 2010 *Mathematics Subject Classification:* 13D09, 14-02, 14-06, 14F05, 16E35, 18E30, **AMS members US$78.40**, List US$98, Order code EMSSCR/8

General Interest



Contributions to the History of Number Theory in the 20th Century

Peter Roquette, *University of Heidelberg, Germany*

The 20th century was a time of great upheaval and great progress in mathematics. In order to get the overall picture of trends, developments, and results, it is illuminating to examine their manifestations locally, in the personal lives and work of mathematicians who were active during this time. The university archives of Göttingen harbor a wealth of papers, letters, and manuscripts from several generations of mathematicians—documents which tell the story of the historic developments from a local point of view.

This book offers a number of essays based on documents from Göttingen and elsewhere—essays which have not yet been included in the author's collected works. These essays, independent from each other, are meant as contributions to the imposing mosaic of the history of number theory. They are written for mathematicians, but there are no special background requirements.

The essays discuss the works of Abraham Adrian Albert, Cahit Arf, Emil Artin, Richard Brauer, Otto Grün, Helmut Hasse, Klaus Hoechsmann, Robert Langlands, Heinrich-Wolfgang Leopoldt, Emmy Noether, Abraham Robinson, Ernst Steinitz, Hermann Weyl, and others.

This item will also be of interest to those working in number theory.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: The Brauer-Hasse-Noether theorem; The remarkable career of Otto Grün; At Emmy Noether's funeral; Emmy Noether and Hermann Weyl; Emmy Noether: The testimonials; Abraham Robinson and his infinitesimals; Cahit Arf and his invariant; Hasse–Arf–Langlands; Ernst Steinitz and abstract field theory; Heinrich-Wolfgang Leopoldt; On Hoechsmann's theorem; Acknowledgements; Bibliography; Name index; Subject index.

Heritage of European Mathematics, Volume 7

December 2012, 289 pages, Hardcover, ISBN: 978-3-03719-113-2, 2010 *Mathematics Subject Classification:* 01-02, 03-03, 11-03, 12-03, 16-03, 20-03, **AMS members US$78.40**, List US$98, Order code EMSHEM/7

(**About the cover** continued from page 325)

in-vivo cell behavior. It is my hope that this process will also drive the development of new and novel mathematical modeling and computational methods.

• *How will you measure its success?*

This is a really great question. First, does our project influence the thinking of biologists and clinicians? Do they start to think beyond the molecular biology of single cells, towards interconnected systems of cells with physical constraints, such as those imposed by transport limitations of oxygen and therapeutic compounds? Second, can we make tools that are sufficiently descriptive and realistic to provide new insights on the underlying cancer biology, and possibly lead us to revisit and refine our operating biological hypotheses? Third, given a set of in-vitro or patient measurements, can we quantitatively predict something biologically or clinically important (e.g., predict growth rates and overall chemotherapy response, based solely upon imaging and pathology inputs)? Fourth, can we create validated models that are sufficiently mechanistic that we can not only predict behavior, but also apply controls to change behavior? That is, we would like to reach the point where we are so good at describing cancer progression and therapy response for individual patients that we can choose a desired outcome (e.g., stay within organ X with size under Y for Z years) and optimize treatment to attain that outcome.

Computational and mathematical oncology is having increasing success at #1 and #2. We're starting to make headway on #3, and even on #4.

• *How do you measure the accuracy of your simulations?*

First, we'd measure it qualitatively: does it match behavior as observed in the clinic, on reasonable space and time scales? If so, can we make a macroscopic prediction (e.g., on growth rates with and without therapy) that match within some relative error bound for most of our patients? What does it predict about the microstructure of the cancer? Do expected correlations pop out, such as between cell position and relative frequency of cell mitosis? Does it predict new correlations that we can verify in existing data?

• *What size are the meshes in the cover animation? What time interval? How long did the computation take?*

It used a 20-micron mesh. The time scale was set to dynamically satisfy a Courant-Friedrichs-Levy condition, typically 1 hour or less. These simulations were done single-threaded on desktop computers about six years ago, and required on the order of days to a week to complete. Assuming four 18-month Moore's law doublings in computer speed, that simulation should take several hours today, and it would be faster if parallelized.

• *What machines and OS are you using for parallelization in the recent 3D stuff?*

The recent 3D work is written in standards-compliant, object-oriented C++, with parallelization in OpenMP. (OpenMP is a cross-platform/cross-architecture programming interface that supports shared memory parallelization in C/C++ and Fortran. In shared memory parallelization, all threads have access to a shared pool of memory, eliminating the need for message passing between threads.) We tend to run the bigger simulations on a machine with two 6-core CPUs with hyperthreading (up to 24 simultaneous execution threads) and 48 GB of memory, running Ubuntu Linux. Bigger simulations (around a half million cells in a 3-5 mm^3 domain) take between several hours and a weekend, depending upon the complexity and the size of the computational domain. I run these on Windows and Mac OSX machines during development, to make sure the simulator works across platforms.

—Bill Casselman
Graphics Editor
(`notices-covers@ams.org`)

Classified Advertisements

Positions available, items for sale, services available, and more

VIRGINIA

VIRGINIA COMMONWEALTH UNIVERSITY
Mathematics and Applied Mathematics

Virginia Commonwealth University invites applications for the position of Chair of the Department of Mathematics and Applied Mathematics. We are looking for an accomplished mathematician who wants to make a difference. The chair must have the vision and skill necessary to lead the department as it expands and strengthens its Ph.D. program, contributes to the university's goal of becoming a leading research university, and continues in its strong commitment to excellence in its undergraduate and graduate programs.

The chair will be required to have a well-developed scholarly/research portfolio with evidence of multi-disciplinary applications and external funding appropriate to complement and expand existing expertise in the department. For complete description see `http://www.pubinfo.vcu.edu/facjobs/facjob.asp?Item=4760`. Submit applications to `https://www.mathjobs.org/jobs/jobs/4286`. Virginia Commonwealth University is an Equal Opportunity/Affirmative Action Employer. Women, minorities, and persons with disabilities are encouraged to apply.

000015

Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2013 rate is $3.50 per word with a minimum two-line headline. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: April 2013 issue–January 30, 2013; May 2013–February 28, 2013; June/July 2013 issue–April 26, 2013; August 2013 issue–May 29, 2013; September 2013 issue–July 1, 2013; October 2013 issue–July 26, 2013.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Oxford, Mississippi

University of Mississippi

March 1–3, 2013

Friday – Sunday

Meeting #1087

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: December 2012
Program first available on AMS website: December 13, 2012
Program issue of electronic *Notices*: March 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Patricia Hersh, North Carolina State University, *An interplay of combinatorics with topology*.

Daniel Krashen, University of Georgia, *Topology, arithmetic, and the structure of algebraic groups*.

Washington Mio, Florida State University, *Taming shapes and understanding their variation*.

Slawomir Solecki, University of Illinois at Urbana-Champaign, *An abstract approach to Ramsey theory with applications*.

Special Sessions

Algebraic Combinatorics, **Patricia Hersh**, North Carolina State University, and **Dennis Stanton**, University of Minnesota.

Approximation Theory and Orthogonal Polynomials, **David Benko**, University of South Alabama, **Erwin Mina-Diaz**, University of Mississippi, and **Edward Saff**, Vanderbilt University.

Banach Spaces and Operators on Them, **Qingying Bu** and **Gerard Buskes**, University of Mississippi, and **William B. Johnson**, Texas A&M University.

Commutative Algebra, **Sean Sather-Wagstaff**, North Dakota State University, and **Sandra M. Spiroff**, University of Mississippi.

Connections between Matroids, Graphs, and Geometry, **Stan Dziobiak**, **Talmage James Reid**, and **Haidong Wu**, University of Mississippi.

Dynamical Systems, **Alexander Grigo**, University of Oklahoma, and **Saša Kocić**, University of Mississippi.

Fractal Geometry and Ergodic Theory, **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Graph Theory, **Laura Sheppardson** and **Bing Wei**, University of Mississippi, and **Hehui Wu**, McGill University.

Modern Methods in Analytic Number Theory, **Nathan Jones** and **Micah B. Milinovich**, University of Mississippi, and **Frank Thorne**, University of South Carolina.

Set Theory and Its Applications, **Christian Rosendal**, University of Illinois at Chicago, and **Slawomir Solecki**, University of Illinois at Urbana-Champaign.

Chestnut Hill, Massachusetts

Boston College

April 6–7, 2013

Saturday – Sunday

Meeting #1088

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2013
Program first available on AMS website: February 21, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Roman Bezrukavnikov, Massachusetts Institute of Technology, *Canonical bases and geometry*.

Marston Conder, University of Auckland, *Discrete objects with maximum possible symmetry*.

Alice Guionnet, École Normale Supérieure de Lyon, *Title to be announced*.

Yanir Rubinstein, University of Maryland, *Geometry: (very) local meets global*.

Special Sessions

Algebraic and Geometric Structures of 3-manifolds, **Ian Biringer**, **Tao Li**, and **Robert Meyerhoff**, Boston College.

Algorithmic Problems of Group Theory and Applications to Information Security, **Delaram Kahrobaei**, City University of New York Graduate Center and New York College of Technology, and **Vladimir Shpilrain**, City College of New York and City University of New York Graduate Center.

Arithmetic Dynamics and Galois Theory, **John Cullinan**, Bard College, and **Farshid Hajir** and **Siman Wong**, University of Massachusetts, Amherst.

Combinatorics and Classical Integrability, **Amanda Redlich** and **Shabnam Beheshti**, Rutgers University.

Commuting Matrices and the Hilbert Scheme, **Anthony Iarrobino**, Northeastern University, and **Leila Khatami**, Union College.

Complex Geometry and Microlocal Analysis, **Victor W. Guillemin** and **Richard B. Melrose**, Massachusetts Institute of Technology, and **Yanir A. Rubinstein**, Stanford University.

Counting and Equidistribution on Symmetric Spaces, **Dubi Kelmer**, Boston College, and **Alex Kontorovich**, Yale University.

Discrete Geometry of Polytopes, **Barry Monson**, University of New Brunswick, and **Egon Schulte**, Northeastern University.

Financial Mathematics, **Hasanjan Sayit** and **Stephan Sturm**, Worcester Polytechnic Institute.

History and Philosophy of Mathematics, **James J. Tattersall**, Providence College, and **V. Frederick Rickey**, United States Military Academy.

Homological Invariants in Low-dimensional Topology, **John Baldwin**, **Joshua Greene**, and **Eli Grigsby**, Boston College.

Homology and Cohomology of Arithmetic Groups, **Avner Ash**, Boston College, **Darrin Doud**, Brigham Young University, and **David Pollack**, Wesleyan University.

Hopf Algebras and their Applications, **Timothy Kohl**, Boston University, and **Robert Underwood**, Auburn University Montgomery.

Moduli Spaces in Algebraic Geometry, **Dawei Chen** and **Maksym Fedorchuk**, Boston College, and **Joe Harris** and **Yu-Jong Tzeng**, Harvard University.

Real and Complex Dynamics of Difference Equations with Applications, **Ann Brett**, Johnson and Wales University, and **M. R. S. Kulenovic**, University of Rhode Island.

Recursion and Definability, **Rachel Epstein**, Harvard University, **Karen Lange**, Wellesley College, and **Russell Miller**, Queens College and City University of New York Graduate Center.

Research by Undergraduates and Students in Post-Baccalaureate Programs, **Chi-Keung Cheung**, Boston College, **David Damiano**, College of the Holy Cross, **Steven J. Miller**, Williams College, and **Suzanne L. Weekes**, Worcester Polytechnic Institute.

Topology and Generalized Cohomologies in Modern Condensed Matter Physics, **Claudio Chamon** and **Robert Kotiuga**, Boston University.

Boulder, Colorado

University of Colorado Boulder

April 13–14, 2013

Saturday – Sunday

Meeting #1089

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: January 2013
Program first available on AMS website: February 28, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 19, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Gunnar Carlsson, Stanford University, *Title to be announced.*

Jesus A. De Loera, University of California, Davis, *Title to be announced.*

Brendan Hassett, Rice University, *Title to be announced.*

Raphael Rouquier, University of California Los Angeles, *Title to be announced.*

Special Sessions

Advances in Mathematical Biology (Code: SS 16A), **Liming Wang**, California State University, Los Angeles, and **Jiangguo Liu**, Colorado State University.

Algebraic Geometry (Code: SS 14A), **Sebastian Casalaina-Martin**, University of Colorado, **Renzo Cavalieri**, Colorado State University, **Brendan Hassett**, Rice University, and **Jonathan Wise**, University of Colorado.

Algebras, Lattices and Varieties (Code: SS 5A), **Keith A. Kearnes** and **Ágnes Szendrei**, University of Colorado, Boulder.

Analysis of Dynamics of the Incompressible Fluids (Code: SS 18A), **Mimi Dai** and **Congming Li**, University of Colorado, Boulder.

Arithmetic Statistics and Big Monodromy (Code: SS 23A), **Jeff Achter**, Colorado State University, and **Chris Hall**, University of Wyoming.

Associative Rings and Their Modules (Code: SS 1A), **Greg Oman** and **Zak Mesyan**, University of Colorado, Colorado Springs.

Cluster Algebras and Related Combinatorics (Code: SS 6A), **Gregg Musiker**, University of Minnesota, **Kyungyong Lee**, Wayne State University, and **Li Li**, Oakland University.

Combinatorial Avenues in Representation Theory (Code: SS 21A), **Richard Green**, University of Colorado Boulder, **Anne Shepler**, University of North Texas, and **Nathaniel Thiem**, University of Colorado Boulder.

Combinatorial and Computational Commutative Algebra and Algebraic Geometry (Code: SS 7A), **Hirotachi Abo**, University of Idaho, **Zach Teitler**, Boise State University, and **Alexander Woo**, University of Idaho.

Diophantine Approximation on Manifolds and Fractals: Dynamics, Measure Theory and Schmidt Games. (Code: SS 15A), **Wolfgang Schmidt**, University of Colorado at Boulder, and **Lior Fishman**, University of North Texas.

Dynamical Systems: Thermodynamic Formalism and Connections with Geometry (Code: SS 10A), **Keith Burns**, Northwestern University, and **Dan Thompson**, The Ohio State University.

Dynamics and Arithmetic Geometry (Code: SS 2A), **Suion Ih**, University of Colorado at Boulder, and **Thomas J. Tucker**, University of Rochester.

Elliptic Systems and Their Applications (Code: SS 20A), **Wenxiong Chen**, Yeshiva University, and **Congming Li**, University of Colorado at Boulder.

Extremal Graph Theory (Code: SS 3A), **Michael Ferrara**, University of Colorado Denver, **Stephen Hartke**, University of Nebraska-Lincoln, and **Michael Jacobson**, University of Colorado Denver.

Foundations of Computational Mathematics (Code: SS 13A), **Susan Margulies**, Pennsylvania State University, and **Jesus De Loera**, University of California, Davis.

Geometric Methods in the Representation Theory of Reductive Groups (Code: SS 19A), **J. Matthew Douglass**, University of North Texas, **Gerhard Roehrle**, Ruhr- Universitaet Bochum, and **Rahbar Virk**, University of Colorado Boulder.

Harmonic Analysis of Frames, Wavelets, and Tilings (Code: SS 12A), **Veronika Furst**, Fort Lewis College, **Keri Kornelson**, University of Oklahoma, and **Eric Weber**, Iowa State University.

Noncommutative Geometry and Geometric Analysis (Code: SS 22A), **Carla Farsi** and **Alexander Gorokhovsky**, University of Colorado, Boulder.

Nonlinear Waves and Integrable Systems (Code: SS 9A), **Christopher W. Curtis**, University of Colorado, Boulder, **Anton Dzhamay**, University of Northern Colorado, **Willy Hereman**, Colorado School of Mines, and **Barbara Prinari**, University of Colorado, Colorado Springs.

Number Theory with a Focus on Diophantine Equations and Recurrence Sequences (Code: SS 8A), **Patrick Ingram**, Colorado State University, and **Katherine E. Stange**, University of Colorado, Boulder.

Set Theory and Boolean Algebras (Code: SS 17A), **Natasha Dobrinen**, University of Denver, and **Don Monk**, University of Colorado, Boulder.

Singular Spaces in Geometry, Topology, and Algebra (Code: SS 11A), **Greg Friedman**, Texas Christian University, and **Laurentiu Maxim**, University of Wisconsin, Madison.

Themes in Applied Mathematics: From Data Analysis through Fluid Flows and Biology to Topology (Code: SS 4A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico, and Enfitek, Inc.

Ames, Iowa

Iowa State University

April 27–28, 2013

Saturday – Sunday

Meeting #1090

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2013
Program first available on AMS website: March 14, 2013
Program issue of electronic *Notices*: April 2013

Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: March 5, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Kevin Costello, Northwestern University, *Title to be announced*.

Marianne Csornyei, University of Chicago, *Title to be announced*.

Vladimir Markovic, California Institute of Technology, *Title to be announced*.

Endre Szemerédi, Siemens Corporate Technology, *Title to be announced* (Erdős Memorial Lecture).

Eitan Tadmor, University of Maryland, *Title to be announced*.

Special Sessions

Algebraic and Geometric Combinatorics (Code: SS 4A), **Sung Y. Song**, Iowa State University, and **Paul Terwilliger**, University of Wisconsin-Madison.

Analysis, Dynamics and Geometry In and Around Teichmuller Spaces (Code: SS 17A), **Alistair Fletcher**, Northern Illinois University, **Vladimir Markovic**, California Institute of Technology, and **Dragomir Saric**, Queens College CUNY.

Commutative Algebra and its Environs (Code: SS 6A), **Olgur Celikbas** and **Greg Piepmeyer**, University of Missouri, Columbia.

Commutative Ring Theory (Code: SS 8A), **Michael Axtell**, University of St. Thomas, and **Joe Stickles**, Millikin University.

Computability and Complexity in Discrete and Continuous Worlds (Code: SS 11A), **Jack Lutz** and **Tim McNicholl**, Iowa State University.

Computational Advances on Special Functions and Tropical Geometry (Code: SS 14A), **Lubjana Beshaj**, Oakland University, and **Emma Previato**, Boston University.

Control Theory and Qualitative Analysis of Partial Differential Equations (Code: SS 16A), **George Avalos**, University of Nebraska-Lincoln, and **Scott Hansen**, Iowa State University.

Discrete Methods and Models in Mathematical Biology (Code: SS 18A), **Dora Matache**, University of Nebraska-Omaha, and **Stephen J. Willson**, Iowa State University.

Extremal Combinatorics (Code: SS 7A), **Steve Butler** and **Ryan Martin**, Iowa State University.

Generalizations of Nonnegative Matrices and Their Sign Patterns (Code: SS 3A), **Minerva Catral**, Xavier University, **Shaun Fallat**, University of Regina, and **Pauline van den Driessche**, University of Victoria.

Geometric Elliptic and Parabolic Partial Differential Equations (Code: SS 13A), **Brett Kotschwar**, Arizona State University, and **Xuan Hien Nguyen**, Iowa State University.

Graphs, Hypergraphs and Counting (Code: SS 26A), **Eva Czabarka** and **Laszlo Szekely**, University of South Carolina.

Kinetic and Hydrodynamic PDE-based Descriptions of Multi-scale Phenomena (Code: SS 25A), **James Evans** and **Hailiang Liu**, Iowa State University, and **Eitan Tadmor**, University of Maryland.

Logic and Algebraic Logic (Code: SS 9A), **Jeremy Alm**, Illinois College, and **Andrew Ylvisaker**, Iowa State University.

Multi-Dimensional Dynamical Systems (Code: SS 15A), **Jayadev Athreya**, University of Illinois, Urbana-Champaign, **Jonathan Chaika**, University of Chicago, and **Joseph Rosenblatt**, University of Illinois at Urbana-Champaign.

Numerical Analysis and Scientific Computing (Code: SS 20A), **Hailiang Liu**, **Songting Luo**, **James Rossmanith**, and **Jue Yan**, Iowa State University.

Numerical Methods for Geometric Partial Differential Equations (Code: SS 22A), **Gerard Awanou**, University of Illinois at Chicago, and **Nicolae Tarfulea**, Purdue University.

Operator Algebras and Topological Dynamics (Code: SS 1A), **Benton L. Duncan**, North Dakota State University, and **Justin R. Peters**, Iowa State University.

Partial Differential Equations (Code: SS 12A), **Gary Lieberman** and **Paul Sacks**, Iowa State University, and **Mahamadi Warma**, University of Puerto Rico at Rio Piedras.

Probabilistic and Multiscale Modeling Approaches in Cell and Systems Biology (Code: SS 19A), **Jasmine Foo**, University of Minnesota, and **Anastasios Matzavinos**, Iowa State University.

Quasigroups, Loops, and Nonassociative Division Algebras (Code: SS 21A), **C. E. Ealy Jr.** and **Annegret Paul**, Western Michigan University, **Benjamin Phillips**, University of Michigan Dearborn, **J. D. Phillips**, Northern Michigan University, and **Petr Vojtechovsky**, University of Denver.

Ring Theory and Noncommutative Algebra (Code: SS 24A), **Victor Camillo**, University of Iowa, and **Miodrag C. Iovanov**, University of Bucharest and University of Iowa.

Stochastic Processes with Applications to Physics and Control (Code: SS 10A), **Jim Evans** and **Arka Ghosh**, Iowa State University, **Jon Peterson**, Purdue University, and **Alexander Roitershtein**, Iowa State University.

Topology of 3-Manifolds (Code: SS 23A), **Marion Campisi** and **Alexander Zupan**, University of Texas at Austin.

Zero Forcing, Maximum Nullity/Minimum Rank, and Colin de Verdiere Graph Parameters (Code: SS 2A), **Leslie Hogben**, Iowa State University and American Institute of Mathematics, and **Bryan Shader**, University of Wyoming.

Alba Iulia, Romania

June 27–30, 2013

Thursday – Sunday

Meeting #1091

First Joint International Meeting of the AMS and the Romanian Mathematical Society, in partnership with the

"Simion Stoilow" Institute of Mathematics of the Romanian Academy.
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2013
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

Viorel Barbu, Universitatea Al. I. Cuza, *Title to be announced*.

Sergiu Klainerman, Princeton University, *Title to be announced*.

George Lusztig, Massachusetts Institute of Technology, *Title to be announced*.

Stefan Papadima, Institute of Mathematics of the Romanian Academy, *Title to be announced*.

Dan Timotin, Institute of Mathematics of the Romanian Academy, *Title to be announced*.

Srinivasa Varadhan, New York University, *Title to be announced*.

Special Sessions

Algebraic Geometry, **Marian Aprodu**, Institute of Mathematics of the Romanian Academy, **Mircea Mustata**, University of Michigan, Ann Arbor, and **Mihnea Popa**, University of Illinois, Chicago.

Articulated Systems: Combinatorics, Geometry and Kinematics, **Ciprian S. Borcea**, Rider University, and **Ileana Streinu**, Smith College.

Calculus of Variations and Partial Differential Equations, **Marian Bocea**, Loyola University, Chicago, **Liviu Ignat**, Institute of Mathematics of the Romanian Academy, **Mihai Mihailescu**, University of Craiova, and **Daniel Onofrei**, University of Houston.

Commutative Algebra, **Florian Enescu**, Georgia State University, and **Cristodor Ionescu**, Institute of Mathematics of the Romanian Academy.

Discrete Mathematics and Theoretical Computer Science, **Sebastian Cioaba**, University of Delaware, **Gabriel Istrate**, Universitatea de Vest, Timisoara, **Ioan Tomescu**, University of Bucharest, and **Marius Zimand**, Towson University.

Domain Decomposition Methods and their Applications in Mechanics and Engineering, **Lori Badea**, Institute of Mathematics of the Romanian Academy, and **Marcus Sarkis**, Worcester Polytechnic Institute.

Geometry and Topology of Arrangements of Hypersurfaces, **Daniel Matei**, Institute of Mathematics of the Romanian Academy, and **Alexandru I. Suciu**, Northeastern University.

Harmonic Analysis and Applications, **Ciprian Demeter**, Indiana University, Bloomington, and **Camil Muscalu**, Cornell University.

Hopf Algebras, Coalgebras, and their Categories of Representations, **Miodrag C. Iovanov**, University of Bucharest and University of Iowa, **Susan Montgomery**, University of Southern California, and **Siu-Hung Ng**, Iowa State University.

Local and Nonlocal Models in Wave Propagation and Diffusion, **Anca V. Ion**, Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy, **Petronela Radu**, University of Nebraska, Lincoln, and **Lorena Bociu**, North Carolina State University.

Mathematical Finance, Stochastic Analysis, and Partial Differential Equations, **Lucian Beznea**, Institute of Mathematics of the Romanian Academy, **Paul Feehan**, Rutgers University, **Victor Nistor**, Pennsylvania State University, **Camelia Pop**, University of Pennsylvania, and **Mihai Sirbu**, University of Texas, Austin.

Mathematical Models in Life and Environment, **Gabriela Marinoschi**, Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy, and **Fabio Augusto Milner**, Arizona State University.

Mathematical Models in Materials Science and Engineering, **Marian Bocea**, Loyola University, Chicago, and **Bogdan Vernescu**, Worcester Polytechnic Institute.

Noncommutative Ring Theory and Applications, **Toma Albu**, Institute of Mathematics of the Romanian Academy, and **Lance W. Small**, University of California, San Diego.

Nonlinear Evolution Equations, **Daniel Tataru**, University of California, Berkeley, and **Monica Visan**, University of California, Los Angeles.

Operator Algebra and Noncommutative Geometry, **Marius Dadarlat**, Purdue University, and **Florin Radulescu**, Institute of Mathematics of the Romanian Academy and University of Rome Tor Vergata.

Operator Theory and Function Spaces, **Aurelian Gheondea**, Institute of Mathematics of the Romanian Academy and Bilkent University, **Mihai Putinar**, University of California, Santa Barbara, and **Dan Timotin**, Institute of Mathematics of the Romanian Academy.

Probability and its Relation to Other Fields of Mathematics, **Krzysztof Burdzy**, University of Washington, and **Mihai N. Pascu**, Transilvania University of Braşov.

Random Matrices and Free Probability, **Ioana Dumitriu**, University of Washington, and **Ionel Popescu**, Georgia Institute of Technology and Institute of Mathematics of the Romanian Academy.

Several Complex Variables, Complex Geometry and Dynamics, **Dan Coman**, Syracuse University, and **Cezar Joita**, Institute of Mathematics of the Romanian Academy.

Topics in Geometric and Algebraic Topology, **Stefan Papadima**, Institute of Mathematics of the Romanian Academy, and **Alexandru I. Suciu**, Northeastern University.

Louisville, Kentucky

University of Louisville

October 5–6, 2013

Saturday – Sunday

Meeting #1092

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: June 2013
Program first available on AMS website: August 22, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 34, Issue 3

Deadlines

For organizers: March 5, 2013
For consideration of contributed papers in Special Sessions: June 18, 2013
For abstracts: August 13, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Michael Hill, University of Virginia, *Title to be announced.*

Suzanne Lenhart, University of Tennessee, *Title to be announced.*

Ralph McKenzie, Vanderbilt University, *Title to be announced.*

Victor Moll, Tulane University, *Title to be announced.*

Special Sessions

Commutative Rings, Ideals, and Modules (Code: SS 3A), **Ela Celikbas** and **Olgur Celikbas**, University of Missouri-Columbia.

Extremal Graph Theory (Code: SS 2A), **Jozsef Balogh**, University of Illinois at Urbana-Champaign, and **Louis DeBiasio** and **Tao Jiang**, Miami University, Oxford, OH.

Set Theory and Its Applications (Code: SS 1A), **Paul Larson**, Miami University, **Justin Moore**, Cornell University, and **Grigor Sargsyan**, Rutgers University.

Philadelphia, Pennsylvania

Temple University

October 12–13, 2013

Saturday – Sunday

Meeting #1093

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2013
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 34, Issue 3

Deadlines

For organizers: March 12, 2013
For consideration of contributed papers in Special Sessions: June 25, 2013
For abstracts: August 20, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Patrick Brosnan, University of Maryland, *Title to be announced.*

Xiaojung Huang, Rutgers University, *Title to be announced.*

Barry Mazur, Harvard University, *Title to be announced* (Erdős Memorial Lecture).

Robert Strain, University of Pennsylvania, *Title to be announced.*

Special Sessions

Contact and Symplectic Topology (Code: SS 5A), **Joshua M. Sabloff**, Haverford College, and **Lisa Traynor**, Bryn Mawr College.

Geometric and Spectral Analysis (Code: SS 3A), **Thomas Krainer**, Pennsylvania State Altoona, and **Gerardo A. Mendoza**, Temple University.

Higher Structures in Algebra, Geometry and Physics (Code: SS 2A), **Jonathan Block**, University of Pennsylvania, **Vasily Dolgushev**, Temple University, and **Tony Pantev**, University of Pennsylvania.

History of Mathematics in America (Code: SS 4A), **Thomas L. Bartlow**, Villanova University, **Paul R. Wolfson**, West Chester University, and **David E. Zitarelli**, Temple University.

Recent Advances in Harmonic Analysis and Partial Differential Equations (Code: SS 1A), **Cristian Gutiérrez** and **Irina Mitrea**, Temple University.

Recent Developments in Noncommutative Algebra (Code: SS 6A), **Edward Letzter** and **Martin Lorenz**, Temple University.

Several Complex Variables and CR Geometry (Code: SS 7A), **Andrew Raich**, University of Arkansas, and **Yuan Zhang**, Indiana University-Purdue University Fort Wayne.

St. Louis, Missouri

Washington University

October 18–20, 2013

Friday – Sunday

Meeting #1094

Central Section
Associate secretary: Georgia Benkart

Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 5, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 34, Issue 4

Deadlines

For organizers: March 20, 2013
For consideration of contributed papers in Special Sessions: July 2, 2013
For abstracts: August 27, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Ronny Hadani, University of Texas at Austin, *Title to be announced*.

Effie Kalfagianni, Michigan State University, *Title to be announced*.

Jon Kleinberg, Cornell University, *Title to be announced*.

Vladimir Sverak, University of Minnesota, *Title to be announced*.

Special Sessions

Algebraic and Combinatorial Invariants of Knots (Code: SS 1A), **Heather Dye**, McKendree University, **Allison Henrich**, Seattle University, and **Louis Kauffman**, University of Illinois.

Computability Across Mathematics (Code: SS 2A), **Wesley Calvert**, Southern Illinois University, and **Johanna Franklin**, University of Connecticut.

Geometric Topology in Low Dimensions (Code: SS 4A), **William H. Kazez**, University of Georgia, and **Rachel Roberts**, Washington University in St. Louis.

Interactions between Geometric and Harmonic Analysis (Code: SS 3A), **Leonid Kovalev**, Syracuse University, and **Jeremy Tyson**, University of Illinois, Urbana-Champaign.

Noncommutative Rings and Modules (Code: SS 5A), **Greg Marks** and **Ashish Srivastava**, St. Louis University.

Riverside, California

University of California Riverside

November 2–3, 2013

Saturday – Sunday

Meeting #1095

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 19, 2013
Program issue of electronic *Notices*: November 2013
Issue of *Abstracts*: Volume 34, Issue 4

Deadlines

For organizers: April 2, 2013
For consideration of contributed papers in Special Sessions: July 15, 2013
For abstracts: September 10, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Christ, University of California, Berkeley, *Title to be announced*.

Mark Gross, University of California, San Diego, *Title to be announced*.

Matilde Marcolli, California Institute of Technology, *Title to be announced*.

Paul Vojta, University of California, Berkeley, *Title to be announced*.

Special Sessions

Computer, Mathematics, Imaging, Technology, Network, Health, Big Data, and Statistics (Code: SS 3A), **Subir Ghosh**, University of California, Riverside.

Developments in Markov Chain Theory and Methodology (Code: SS 2A), **Jason Fulman**, University of California, Riverside, and **Mark Huber**, Claremont McKenna College.

The Mathematics of Planet Earth (Code: SS 1A), **John Baez**, University of California, Riverside.

Baltimore, Maryland

Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel

January 15–18, 2014

Wednesday – Saturday

Meeting #1096

Joint Mathematics Meetings, including the 120th Annual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic *Notices*: January 2013
Issue of *Abstracts*: Volume 35, Issue 1

Deadlines

For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Knoxville, Tennessee

University of Tennessee, Knoxville

March 21–23, 2014
Friday – Sunday

Meeting #1097
Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: August 21, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

University of Maryland, Baltimore County

March 29–30, 2014
Saturday – Sunday

Meeting #1098
Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: March 2014
Issue of *Abstracts*: To be announced

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Albuquerque, New Mexico

University of New Mexico

April 5–6, 2014
Saturday – Sunday

Meeting #1099
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: April 2014
Issue of *Abstracts*: To be announced

Deadlines
For organizers: September 5, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: February 11, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

The Inverse Problem and Other Mathematical Methods Applied in Physics and Related Sciences (Code: SS 1A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico and Enfitek, Inc.

Lubbock, Texas

Texas Tech University

April 11–13, 2014
Friday – Sunday

Meeting #2000
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: September 18, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

Topology and Physics (Code: SS 1A), **Razvan Gelca** and **Alastair Hamilton**, Texas Tech University.

Tel Aviv, Israel

Bar-Ilan University, Ramat-Gan and Tel-Aviv University, Ramat-Aviv

June 16–19, 2014
Monday – Thursday
The 2nd Joint International Meeting between the AMS and the Israel Mathematical Union.

Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

Special Sessions

Mirror Symmetry and Representation Theory, **David Kazhdan**, Hebrew University, and **Roman Bezrukavnikov**, Massachusetts Institute of Technology.

Nonlinear Analysis and Optimization, **Boris Mordukhovich**, Wayne State University, and **Simeon Reich** and **Alexander Zaslavski**, The Technion-Israel Institute of Technology.

Qualitative and Analytic Theory of ODE's, **Yosef Yomdin**, Weizmann Institute.

Eau Claire, Wisconsin

University of Wisconsin-Eau Claire

September 20–21, 2014

Saturday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: February 20, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: August 5, 2014

Halifax, Canada

Dalhousie University

October 18–19, 2014

Saturday – Sunday
Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 18, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

San Francisco State University

October 25–26, 2014

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2014
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 25, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: September 3, 2014

Greensboro, North Carolina

University of North Carolina, Greensboro

November 8–9, 2014

Saturday – Sunday
Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015
Saturday – Tuesday
Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2015
Issue of *Abstracts*: Volume 36, Issue 1

Deadlines
For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Las Vegas, Nevada

University of Nevada, Las Vegas

April 18–19, 2015
Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: September 18, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Porto, Portugal

University of Porto

June 11–14, 2015
Thursday – Sunday
First Joint International Meeting between the AMS and the Sociedade Portuguesa de Matemática.
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Not applicable

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Chicago, Illinois

Loyola University Chicago

October 3–4, 2015
Saturday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2015
Issue of *Abstracts*: To be announced

Deadlines
For organizers: March 10, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Fullerton, California

California State University, Fullerton

October 24–25, 2015
Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2015
Issue of *Abstracts*: To be announced

Deadlines
For organizers: March 27, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention Center and the Sheraton Seattle Hotel

January 6–9, 2016
Wednesday – Saturday
Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th Annual Meeting of the Math-

ematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday
Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday – Saturday
Joint Mathematics Meetings, including the 124th Annual Meeting of the AMS, 101st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2017
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2017
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel at Camden Y

January 16–19, 2019

Wednesday – Saturday
Joint Mathematics Meetings, including the 125th Annual Meeting of the AMS, 102nd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM)and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2018
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 2, 2018
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: Georgia Benkart, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

Eastern Section: Steven H. Weintraub, Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: steve.weintraub@lehigh.edu; telephone: 610-758-3717.

Southeastern Section: Brian D. Boe, Department of Mathematics, University of Georgia, 220 D W Brooks Drive, Athens, GA 30602-7403, e-mail: brian@math.uga.edu; telephone: 706-542-2547.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at www.ams.org/meetings/.**

Meetings:

Important Information Regarding AMS Meetings

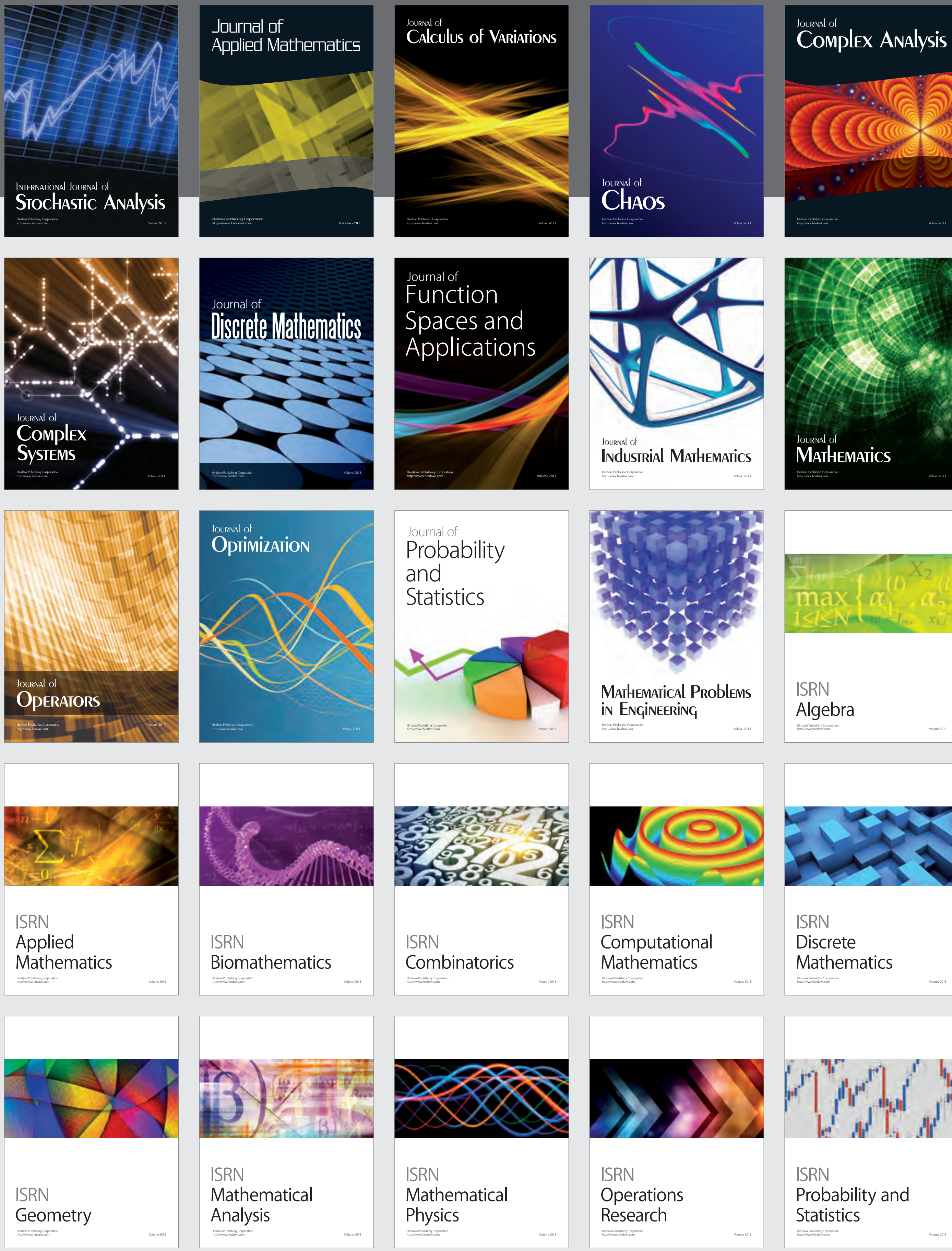
Potential organizers, speakers, and hosts should refer to page 111 in the the January 2012 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences in Cooperation with the AMS: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

July 22–26, 2013: Samuel Eilenberg Centenary Conference (E100), Warsaw, Poland.


International Journal of Stochastic Analysis
Journal of Applied Mathematics
Journal of Calculus of Variations
Journal of Chaos
Journal of Complex Analysis
Journal of Complex Systems
Journal of Discrete Mathematics
Journal of Function Spaces and Applications
Journal of Industrial Mathematics
Journal of Mathematics
Journal of Operators
Journal of Optimization
Journal of Probability and Statistics
Mathematical Problems in Engineering
ISRN Algebra
ISRN Applied Mathematics
ISRN Biomathematics
ISRN Combinatorics
ISRN Computational Mathematics
ISRN Discrete Mathematics
ISRN Geometry
ISRN Mathematical Analysis
ISRN Mathematical Physics
ISRN Operations Research
ISRN Probability and Statistics

American Mathematics Society

2012: The Year in Books

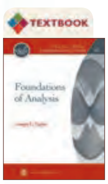
A sampling of notable AMS titles published over the last year

Algebraic Geometry
A Problem Solving Approach

Thomas Garrity, **Richard Belshoff**, **Lynette Boos**, **Ryan Brown**, **Carl Lienert**, **David Murphy**, **Junalyn Navarra-Madsen**, **Pedro Poitevin**, **Shawn Robinson**, **Brian Snyder**, and **Caryn Werner**

A problem-driven introduction to algebraic geometry that requires its readers to think through the mathematics, allowing for greater comprehension.

Student Mathematical Library, Volume 66; 2013; 335 pages; Softcover; ISBN: 978-0-8218-9396-8; List US$53; AMS members US$42.40; Order code STML/66



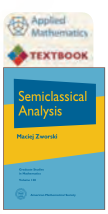
Foundations of Analysis

Joseph L. Taylor, *University of Utah, Salt Lake City, UT*

"...The book is well-written, clear, and concise, and supplies the students with very good introductory discussions of the various topics, correct and well-thought-out proofs, and appropriate, helpful examples."

—Robert Brooks, University of Utah

Pure and Applied Undergraduate Texts, Volume 18; 2012; 398 pages; Hardcover; ISBN: 978-0-8218-8984-8; List US$74; AMS members US$59.20; Order code AMSTEXT/18



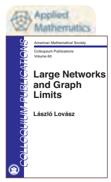
Semiclassical Analysis

Maciej Zworski, *University of California, Berkeley, CA*

"This book is an excellent, comprehensive introduction to semiclassical analysis. I believe it will become a standard reference for the subject."

—Alejandro Uribe, University of Michigan

Graduate Studies in Mathematics, Volume 138; 2012; 431 pages; Hardcover; ISBN: 978-0-8218-8320-4; List US$75; AMS members US$60; Order code GSM/138



Large Networks and Graph Limits

László Lovász, *Eötvös Loránd University, Budapest, Hungary*

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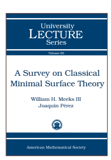

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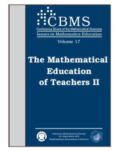

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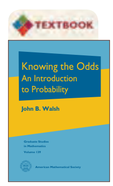

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